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0 EXECUTIVE SUMMARY

As part of the fourth generation concession program, the National Infrastructure Agency (*Agencia Nacional de Infraestructura - ANI*), through the Concession Agreement under APP scheme No. 15 of September 11, 2015, awarded to Concesionaria Vial Unión del Sur S.A.S. the performance of studies and designs, environmental, property and social management for the Rumichaca-Pasto Divided Highway Project.

The Rumichaca-Pasto Divided Highway Project, pursuant to the recommendations contained in CONPES 3820 to apply in the Second Wave projects the functional unit structuring, has five Functional Units (FU), based on the designs previously prepared by the ANI (See **Table 0.1**.)

Table 0.1 Project Functional Units

FUNCTIONAL UNIT (FU)	SECTOR	KP STARTING POINT	KP ENDING POINT	LENGTH
1	1.1 Rumichaca - Ipiales	KP 0+000	KP 0+900	0.9 km
	1.2 Ipiales –San Juan	KP 0+900	KP 17+000	16.10 km
	1.3 San Juan - Contadero	KP 17+000	KP 25+600	8.60
2	2.0 Contadero - Iles	KP 25+600	KP 37+600	12.00 km
3	3.0 Iles - Pedregal	KP 37+600	KP 44+909	7.31 km
4	4.0 Pedregal - Tangua	KP 0+000	KP 15+760	15,76 km
5	5.0 Tangua - Catambuco	KP 15+760	KP 32+700	16.94 km
	5.1 Catambuco - Pasto	KP 32+700	KP 37+959	5.3 km

The project intends to integrate, through a better road connection, the southwestern part of Colombia, thus strengthening regional development as well as the international axis connecting Colombia with Ecuador, optimizing road traffic, hence reducing accident rates, traveling times and vehicle operating costs.

Furthermore, the Agencia Nacional de Infraestructura -ANI-, through document 4120-E1-25763 of June 20, 2013, filed with the ANLA, requested opening the NDA case file for the project "Construction of the Second Roadway between Rumichaca and Pedregal", in the department of Nariño. File NDA 0905 was opened to manage this request.

Finally, this Environmental Impact Assessment is a requirement for performance of construction activities for the Rumichaca-Pasto road corridor, San Juan-Pedregal Segment, corresponding to functional units 1, sector 1.3 and functional units 2 and 3, by means of the description, characterization, analysis and evaluation of the physical, biotic and socioeconomic environment of the territory. Also, to develop plans and programs for proper management of impacts derived from various environmental components, pursuant to that provided for in the respective regulations, and enabling the obtaining of the Environmental License.

1 OBJECTIVES

1.1 PROJECT GENERAL OBJECTIVE

Building a new Divided Highway for the Rumichaca-Pasto road axis, San Juan-PEDREGAL Segment, to improve communication and connectivity of Colombia's southwestern region with the rest of the country and with its neighboring country, Ecuador.

1.2 PROJECT SPECIFIC OBJECTIVES

- Coordinate an enhanced road connection of Southwestern Colombia, to thus strengthen the regions development.
- Strengthen the international axis connecting Colombia with Ecuador, through the construction of the road infrastructure of the Rumichaca – Pasto, San Juan – Pedregal Segment, contributing to the country's economy, improving public utility supply, promoting national tourism, and creating work opportunities and investment.
- Optimize road coordination and traffic, thus reducing accident rates, traveling times, and vehicle operating costs.

1.3 ASSESSMENT GENERAL OBJECTIVE

Perform the Environmental Impact Assessment required for performance of construction activities for the Rumichaca-Pasto road corridor, San Juan - Pedregal Segment, corresponding to functional units 1, sector 1.3 and functional units 2 and 3, by means of the description, characterization, analysis and evaluation of the physical, biotic and socioeconomic environment of the territory. Also, to develop plans and programs for proper management of impacts derived from various environmental components, pursuant to that provided for in the respective regulations, and enabling the attainment of the Environmental License.

2 GENERAL ASPECTS

2.1 SCOPE

The scope of this document is framed within the technical and information characteristics obtained from the design and technical studies implied in a road construction project, provided for by the Transport Ministry, the National Road Institute (*Instituto Nacional de Vias* - INVIAS) and the National Infrastructure Agency (*Agencia Nacional de Infraestructura* -ANI).

The scope of the assessment if based on that required in the Terms of Reference for the Preparation of the Environmental Impact Assessment - EIA in Road and/or Tunnel Construction Projects, issued by the Ministry of the Environment and Sustainable Development through Resolution 0751 of March 26, 2015. Additionally, it also relied on the General Methodology document for Presentation of Environmental Assessments of 2010,

issued by the Ministry of the Environment, Housing and Territorial Development, and the provisions set forth in Resolution 2182 of December 23, 2016, which amends and consolidates the Geographical Storage Model.

This assessment specifically supplies all the necessary primary and secondary data for the description and analysis of the abiotic, biotic and socioeconomic environments.

2.2 METHODOLOGY

The environmental impact assessment was developed in two phases, the first one to collect secondary data and primary data for each of the specialties within the project's area of influence, and a second one consisted in processing the collected data and carrying out interdisciplinary workshops to determine the scope of the traffic project, propose activities that would generate environmental impact, discuss environmental impact with and without the project, propose environmental management, follow-up and monitoring programs, and socialization of the project with the community.

Described below is the methodology for environmental assessment of impacts.

2.2.1 Environmental assessment methodology

In order to know the environmental conditions in the area, an environmental impact assessment was performed of activities without the project; that is, those carried out by the community in the area of influence, and other activities to be developed by the traffic project (scenario with the project). The methodology used was assigning value to a series of attributes that describe the environmental significance of the impact, which was developed by Vicente Conessa Fernández, 2010. Described below are the steps followed for assessing the environmental impact for both scenarios.

2.2.1.1 Identification and rating of environmental impacts.

As an initial phase, the assessment activities were analyzed and the resources required in each of them were determined to then identify the impacts and effects that could be derived from the project and for the scenario without the project. The activities that will be carried out in the assessment area were determined, with their effect on the environment to obtain an idea of the potential impact. In both scenarios the tool used was a double entry matrix.

Additionally, the methodology used for assessing environmental impact includes as part of its evaluation criteria those that are considered cumulative, as provided for in Decree 2041 of October 15, 2014 of the Ministry of Environment and Sustainable Development (MADS).

The identification and rating process was performed based on the following general steps:

Identification of Project Activities: summarized description of each activity performed by the community (scenario without the project) and activities to be performed by the project.

Characterization of the project's area of influence: based on information from the abiotic, biotic and socioeconomic base line, there is a diagnosis of the current condition of the study area and its current socio-environmental problems.

Determination of the Required Natural Resources: the needs for use and exploitation of the natural resources required by the activities developed and projected for the assessment.

Inventory of Waste Generated by the Activity: list of the type of residues generated by activities implied in the various activities, both in the scenario without the project and with the project (domestic, industrial and special waste) that could cause negative impact on the environment.

Determination of Environmental Impact and Effects Significance: to determine the significance of environmental impacts, a matrix is filled out, which shows the activities, the environmental issues, the generated impacts identified, and these are cross-checked with the evaluation criteria (see **Table 2.1**.)

After identifying and evaluating the impacts, these are cross-checked with the Environmental Management Plan, so that these have their respective management measures, whether on prevention, mitigation, correction and/or compensation.

2.2.1.2 Evaluation of Environmental Impact Significance (EIS).

The evaluation of environmental significance is determined based on criteria related to the Nature, Intensity, Extension, Duration, Periodicity, Recoverability, Reversibility, Moment, Effect, Resilience, Synergy and Accumulation, which are evaluated in accordance with the criteria listed in **Table 2.1**.

The values of **ENVIRONMENTAL IMPACT SIGNIFICANCE** are obtained from the weighting of values of the aforementioned criteria.

Table 2.1 Criteria for Evaluation of Environmental Impact Significance (EIS) .

ATTRIBUTE	DEFINITION	SCALE	RANGE
Nature or Character (C)	It is the positive (+) or harmful (-) character of the various actions affecting the different factors involved.	Positive Harmful	(+) (-)
Intensity (INT)	It is interpreted as the level of effects from the action on specific environmental components. **Low**: Its effect is just a minimum change on the socio-environmental component assessed. **Medium:** Even though changes or modifications occur, these do not affect seriously the socio-environmental component assessed. **High:** Its effect causes serious impact on the socio-environmental component. **Very High:** It expresses a nearly total effect on the socio-environmental component assessed.	Low Medium High Very High Total	1 2 4 8 12

ATTRIBUTE	DEFINITION	SCALE	RANGE
	Total: Damage or total perturbation of the socio-environmental component.		
Extension (EXT)	It refers to the location of the effects, considering the area of influence of the project according to the socio-environmental component assessed. **Specific:** When the impact action caused a specific effect, that is, on an only intervention site. From a social perspective, it refers to property level. **Partial:** The effects go beyond the intervention sites, still being within the project's area of influence. With respect to the social environment, it refers to rural districts. **Extensive:** Effects go beyond the sites that are closer to the project's area of influence. From the social standpoint, it refers to municipalities. **Total:** The impact affects all of the direct and indirect area of influence. As regards the social environments, it affects all towns in its area of influence.	Specific Partial Extensive Total	1 2 4 8
Duration (DUR)	It is the apparent time of impact duration as of its commencement. **Brief:** If the effect lasts less than one month. **Temporary:** if it lasts between 1 to 3 months. **Prolonged:** between 4 and 10 months. **Permanent:** if it is of longer duration.	Brief Temporary Prolonged Permanent	1 2 4 7
Frequency (FR)	The frequency refers to their regularity on impact occurrence related to environmental aspects' development. **Irregular**: The environmental aspect assessed generates impact in an unpredictable manner or only once over time. **Periodical:** The environmental aspect assessed generates impacts in a cyclic or recurrent manner.	Irregular Periodical Continuous	1 3 7

ATTRIBUTE	DEFINITION	SCALE	RANGE
	Continuous: The environmental aspect assessed generates impact constantly over time.		
Recoverability (RC)	It refers to the possibility and the time of introducing corrective actions that were measures to remedy the impact caused. **Recoverable:** (Immediate or in the medium term) is the fact can be eliminated through corrective measures, supposing an alteration that can be replaceable (e.g. when vegetation is eliminated in a zone, its fauna disappears; when the zone is reforested, the fauna will come back). **Mitigable:** its effect can be attenuated through mitigating measures. (For example, noise control barriers). **Irrecoverable:** its alteration or loss is impossible to repair (e.g. any cement or concrete works).	Recoverable Mitigable Irrecoverable	1 4 7
Reversibility (RV)	It refers to the possibility of returning to original conditions previous to the accident, by natural means, once it no longer affects the environment. **Reversible:** The affected socio-environmental component returns on its own to its natural condition in less than 12 months. **Medium reversibility:** The environmental component takes 1 to 5 years to go back to its natural condition. **Irreversible:** The environmental component takes longer than five years, or it may be impossible that it would go back to its previous situation by natural means.	Reversible: Medium reversibility Irreversible	1 4 7
Moment (MO)	The Impact manifestation is defined as of the time elapsed between execution of an accident and the appearance of its effects on the socio-environmental component assessed. **Immediate**: If the time elapsed is nil.	Long Term Medium Term Immediate	1 2 4

ATTRIBUTE	DEFINITION	SCALE	RANGE
	Medium term: if the period ranges between 1 and 3 months. **Long term:** the impact lasts more than three months.		
Effect (EF)	Cause-Effect Relationship	Indirect Direct	1 4
Resilience (RS)	Ability to absorb perturbation, without significant alteration of its structure characteristics and functionality. **High:** Return to original conditions takes less than two (2) years **Medium**: It requires from two to fifteen years (2-15). **Low or Nil:** It takes more than 15 years or does not return to its natural condition without management measures. **Note:** The Resilience Rating must be consistent with the reversibility rating (RV) for negative impacts.	For impacts (-): High Medium Nil For impacts (+): Low Medium High	 1 2 4 1 2 4
Synergy (SI)	It refers to the merger of several impacts that generate effects of greater magnitude than those generated if acting separately.	Non synergistic Synergistic	1 4
Accumulation (A)	Impact increased progressively after performance of the activity, when the generating action persists continuously or repeatedly.	Non-cumulative Cumulative	1 4

Source: Vicente Conesa Fernández-Vítora. Methodological guide for the Environmental Impact Assessment.

Adapted by GEOCOL CONSULTORES S.A. 2017.

2.2.1.3 Assessment and determination of Environmental Significance (ES).

The assessment of impacts is a procedure to alternately establish the significance of an impact and then established the type of socio- environmental management measure required.

The significance of the impact is obtained from the correlation of attributes, based on the equation shown in **Table 2.2,** whereby a value is obtained for the most significant actions (high negative values), moderate (low negative values) and positive (high and low positive values).

In accordance with the foregoing, severe and critical impacts require special management measures; those that are irrelevant, not significant and moderate, require general management measures. Activities that generate critical or inadmissible environmental impact must be reassessed not from the impact standpoint

per se, but from that of social and/or environmental viability of the project or specific activity. **Table 2.2** shows the evaluation rates that can be obtained from implementing the environmental significance evaluation as per the aforementioned methodological parameters.

Table 2.2 Impact rating ranges according to the environmental significance (ES).

Environmental Significance (ES)	The significance of the impact is interpreted as an action on a specific socio-environmental component. It is calculated using the following equation: **IMA = +/- ((3 x I) + (2 x EX) + DU + PR + MC + RV + MO + EF + RS +SI + A)**	**Slight or irrelevant impact**	< 33
		Moderate Impact	Between 33 - 51
		Severe Impact	Between 52 - 74
		Critical Impact	> a 74

Source: GEOCOL CONSULTORES S.A., 2017.

2.2.1.4 Level of Negative Global Intervention (NIGN for its acronym in Spanish)

The Level of Negative Global Intervention is a value established in percentage terms to confirm the comprehensive level of impact, considering the minimum and maximum rating of the environmental criteria assessed.

In this same token, it is a supplement to the analysis performed using an environmental impact assessment methodology, which in this case was that of Vicente Conesa Fernández, for the scenarios without the project and with the project.

The Level of Global Intervention is based on the following formula:

$$NIGn = 100\% - \frac{(Int.Max - Int) * 100\%}{(Int.Max - Int.Min)}$$

Where:

- **NIGN** is the level of negative global intervention of the project. (For this scenario without the project, it refers to the set of activities performed up to this date).
- **Int** is the total project or activity intervention resulting from adding up the negative impact from all actions (absolute data).
- **(Int) Max** is the maximum negative rating possible for the project or activity (absolute data) (This value corresponds to the number of interactions that would generate negative impact times the maximum value possible from the environmental impact, which is -100).
- **Int.Min.** is the minimum negative rating possible (absolute data) (This value corresponds to the number of interactions that would generate negative impact times the minimum value possible from the environmental impact, which is -14).

The value of the level of global intervention of the activities must be compared with the values listed in **Table 2.3**, to thus mathematically determine from the socio-environmental perspective what the most impacting activity was.

Table 2.3 Impact valuation and rating.

LEVEL OF NEGATIVE GLOBAL INTERVENTION (NIGN for its acronym in Spanish)	CATEGORY
0 – 25 %	Low Level of Intervention
25.1 – 50 %	Medium Level of Intervention
50.1 – 75 %	High Level of Intervention
75.1 – 100 %	Very High Level of Intervention

Source: Inter-American Development Bank Project environmental analysis. 2006.

3 PROJECT DESCRIPTION

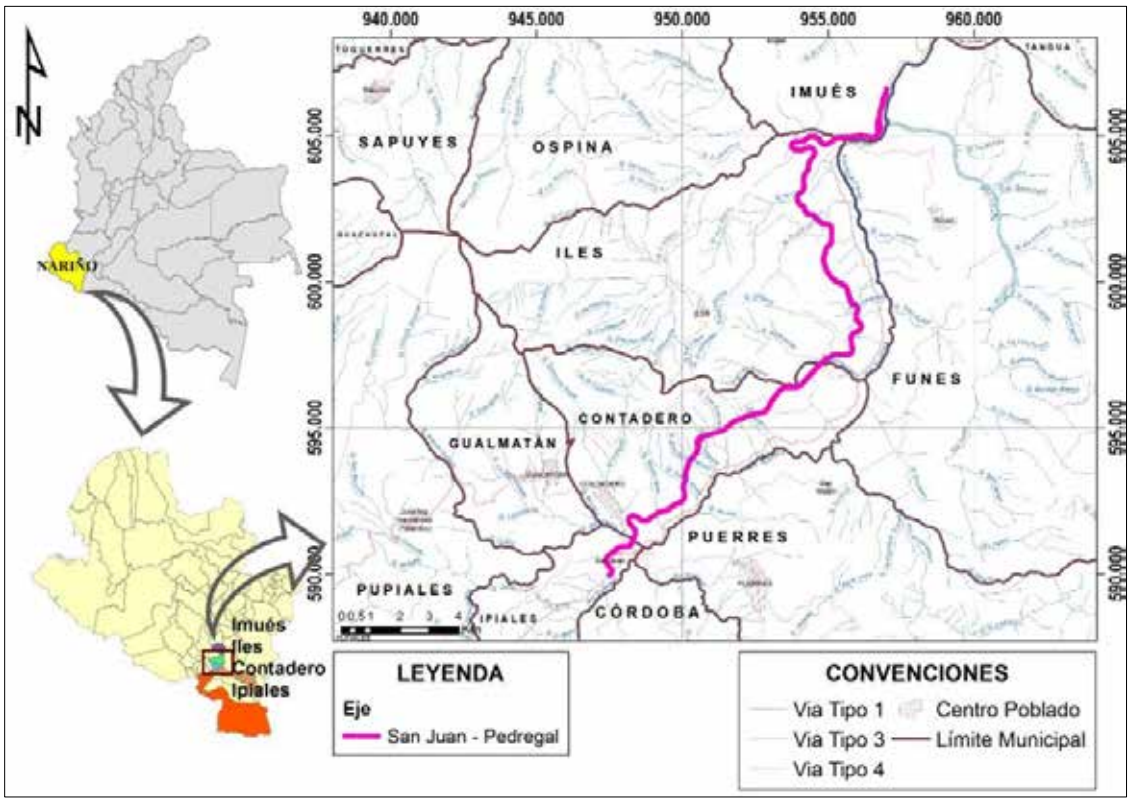
The Rumichaca-Pasto Divided Highway Project, San Juan-PEDREGAL SEGMENT, is located in the department of Nariño, in the towns of Ipiales, Contadero, Iles e Imués; **figure 3.1** shows the graph with its location, as in **Annex 10. Mapping. Map 01 - General Location**; it shows the project's geographical location and political/administrative map.

The Rumichaca-Pasto Divided Highway Project, San Juan-PEDREGAL SEGMENT will be located from KP15+750 to KP44+909; the construction section of a second roadway parallel to the existing one from KP15+750 to KP17+000 (1.25 km); a new road section from KP17+000 to KP41+992 (24.99 km) and the construction of a second roadway parallel to the existing road, which will be developed from KP41+992 to KP44+844 (2,85 km). It is worth noting that in the sections where the existing roadways are used, it will be enhanced. The total length of the project's layout will be 29.09 km, with 60 km/h design speed, two roadways, 7.30 m wide (each) in each direction, each roadway with two 3.65 m wide lanes, 2.0 m wide central separator, 0.50 m wide internal berms, 1.80 m wide external berms; the external side of each roadway will include an additional 2.0 m additional width as service zone in the landfill area and 1.0 m width in the cut-off zone intended for installing vertical signage, networks, S.O.S posts, etc., for a total of 23.20 m of road width.

The project's route will be located on a mountainous topography and, therefore, its typical cross-section will be mostly mixed (cutting and filling).

As part of the project's layout there are zones proposed where the roadways meet non-matching axis or divided roadways.

Figure3.1 Location of the Rumichaca-Pasto Divided Highway Project, San Juan - PEDREGAL SEGMENT.



Source: GEOCOL CONSULTORES S.A., 2017.

There will be a right of way for zones that have a central separator and matching axis roadways, minimum 50.30 to the point where the chamfer line extends, and for roadway zones with segregated axis, it corresponds to a primary one-lane road, that is, minimum 60 m for each lane or to the point of chamfer extension.

For handling runoff water, there will be lateral ditches, median ditches, intercepting ditches, berm ditches, cross ditches on access points and culverts. Furthermore, for management of slopes and according to the intervened zone, the road will have re-excavation, mesh guides, Californian drainage, cutting bottom treatment, back-filling boxes in mid slopes, land-filling, rock-fill in back-filling zones, concrete walls and flexible walls.

In densely populated urban areas, in intersections and in some road replacements, sidewalk will be built for pedestrian safety purposes.

For waterway crossings, there will be 900 mm and 1200mm circular culverts, box culverts with 1.0 x 1.0 m, 1.5 x 1.5 m, 2.0 x 2.0 m, 3.0 x 2 .0 m, 3.0 x 3.0 m and 5.0 x 3.5 m boxes, their supplementary works, such as drainage ditches, in addition to sub-drainage infrastructure. Similarly, five bridges or viaducts will be built (**Table 3.1**).

Table 3.1 Characteristics of the bridges to be built in the Rumichaca-Pasto Divided Highway Project, San Juan-PEDREGAL SEGMENT

Bridge	Location	Length (m)	Width (m)
Boquerón	Between chainage KP37+100 and KP 37+285	260	21,80
Tablón Alto	Between chainage PK36+356.5 and KP 36+600	243,50	21,80
El Macal stream	Between chainage KP37+100 and KP 37+285	185	21,80
El Porvenir rural district	Between chainage KP37+100 and KP 37+285	225	21,80
Sapuyes river	Between chainage PK36+356.5 and KP 36+600	200	21,80

Source: GEOCOL CONSULTORES S.A., 2017.

There will be level intersection and overpassing crossings with existing roads, among others; interchange connection with San Juan (KP17 + 100), interchange connection at Contadero (KP18+600), connection of the Iles road (KP35+600) and interchange connection at Pilcuan (KP41+700); furthermore, there will be three slowdown slopes.

The activities of the Rumichaca-Pasto Divided Highway Project, San Juan PEDREGAL SEGMENT, do not envisage tunnel construction in its layout.

For the Rumichaca-Pasto Divided Highway Project, San Juan Pedregal segment, five (5) bridges will be built:

The project will have an operations control center and a service area located at 40+300, four camps; San Juan Camp KP18+800, Iles Camp KP K31+000, Iles Camp KP35+600 and Mikel Camp KP1+300, which will have office areas, casino, auditorium, dormitories, service station, warehouses, shops, gunpowder warehouses, concrete plant, crushing plant, asphalt plant, etc.

To handle excavation waste material there will be 39 Zodmes, with 14,183,454 m3 capacity and three non-structural landfills with 1,272,161 m3 capacity.

3.1 PROJECT PHASES AND ACTIVITIES

The Rumichaca-Pasto Divided Highway Project, San Juan-Pedregal Segment will include the phases and activities listed in **Table 3.2**.

Table 3.2 Project phases and activities.

PHASE	ACTIVITIES	DEFINITION
PRE-CONSTRUCTION	Approaching and informing the community and the competent authorities.	It consists in communicating the activities related to the project and its scope to the population that could be affected and the authorities in the area of influence. It includes the preparation of studies and the processing of permits with the authorities, which are required to perform the project.

PHASE	ACTIVITIES	DEFINITION
	Negotiation of properties and easements	It consists in purchasing areas where it will be necessary to establish the project infrastructure (road layout, camps and Zodme), through the agreement with land and real estate owners, and clear commercial negotiation mechanisms.
	Personnel hiring and training	The activity consists in hiring professional, technical and operating personnel required to carry out all civil works and socio-environmental activities related to project execution. The hiring of skilled and unskilled labor will be conducted based on the needs of each construction activity.
	Mobilization of material for construction, supplies, machinery, equipment and personnel	It implies land mobilization of necessary items for project performance: material, supplies, machinery, equipment and personnel. Executed using vans, trucks, dump-trucks, low-bed trailers, which will run over the existing roads in the area of intervention, taking the necessary measures to prevent accidents and abiding by that provided for in the current regulations.
CONSTRUCTION	Purchase of goods and services	This activity is considered preliminary but can also be carried out during other project stages. It consists in the procurement of goods and services required for project performance.
	Surface water intake	It consists in the use of water resources through the construction of the necessary for catchment and distribution of water for the various activities of the project.
	Generation of solid waste by the project	It refers to the production of solid, domestic and hazardous waste during the various phases and activities of the project.
	Generation of domestic liquid and industrial waste for the project	It refers to the production of liquid waste such as domestic and industrial waste water, in the various phases and activities performed during the project.
	Removal of vegetation cover, clearing and cleaning	It includes removal of the vegetation cover and clearing of the corridor where the road will be constructed and the lateral zones or strips of the easement, those covered with stubble, weeds, crops, pasture, trees and forest, including removal of stubs, roots, debris and garbage, so that the right of way and the terrain are cleared and free of vegetation cover and the surface will be ready for the civil works. It includes the removal of debris resulting from the activity towards debris and excavation material handling zones (Zodme).

PHASE	ACTIVITIES	DEFINITION
	Demolition and removal of existing infrastructure in the areas to be worked on	Demolition of structures located within the intervention corridor for construction of the road, areas where the camps will be installed and areas where the debris and excavation material handling zones (Zodme) will be located.
	Land movement (Excavations and Landfills)	It entails excavation, scarification, grading and compacting of the terrain where the road foundations will be located. It includes removal of excavation excess material towards the Zodme.
	Setup and operation of camps	It covers the installation and operation of work fronts and provisional or permanent camps, where the yards for gathering and storing construction material and waste will be located, as well as the infrastructure for personnel accommodation and offices for logistics and administration of the civil works.
	Setup and operation of process plants (asphalt, concrete, crushing)	It corresponds to the construction and installation of infrastructure, equipment patios, crushing plants, concrete and mixes, and other infrastructure required for civil works logistics and administration. Within these areas, there will be activities for management of solid and liquid waste, added to management of catchment and discharges.
	Operation and maintenance of machinery and/or equipment	The project requires the use of equipment and machinery for performance of civil works. In order to optimize the productivity of equipment and machinery and to reduce the probability of causing environmental impacts, it is necessary to carry out preventive and corrective maintenance.
	Construction and operation of Zones for the management of debris and excavation materials	For management of excess material from the cutting, clearing and earth moving activities, debris and excavation material management zones (Zodme) will be established. Management of these areas implies loading and mobilization of excess material, controlled disposal of such material in layers, forming of terraces and slopes, material compacting, management of runoff water, and revegetation
	Preparation of the sub-base, base and granular base	It consists in the supply, conformation, grading and compaction of stone material (river crude, granular rock sand material ,etc.) over the terrain (with prior cutting, clearing and earth moving activities), using equipment and machinery such as backhoes, loaders, bulldozers, graders, vibrating compactors, etc.
	Conformation of surface course	It consists in transport, spreading and compacting of bituminous products and asphalt mixes that make up the road's surface course.

PHASE	ACTIVITIES	DEFINITION
	Foundations and pier work for bridges and viaducts	These structures are made of reinforced concrete and include the construction of foundation structures in terms of abutments, piles, piers, blocks, footings, flanges and columns that serve as support for the superstructures of bridges and viaducts.
	Construction of superstructures for bridges and viaducts	Comprises the concrete and steel construction of the upper part of bridges and viaducts. These structures are composed of beams, struts, trusses, boards, slabs, tension cables, curbs, platforms and railings, among others.
	Construction of hydraulic works (including channel use)	Consists of the construction of works (generally using concrete) for the management of runoff waters and water way crossings (streams and rivers): pipe drains, box culverts, gutters, energy dissipating elements, sub-drains and drains. This is in order to guarantee the natural flow of the water.
	Slope treatment	In order to mitigate them, prevent instability and erosion of slopes, geotechnical and hydraulic protection works are performed for protection thereof. The slope profiling (inclination ratio), protection of slope face turning it into grassland, fascines, biomanto fiber, crowning ditch building, forks, gabions, studs, contention walls, etc.
	Grass laying and vegetation restoration	Consists of establishing grasses, seeds or bio-matting in the areas of the project that require revegetation, i.e. slopes, Zodme and abandoned areas, etc.
	Toll installation	The Tollbooths and Tool Offices were designed to be sustainable in the long term, with low maintenance cost. The Office building is strategically located to support the Tollbooth cover and, thus create a particular design for the surroundings that would be physically attractive to view and to use. Located on PR 11+100.
ABANDONMENT AND FINAL RESTORATION	Dismantling temporary facilities and camps	It implies dismantling and removal of camp infrastructure, crushing, concrete and asphalt mixing plants and other areas used for project execution.
	Final cleanup of the areas intervened	At the end of the construction activities, the constructor must remove from the area any construction equipment, excess material, definitive and temporary works, leaving the area in adequate, clean conditions.
	Landscape Management	Landscaping conditioning (visual) of the intervened areas through implementation of works that integrate the infrastructure of the road with the environment. These activities are generally carried out using native vegetation.

Source: GEOCOL CONSULTORES S.A., 2017.

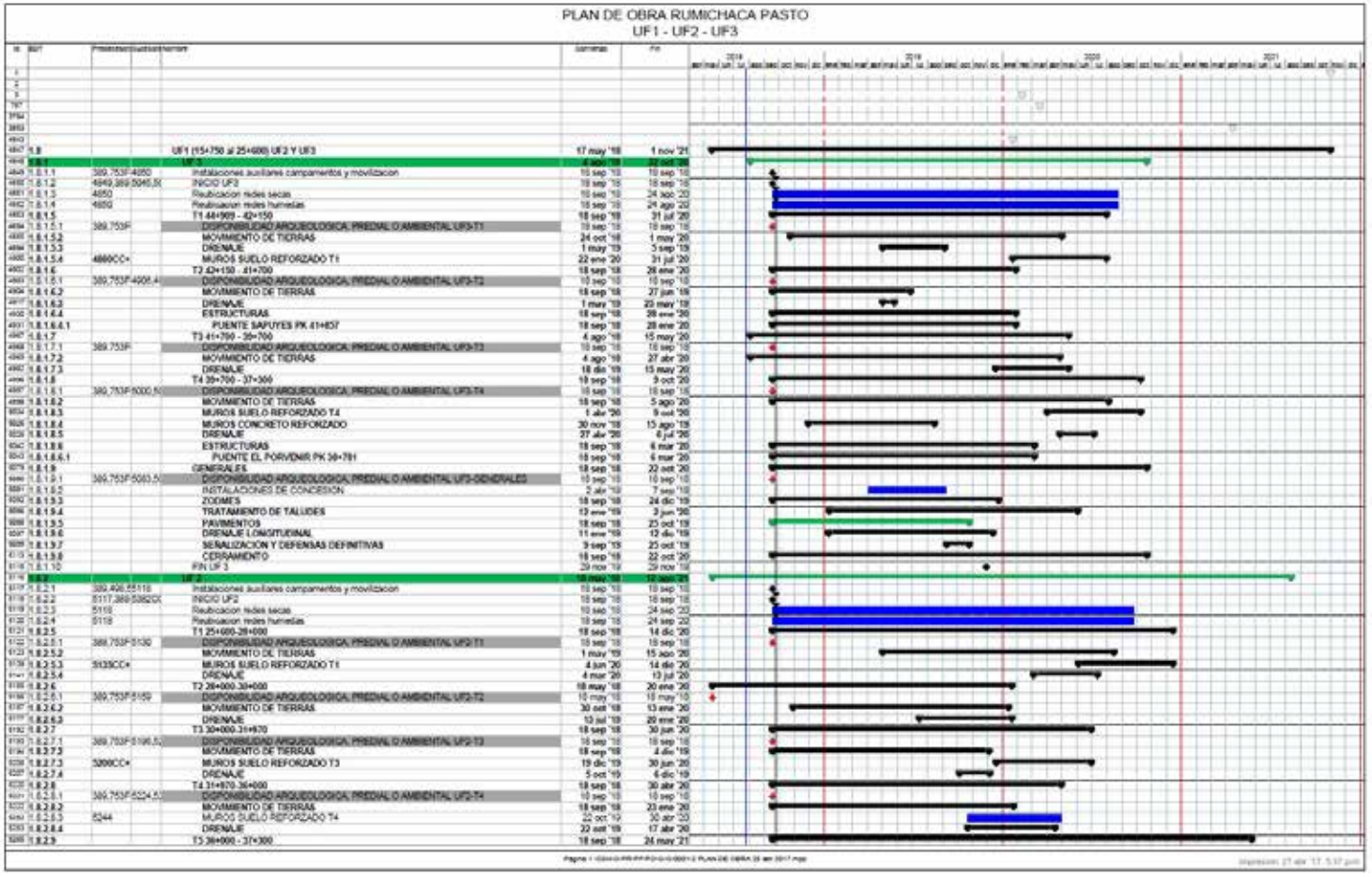
3.2 TOTAL PROJECT ESTIMATED COST

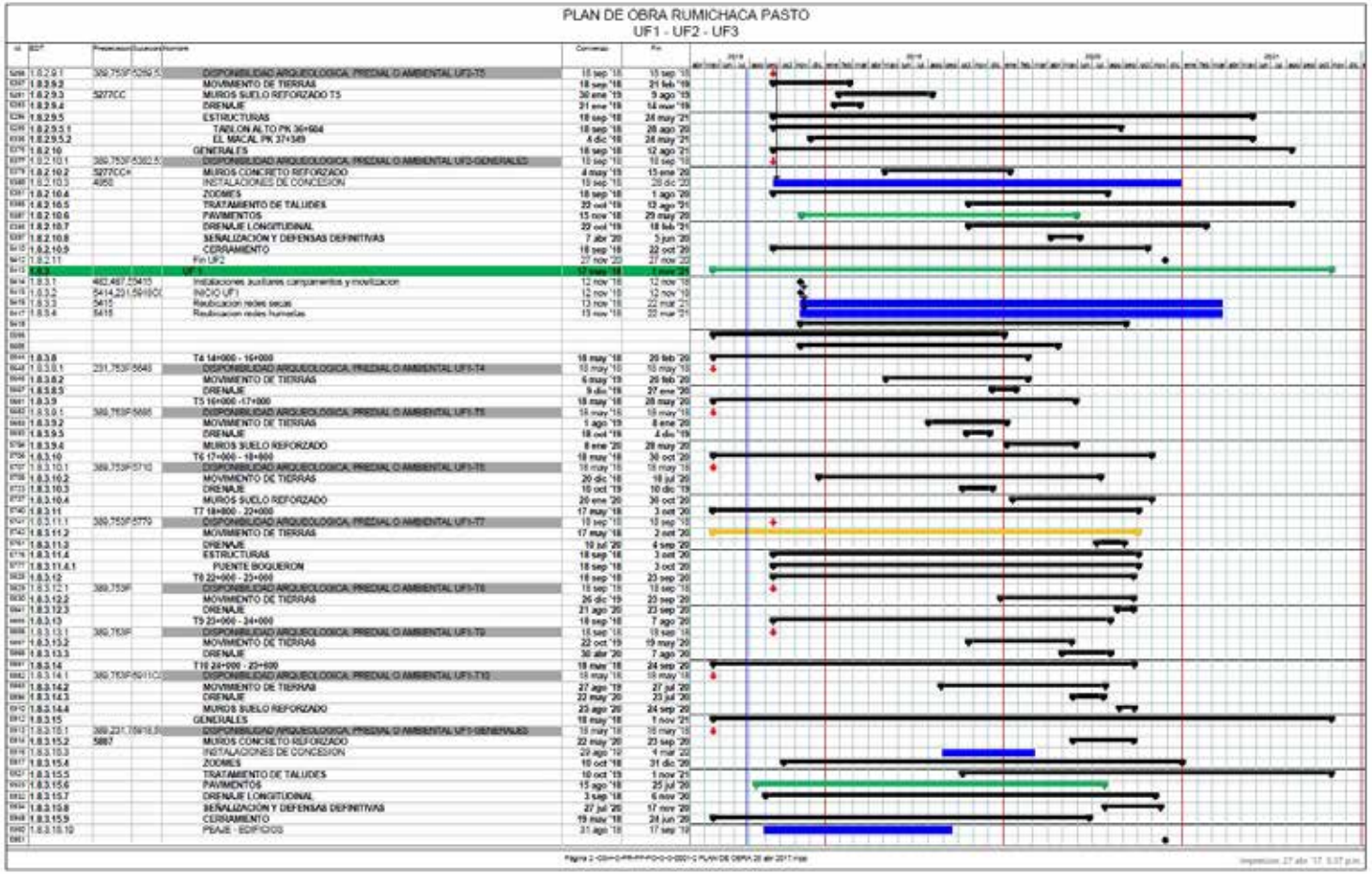
The performance of activities for the Rumichaca-Pasto Divided Highway Project, San Juan-Pedregal Segment, has an average estimated cost of ($778,223,713,106) seven hundred seventy eight two hundred twenty three million seven hundred thirteen thousand one hundred six Colombian pesos.

3.3 GENERAL ESTIMATED SCHEDULE FOR PROJECT EXECUTION

The Rumichaca-Pasto Divided Highway Project, San Juan-Pedregal Segment project will have a duration of 1,264 days according to the work schedule listed in **Annex 2. Civil. XII. Schedule and Organizational Chart** (See**Figure 3.2**).

Figure3.2 Work plan for the Rumichaca-Pasto Divided Highway Project, San Juan - Pedregal Segment.





Source: Consorcio SH, 2017

4 DESCRIPTION OF AREA OF INFLUENCE

The area of influence of the Rumichaca-Pasto Divided Highway project, San Juan - Pedregal Segment was defined, identified and delivered based on that set out in the terms of reference for the preparation of the Environmental Impact Assessment for highway and/or tunnel construction projects M-M-INA-02, Version No. 2, (ANLA, 2015), adopted through Resolution 7510 of March 26, 2015 issued by the Ministry of Environment and Sustainable Development (MADS).

4.1 TECHNICAL CONSIDERATIONS

To define that area of influence of the Rumichaca-Pasto Divided Highway project, San Juan-Pedregal Segment, concession agreement under APP Scheme No. 15 of 2015, the physical area to be occupied was considered, whether permanent or temporary, during construction of the whole road infrastructure, associated infrastructure, as well as adjacent areas, performance of activities planned for the various stages in accordance with project needs, requirements for use and exploitation of natural resources, components of the abiotic, biotic and socioeconomic environments, and the area where significant environmental impacts are evident, in order to define a single limit on which to conduct the analysis of the components involved.

The area of intervention of the Divided Highway Project has an extension of 1629.23 hectares, located in the jurisdiction of the municipalities of Ipiales, Contadero, Iles and Imués, in the department of Nariño.

4.2 DEFINITION, IDENTIFICATION AND DELIMITATION OF THE AREA OF INFLUENCE

The area of influence (hereinafter IA) for the physical-biotic components group of the San Juan-Pedregal segment, extends over a total of 4040.72 ha. It was defined based on the components that make up the physical and biotic environment. Hence, described below are the components considered in the delimitation of the area of influence:

4.2.1 Abiotic Environment Area of Influence

The area of influence of the physical environment is delimited based mostly on the morphology of the area's geomorphology units in the zone (slope changes due to roads and drainage, which influence the distribution of physical processes), added to the impact that could be caused by eventual mass movements in the normal behavior of hydrology systems, specially downstream of the road project, in some sectors, up to the Eastern limits with the Guaítara River, which are related to changes in water quality, potential damming of narrow riverbeds, avalanches and sludge flows. Similarly, the boundaries of the mentioned area, upstream of the road project, are related mostly to the potential impact on the decline of ground water resources and changes in the surface hydrology regime; currently, these changes are somehow related to human activities such as rural roads and/or farming plots delimited with live fencing. Therefore, the upper limits defined for the area of influence are delimited in some cases by said boundaries.

4.2.2 Biotic Environment Area of Influence

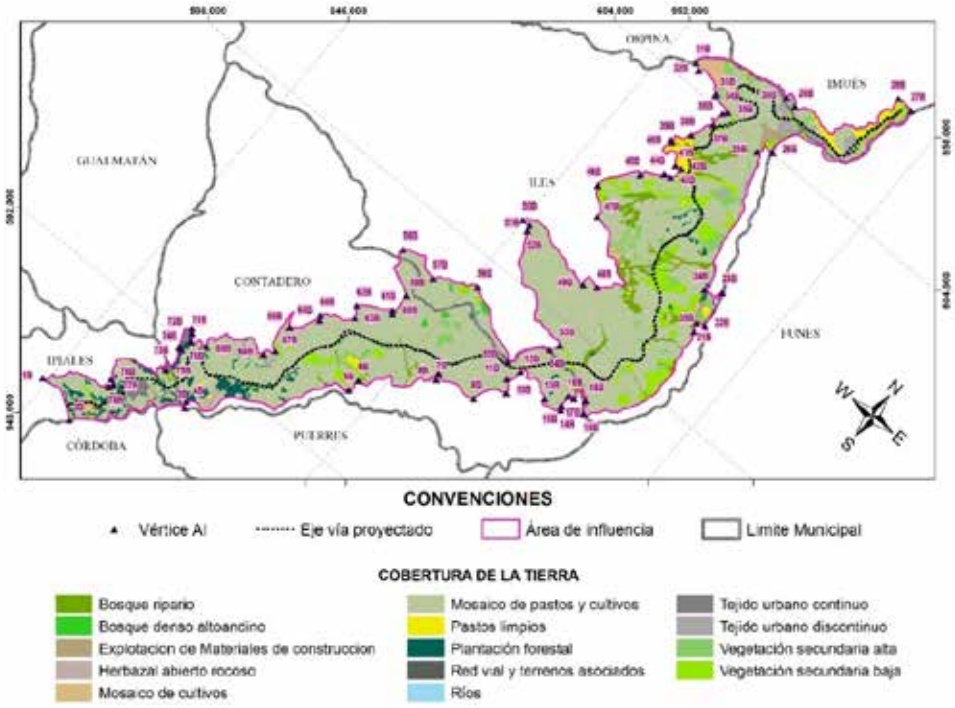
The area of influence of the biotic environment was defined based on analysis units such as watersheds, ecosystems, and territorial units. Given the high level of fragmentation of the study area and the evidence of

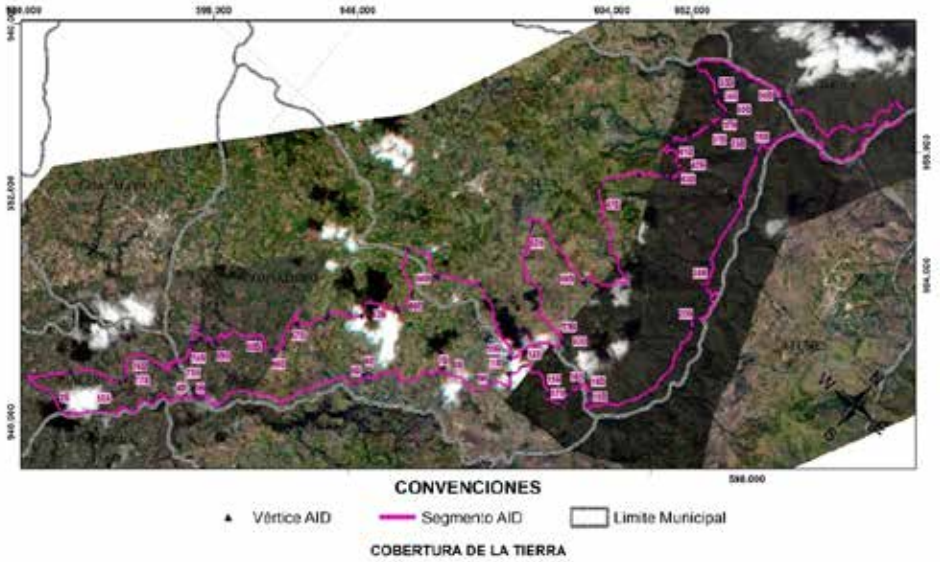
impact, minimal analysis units to find were land cover, water bodies, road network, and abrupt terrain changes.

4.2.3 Physical – Biotic Area of Influence.

To describe the area of influence, 78 vertices were identified, which were differentiated based on changes in the physical or biotic criteria described above (**Figure 4.1**).

Figure4.1 Physical – Biotic Area of Influence.





Source: GEOCOL CONSULTORES S.A., 2017 (Satellite Image Rapieye (2016) and Worldview (2015)).

4.2.4 Socioeconomic Area of Influence

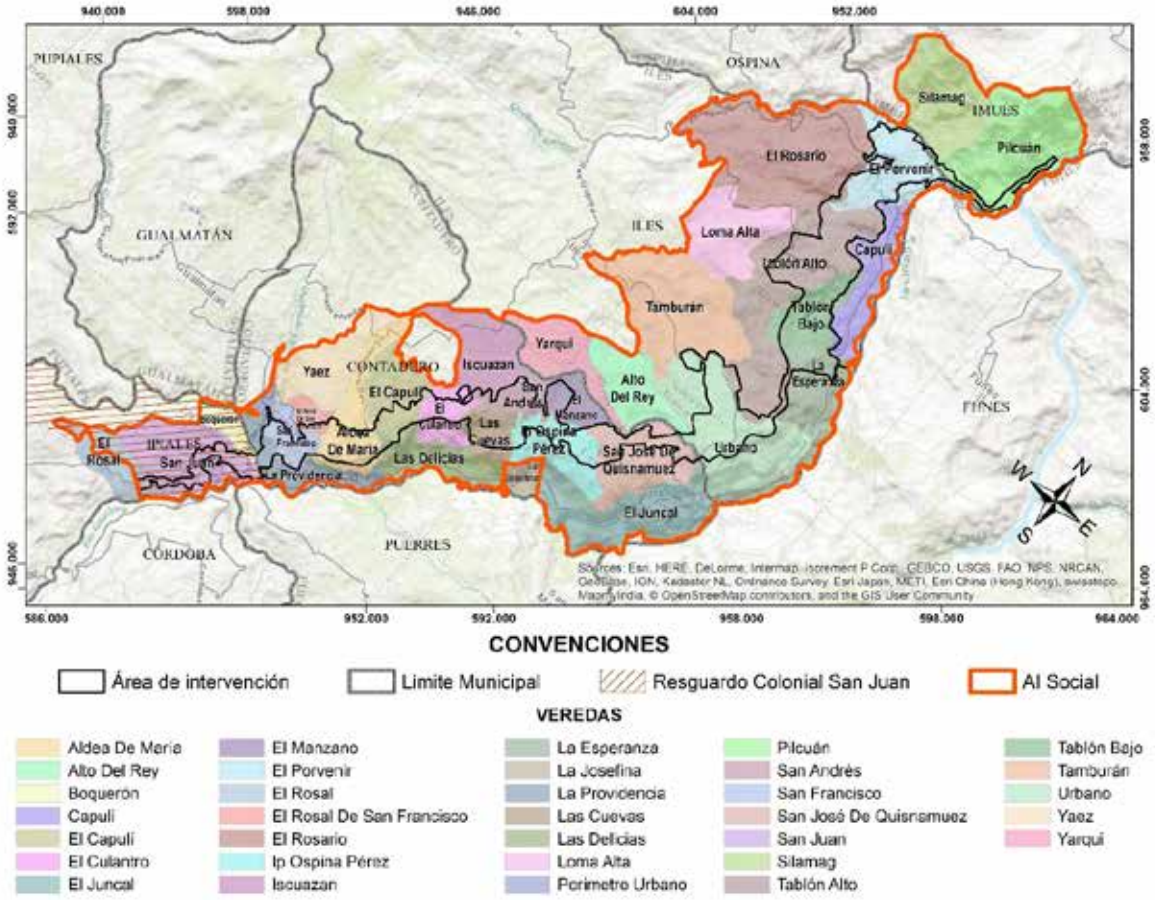
Considering the M-M-INA-02 Terms of Reference that were approved by Resolution 0751 of March 26, 2015 for the preparation of the Environmental Impact Assessment - EIA, which were used to prepare this study, the area of influence corresponds to that showing significant impacts caused by project performance, which vary from one component to the other and, therefore, the socioeconomic area of influence is proposed based on the physical – biotic area of influence.

The definition of the socioeconomic area of influence considers those impacts that may be caused on the environment's components, in such a way that the minimum analysis unit included in this assessment are such territorial units embedded in the physical and biotic area of influence, given that there is evidence pointing to their existence as the minimum political and administrative subdivision of the municipality. Therefore, potential socioeconomic impacts will take place on demographic, spatial, economic, cultural, and organizational-political components of clusters in these territorial units, which independently have a population, infrastructure, economic activities and community organization.

The total socioeconomic area of influence covers 75.345,21 ha, which encompasses the summation of all the areas in the minor territorial units.

Keeping in mind that the physical and biotic area is where the highway's layout is located, as well as the specific zones of interest where ZODMES are to be executed, camps and other activities related to the road project, in addition to possible support areas and locations where exploitation of natural resources is foreseen, the socioeconomic area of influence extends up to where important impacts will emerge and up to where foreseen impacts will go beyond the expected impacts, so it comprises the complete territorial units of zones where such activities will be performed, as depicted in Figure 4.9.

Figure 4.2 Socioeconomic Area of Influence



Source: GEOCOL CONSULTORES S.A., 2017.

5 MAIN CHARACTERISTICS OF THE AREA OF INFLUENCE BY COMPONENTS

5.1 ABIOTIC ENVIRONMENT

5.1.1 Geology

The regional stratigraphy, which covers the geological environment, is conformed by volcanic units, volcano-sedimentary and sedimentary units of continental origin, which underlie the existing Mesozoic, Paleozoic and Precambrian rocks.

Locally, the area of influence is predominantly covered by volcano-sedimentary and volcanic deposits that, in general, are associated to extinct or active volcanoes, such as the Volcan Galeras. In the area of influence the units described in **Table 5.1** outcrop.

Table 5.1 Description of the geological units present in the area of influence

Geological Unit	Symbol	Description
Lava	**TQvl**	Volcanic igneous rocks that show a strong melanocratic affinity. There is predominance of porphyritic textures with aphanophynic matrix and subhedral phenocrists no large than 2 mm, corresponding to plagioclass, anphiboles, biotite, quartz pyroxenes. Depending on their variation in the quartz content, they are classified asandesites and dacites.
Lava and Pyroclasts	**NQlp**	The pyroclastic deposits show rocks that form ashes and tuff, with abundant fragments of angular to rounded pumices, with variable sizes between ashes and bombs, that in general contain oxidized lithic; these are supported matrices that in some sectors are found as pyroclastic agglomerates, while in others they are pyroclastic flows. Lavas are rocks of andesitic composition, greenish gray color, afanitic to porfiritic texture. Plagioclass predominates in phenocrists and accessories such as hornlende and pyroxene, and occasionally biotite. The matrix is afanitic to vitreous.
Rumichaca ashes deposits.	**Qdcr**	Made up of fine sands and silts, with interbedded felling pumice, resulting from the wind transporting volcanic ashes placed on layers of decimeter to centimeter thickness. There are paleosoils observed in some sectors within this unit.
Colluvial deposits	**Qcl**	Constituted by angular detrites of various sizes, poorly selected and with low matrix content. In general, they are clast supported with a single inner lithology.
Alluvial deposits	**Qal**	Conformed by sub-angular to sub-rounded particles, ranging from blocks to boulders, with or without matrix, varied lithological composition corresponding mostly to volcanic and volcano-sedimentary rocks covering the area through which the channel drains. When the matrix is present, it corresponds to a silt-clay mix, in imbricates and arranged in fining form.

Source: GEOCOL CONSULTORES S.A., 2017.

The geological structures, mapped in this area, evidence the tectonic activity that has become the current expression of the North Andes mountainous system, particularly the portion corresponding to the differentiation between the Andes in Ecuador and in Colombia. The following structures are found in the area of influence:

- Romeral fault system
- Patía – Guáitara Fault
- Iles Fault
- Gualmatán Fault

5.1.1.1 Threats

5.1.1.1.1 Seismic threat

The area of influence is seismically active. Due to the volcanic activity in the area, over the years, strong earthquakes are expected, with effective acceleration between 0.30 and 0.35, considered a zone with high seismic threat.

According to the map of maximum seismic intensity (2015), in the area of influence observed for this EIA, it has been determined that there have been earthquakes, whose intensity may generate moderate damage

Figure 5.1 2015 Maximum seismic intensity observed

Source: Servicio Geológico Colombiano (2017)

5.1.1.1.2 Geological threats

Geological threats in the area of influence are associated with volcanism in the region, including pyroclastic flows, pyroclastic falls, sludge flows, lava flows, ballistic projectiles, volcanic gases and volcanic seisms, mostly.

- **Volcanic Threat**

The main geological threat to which the area of influence is exposed to is its proximity to the Galeras, Azufral, Chiles, Cumbal and Cerro Negro volcanoes. **Table 5.2**. It is worth noting that for the area of influence of this EIA, only the Galeras, Chiles and Cerro Negro volcanoes represent a threat.

Table 5. Characteristics of volcanoes close to the assessed area

Name	Height (masl)	Classification	Last eruption
Galeras Volcano	4276	Stratovolcano- boiler	2014
Azufral Volcano	4070	Stratovolcano- boiler	930 b.C.
Chiles Volcano	4748	Stratovolcano, dominantly effusive, with evidence of highly explosive stages	Pleistocene
Cumbal Volcano	4764	Stratovolcano	2014
Cerro Negro	4470	Stratovolcano, dominantly effusive, with evidence of highly explosive stages	1999

Source: SGC, Pasto volcanologic observatory, 2017

5.1.2 Geomorphology

The following information was used for the geomorphology analysis:

- Methodological proposal for standardization of geomorphology mapping in Colombia, prepared by(Carvajal 2012).
- A 4-band multispectral Worldview image (including: natural color, infrared color, 4-band pan-sharpened, 4-band bundle) of 19 August 2015, with 0.5 m spacial resolution, which covers the North area.
- A multi-spectral 5-band Rapideye image, dated 27 January 2016, with 5 m spatial resolution, which covers the central area.

5.1.2.1 Morphogenesis

In the area of influence of the Rumichaca-Pasto divided highway project, San Juan-Pedregal segment, there are four (4) morphogenesis environments: Anthropogenic Environment, Denudational Environment, Fluvial Environment and Volcanic Environment. **Table 5.3** shows the predominant geomorphology units.

Table 5.2 Description of the geomorphology units present in the area of influence

Geo-morphological unit	Symbol	Description
Volcanic highland plain	**Vav**	Geoform of volcanic origin conformed by pyroclastic flows belonging to different events, characterized by a flat morphology throughout its extension, limited by steeply sloped, scarped hillsides.
Active waterway	**Fca**	Geoform of fluvial origin corresponding to areas were permanent waterways circulate, mostly associated to the Guáitara and Sapuyes rivers. It is limited to the deepest zone of the valleys.
Lava scarp	**Vel**	Geoform of volcanic origin conformed by adesitic to dadesitic lava, massive, fractured that form scarps with slopes that exceed 45°, mainly with elongated, convex hillsides.
Steep the denudational hillsides in pyroclasts	**Dlap**	Geoform of denudational origin conformed by pyroclastic flows with low weathering levels, were residual soils of little thicknesses are developed, with slopes of 15° and 30°. The hillsides are elongated, concave and convex, with predominance of undulated relief.
Denudational hillside in ashes	**Dlce**	Geoform of denudational origin conformed by pyroclastic flows with predominance of volcanic ashes; there is evidence of a moderate weathering level; hillsides have slopes of 5° and 20°, elongated, with predominance of undulated relief.
Residual denudational hillside	**Dir**	Geoform of denudational origin conformed by pyroclastic flows with high level of weathering, where residual soils developed, with slopes of 5° and 20°. The hillsides are elongated, concave and convex, with predominance of undulated relief.
Colluvial denudational hillside	**Dlco**	Geoform of denudational origin conformed by sloped clast-supported deposits with thicknesses ranging between 5 and 30 m; rectilinear hillsides keeping those low as per the depositional gradient.
Scarped hillside support in pyroclasts and lava	**Vlep**	Geoform of volcanic origin conformed by pyroclastic flows and lava windows of mafic composition, forming hillsides with slopes greater than 45°, elongated, concave and convex.
Alluvial terrace	**FT**	Geoform conformed by alluvial deposits derived from fluvial dynamics, with flat to slightly sloped morphologies.
Anthropic terrace	**High**	Geoform originated from human intervention due to urban development, roads, mining and agricultural activities. The topography resulting from this general form is flat to slightly undulated.

Source: GEOCOL CONSULTORES S.A., 2017.

5.1.2.2 Morphodynamics

In the area of influence of this EIA, the morph-dynamic movements have been mostly determined by low terrain slope, fluvial dynamics, whether Rick James and, partially generated and/or accelerated by human activity. The field distance traveled within the area of influence showed total presence of 35 morpho-dynamic processes, out of which 11 were erosion processes (six (6) laminar erosion processes, two (2) erosion processes derived from human activity, two (2) erosion processes in furrows, and one (1) erosion process from lateral scouring), and 24 mass removal processes (eight (8) rotational landslides, four (4) translational landslides, seven (7) rock falling, and five (5) detritical flows).

5.1.3 Landscape

82 landscape units were identified, grouped in eleven (11) different geoforms, with predominance of grass mosaic and residual denudational hillside crops (DIr-242), occupying 32.07% of the influence area (1, 295.8 ha), followed by the grass mosaic and residual denudational sloped hillside crops in Pyroclasts (DIap-242), which represents 21.09% of the AI width 852.3 ha. Furthermore, the landscape units associated to natural covers are related to the presence of secondary high and low vegetation, riparian forests, dance high Andean forests and rivers, with predominance of secondary high and low hillside vegetation, degradation will and sloped in pyroclasts Dlap-3231 and Dlap-3232), with an area of 77.29 ha and 183.69 ha respectively, adding up to 6. 46% of the influence area.

Additionally, the landscape analyzed for the area of influence corresponds to a mosaic dominated by small-scale productive systems, with natural spaces represented by live fencing, remaining patches of native vegetation and riparian forests; with moderate visual fragility (due to presence of natural elements that absorbs the visual impact generated), medium landscape quality (due to moderate presence of visual attributes such as native vegetation and a pleasant scenic background), and scenic integrity that varies between moderate and high, as even though there is presence of discordant elements, it still has elements such as native vegetation, biological corridors and live fencing, which increase the chromatic correspondence in the landscape.

5.1.4 Soils and land use

The soils in the area of influence are characterized by variability of landscape, climate, soils and parental material, because of erosion phenomena, mass removal and contribution of alluvial and marine material, the latter originating in repeated erosion of the Galeras, Cumbal and Azufral volcanoes.

In general, soils corresponds to the Entisol, Andisol, Inseptisol and Mollisol types; these soils are underdeveloped and developed, deep and shallow, limited by rock fragments, slow to fast internal drainage, high to low fertility.

Their use is mostly for agriculture, represented mainly by potato, peas, onion, and bean crops, followed by the use for conservation.

5.1.5 Hydrology

5.1.5.1 Watersheds

The hydrological features of water bodies of interest, as related to hydrological regime and characteristic flows, are based on that historical serious of hydrographic units data prepared by the IDEAM, through active hyper-metric stations that are representative for this project.

The project is located in one of the five watersheds corresponding to the Pacific hydrographic area (5), which is formed by over 200 rivers. It is fundamentally represented by the presence of the Western Cordillera in its eastern end and the Baudó and Pacific mountain range, which act as hydrographic center of river sources, as well as natural barriers to oceanic wind that give rise to permanent rains that feed their flow.

Furthermore, as per hydrographic zones established by the IDEAM, the project is located on No. 52 - Patía river, and out of 311 sub-zones on that corresponding to the Guáitara river (5205), as shown in **Table 5.4**.

Table 5.3 Ranking of the Hydrographic networks pursuant to Decree 1640 of 2012

DRAINAGE BASIN (HYDROGRAPHIC AREA)	GREAT WATERSHED HYDROGRAPHIC ZONE	BASIN HYDROGRAPHIC ZONE	SUB-BASIN POMCAS CODE
Pacific (5)	Patía (52)	Guáitara River (5205)	Guaítara River Direct Affluents

Source: GEOCOL CONSULTORES S.A, 2017.

The ranking of the hydrographic network in its broadest extent is evidenced in **Table 5.5**, where the components of the hydrographic network for the EIA 1B are arranged from 0 to 5.

Table 5. Ranking of the hydrographic network in the direct area of influence, Rumichaca-Pasto Highway project, San Juan-Pedregal segment.

ORDER 0	ORDER 1	ORDER 2	ORDER 3	ORDER 4	ORDER 5	ORDER 6
Pacific Ocean	Patía River	Guáitara River	Guaítara River Direct Affluents	El Macal Stream	El Salado Creek	
					San Javier Creek	
				San Francisco Stream	La Batea Creek	
				La Humeadora Creek	Los Arrayanes Creek	
					El Manzano Creek	
					Urbano Creek	
				La Brigada Creek		
				La Cueva Stream		
				El Culantro Creek		
				Honda Creek	Cuayarín Creek	
				San Francisco Stream		
				Moledores Stream	La LLave Creek	
				El Tablón Creek		
				Chorrera Negra Ditch		
				Yamurayán Stream		
				MI Direct Affluents - Guaítara River 01		

ORDER 0	ORDER 1	ORDER 2	ORDER 3	ORDER 4	ORDER 5	ORDER 6
				MI Direct Affluents - Guaítara River 17		
				MI Direct Affluents - Guaítara River 15		
				MI Direct Affluents - Guaítara River 16		
				MI Direct Affluents - Guaítara River 14		
				MI Direct Affluents - Guaítara River 02		
				MI Direct Affluents - Guaítara River 03		
				MI Direct Affluents - Guaítara River 11		
				MI Direct Affluents - Guaítara River 05		
				MI Direct Affluents - Guaítara River 06		
				MI Direct Affluents - Guaítara River 07		
				MI Direct Affluents - Guaítara River 08		
				MI Direct Affluents - Guaítara River 09		
				MI Direct Affluents - Guaítara River 10		
				MI Direct Affluents - Guaítara River 12		
				MI Direct Affluents - Guaítara River 13		
				El Manzano Creek		
				MI Direct Affluents - Guaítara River 04		
				La Lechuza Ditch		
			Carchí River - Guaítara Alto	Guaítara River Direct Affluents		
			Boquerón River	Chorrera Negra Creek		
				MD DIrect affluents - Boqueron River		
			Sapuyes River	Chorrera Negra Creek	Saraconcha Creek	
				MD Affluents - Sapuyes River 01		
				MD Affluents - Sapuyes River		
				MD Affluents - Sapuyes River 03	Guingal Creek	
				MD Affluents - Sapuyes River 02		
Drainage present in the direct area of influence of the Rumichaca-Pasto roadway project, sector San Juan - Pedregal.						

Source: GEOCOL CONSULTORES S.A, 2017.

5.1.6 Water quality

According to the Water Quality Index (WQI), it was determined that 14 of the 44 stations have medium water quality resulting, mainly, from the presence of fecal coliforms, added to high values of total solids, and relatively high to medium dissolved oxygen and medium content of all other parameters used in the calculation of the index such as pH, turbidity, nitrates and phosphates. The remaining 30 stations had good water quality possibly because of lower values of fecal coliforms, low DB05, turbidity and, mainly, lower content of solids.

As regards the Contamination Indices (ICO) the following were calculated: index of mineralization (ICOMI), index of contamination from suspended solids (ICOSUS), index of contamination from organic matter (ICOMO), and trophic contamination index (ICOTRO).

In relation with the ICOMI, most of the monitoring points showed very low contamination, with low contamination corresponding to only nine stations. In contrast, those high contamination upstream in the Chorrera Chiquita Ditch, while in the NN3 creek and its affluent downstream, El Tablón, there was medium contamination.

In turn, the ICOSUS, showed very high contamination for the Boqueron river downstream, the NN3 creek, the Guáitara 2 River and the Sapuyes river upstream, while for the Boqueron river upstream, the Sapuyes river downstream and the Guáitara 3 river there was high contamination. Additionally, the Tablon creek downstream, and the affluent downstream together with the Saraconcha and el Macal creeks, reported low contamination, with that corresponding to other sampling points showing very low contamination from suspended solids.

The index of contamination from organic matter, ICOMO, reported high contamination at the Saraconcha creek, San Francisco 2, el Macal and the Sapuyes river downstream, while in twelve (12) sampling points, there was medium contamination, with that corresponding to other stations assessed showing very low contamination

As regards the trophic contamination index (ICOTRO), thirty eight (38) monitoring points reported very low contamination, three (3) low contamination and three (3) very high contamination.

5.1.7 Water uses

5.1.7.1 Domestic use

In general, in the influence area of the Rumichaca-Pasto divided highway project, San Juan-Pedregal segment, surface water is used for domestic purposes. Water intakes are at the springlets, where catchment and storage tanks are built, or on the high parts of micro watersheds, which are sources that supply rural or local aqueducts, distributing this resource to the community belonging to the supply area. Similarly, some dwellings have tanks for supply of water when the aqueducts are out of service.

5.1.7.2 Agricultural use

Agricultural zones in the area of influence of the project corresponded predominantly to potato, followed by other crops such as corn, wheat, beans, field beans, peas, ulloco, oca, barley, carrots and vegetables. Water os used for irrigation and fumigation.

5.1.7.3 Cattle farming use

The use of water resources in cattle farming activities is basically destined to consumption by minor species, mostly cattle, which drink water directly from the creeks or in some properties water is conducted with hoses from the creeks to the troughs.

5.1.7.4 Water demand at exploitation sites

In sources susceptible of exploitation by the project, regarding uses that could be influenced, either directly or indirectly, it was determined that surface water is used in the area mostly for agriculture and cattle farming activities.

This idea stemmed from inspections and engagement with the communities. It is worth noting that 1 km was inspected (according to access possibilities) upstream and downstream of the defined intake sites. Additionally, the uses for this assessment at the intake points were identified based on Decree 3930 of 2010, which in its Chapter IV, article 9, establishes and defines uses of the water resource.

5.1.8 Hydro-geology

From a hydro- geological standpoint in the assessment area, the following units are classified:

Free and semi-confined aquifers, of regional "A3" extension, with essentially inter-granular flow and correspond to the Cenizas de Rumichaca Aquifer unit, "A3-1", which is performed by volcanic- sedimentary deposits; the static levels in these aquifer range between 6 and 30 m and the production flows are very low, averaging 1 l/s; according to hydraulic tests performed in this unit, there is evidence of two types of material present. The first one characterize free to semi- confined type aquifers $^{-3}$), with "Low" specific capacity (<1.0 LPS/m), "Insignificant" potential (T < 1 m^2/day),which classifies wealth of less than 1l/s with 10 m of theoretical depression and "Very Low" (K < 10^{-2} m/day). The second one characterize free to semi- confined type aquifers (S<10^{-3}), with "Low" specific capacity (<1.0 LPS/m), "Weak" potential(1 < T < 10 m^2/day),which classifies wealth of less than 1l/s with 10 m of theoretical depression and "Low" permeability (10-2 < K < 1 m/day).

Residual Soil Aquifer and Lava Saprolite and Pyroclasts "A3-2", which is formed by flow and fall Pyroclast deposits; this aquifer contains water predominantly under free to semi- confined conditions; locally it may behave as confined due to clayish interbeddings or very compact ashes. The static levels in this aquifer range between 1 and 10 m and the production flows are very low, averaging 1 l/s. The transmissibility ranges from 0.01 210 m2/day with storage coefficients of 1.0 E^{-01} to 1.0 E^{-05}, which rates its potential as weak to insignificant.

The Alluvial Deposits Aquifer unit "A4-1", is formed by sub-angular to sub-rounded particles (depending on the transport to which they were subjected) from blocks to boulders, with or without matrix; their extension

and thickness are inversely proportional to the depth and narrowness of the generated valley and the Colluvial Deposits Aquifer "A4-2"; the aquifer is formed by blocks of different sizes embedded in a sandy- clayish silt matrix, of varied lithology composition that corresponds mostly to volcanic and volcanic- sedimentary rocks that covered the area where the channel drains. Its extension is variable, being recharged by direct precipitation; the potential of the unit is "Weak" to "Insignificant"; the record of static levels is above 5,9 meter deep.

Sediments on rocks with limited to nil resources of ground water, Lava Aquifer and Pyroclasts (NQlp) “C2-1” and Lavas (TQvl) “C2-2”, which correspond to a complex of igneous origin rocks, with low to nil productivity, very compact and occasionally fractured, Tertiary to Neogene. Occasionally there are ground water outcrops in particular sectors where recent pyroclastic deposits lie over lava material and where the mentioned lavas show high degree of fracturing.

It is established that the best aquifer conditions are located southeast of the area of influence, which is valid taking into account the results of direct and indirect subsurface exploration and concentration of groundwater points in this area (Km20-Km30), which corresponds in total for the area to 23 wells, with depth of less than 26 meters; 50 springs for agricultural and domestic use; 22 anthropic suggestions, most without preferential use and 41 piezometers usually not exceeding a 30-meter depth; most of them are dry, others for static levels at about 11 meters depth.

The recharge zones of aquifer units are found towards the high mountain zones in weathered rock outcrops from the Neogene; the direct recharge from precipitation of rainwater is possible mostly in the Nariño high plateau areas. Other local recharge zones are characterized by direct outcrop of the various aquifer units, mainly influenced by terrain slopes; transit zones usually are located in the hillsides of the left slope of the Guáitara river; it is common to find ground water outcrops (springlets), giving rise to local discharge points. Based on field evidence and characterization of the geological model at depth (isoresistivity maps and profiles), it is concluded that usually in these micro-basins, local aquifers are often generated, which are not connected, with flow lines towards the main hillside drainage.

The aquifer discharge zones correspond to hide permeability and/or low slope areas, were local rain is seeped, generating predominantly horizontal flows, sub-superficial, or feeding free aquifers that regulate the hydrological cycle, maintaining the water inflow in the low water level seasons. The regional discharge zones of aquifers occurs on recent alluvial deposit units on the left margin of the Guáitara river, to the east of the influence area and on both margins of the Sapuyes, Boqueron rivers and major tributaries. Locally, the aquifer discharge occurs where the drainage narrows due to the formation of natural springs and human surges derived from the partial cut off of the aquifer volume (box cutting of road layouts).

Piezometric levels existing in the assessment areas are controlled by direct seepage from precipitations and have a constant recharge source from surface outcrops. The direction of ground water flows is strongly influenced by the structural condition of the zone; in the area of influence such directions move towards topographically lower lands, influenced by the action of the Guáitara river and its major affluents; thus, the direction of general flows has a preferential northwest-southeast orientation.

The intrinsic vulnerability to aquifer contamination results from the low and very low levels, characterizing aquifers that are vulnerable to very mobile and persistent contaminants, to continuous contamination events for long periods; additionally, in the very low vulnerability sectors, surface materials represent an obstacle that hinders to a large extent a significant flow of contaminants up to the aquifer.

5.1.9 Geotechnics

5.1.9.1 Susceptibility to mass removal processes.

Zoning is presented in accordance with the susceptibility to mass removal processes along the area of influence, having analyzed the following factors: geology, geomorphology, precipitation, slope, roughness, fault density, morph-dynamic processes and seisms. Based on this analysis, three (3) differentiated areas were identified for the Rumichaca – Pasto divided highway project, San Juan – Pedregal segment.

Between KP15+700 and KP26+600 there is a susceptibility zone with respect to low to medium mass removal processes, with little probability of occurrence of landslides; however, it is likely that erosion processes will occur in the planned cut slopes and on hillsides intervened by humans. Between KP 26+600 to KP34+200, there was a medium to high susceptibility zone due to mass removal processes; finally between KP34+200 to KP45+00, there is a high to very high susceptibility zone with respect to occurrence of mass removal processes, leading to poor geotechnical behavior of materials with respect to execution of cut slopes along the assessed segment; therefore, special attention should be given to this segment because the mass removal processes are more prone to develop.

5.1.9.2 Geotechnical zoning

The geotechnical zoning was obtained based on a susceptibility analysis relative to the occurrence of mass removal processes, defining five geotechnical homogeneous areas, and assigning a qualifier to the degree of stability. Table **5.6** shows the categorization of the defined geotechnical zones.

Table 5.4 Categorization of homogeneous zones to be considered for the geotechnical zoning in the area of influence, Rumichaca-Pasto divided highway, San Juan-Pedregal segment.

Geotechnical Stability Zones	Symbol	Description
Very high geotechnical stability	V	Rocky material, volcanic ashes, low slopes, absence of morpho-dynamic processes and high cut resistance values.
High geotechnical stability	IV	Competent material and volcanic ashes, low slopes, presence of diffuse and specific morpho-dynamic processes
Medium geotechnical stability zone	III	Competent soils, moderate slopes, and presence of low intensity morphodynamic processes
Low geotechnical stability zone	II	Moderate slopes, soft soils, and presence of moderate to intense morpho-dynamic processes
Very low geotechnical stability zone	I	Rocky materials, high slopes, and presence of intense morpho-dynamic processes

Source: GEOCOL CONSULTORES S.A., 2017.

5.1.10 Atmosphere

5.1.10.1 Meteorology

To analyze the climate of the area of influence of the project, the weather information was used that is available at the stations closest to the zone of influence operated by the Institute of Hydrology, Meteorology, and Environmental Studies – IDEAM.

The following are the results of the statistical analyses of the weather parameters used for the characterization of the climate in the area of influence:

· **Precipitation**

The project's area of influence is located in the hydrographic area of the Pacific. According to the results obtained from the histograms for the stations analyzed, it was established that in the project's area of influence, the rainfall pattern is bimodal. There are on average two rainy seasons, separated midyear by a season of little rain called summer, and an Indian summer at the beginning of January.

In general, total monthly precipitation in the project's area of influence is in the order of 21.6 mm to 141.5 mm. On average, the rainiest month is November, with total average monthly values of 124.4 mm, while the month of August is the least rainy month, with total average monthly values of 36.7 mm.

· **Temperature**

In general, in the area of influence of the project, the average monthly temperature varies from 10.9°C to 16.1°C. According to the records at the stations analyzed the average temperature is 13.6°C.

On average, the low temperatures in the zone occur in the seasons with less rain (July – August), associated with a phenomenon of cold winds, with values from 13.2°C to 13.3°C, according to the estimated average temperature for the zone. In addition, it can be seen that the month of April has the highest temperatures at 13.91°C.

· **Relative Humidity**

According to the records from the stations analyzed for the project's area of influence, the average monthly relative humidity varies from 73% to 86%.

On average, the highest relative humidity is recorded during the periods of low temperatures, with average monthly values of 82.6%, with December being on average the month showing the highest values for relative humidity. The lowest values for average relative humidity are during the months of September and August, with mean values that vary from 76.4% to 77.5%, respectively, for each period. August is the month with the lowest relative humidity in the area of the project.

· **Evaporation**

According to the records at the station analyzed in the project's area of influence, the average monthly evaporation varies from 79.9 mm to 122.1 mm. Therefore, on average, the total evaporation in the zone is on the order of 96.8 mm per month.

In accordance with the average estimated histogram for evaporation in the area of influence of the project, the period in which the greatest evaporation occurs is the month of August, with average monthly values of 117.1 mm.

· **Solar radiation**

The records for solar radiation or sunshine at the stations analyzed in the area of the project, show that it varies each month from 85.3 hours to 158.6 hours, and therefore on average the total radiation for the zone is on the order of 118.3 hours per month.

On average, the lowest levels of solar radiation occur during the rainy season (February – April), with monthly variations from 87.6 hours to 104 hours. The month that on average has the least sunshine is March, considered to be one of the rainiest months.

In addition, it can be seen that the greatest levels for radiation or sunshine occur during the summer periods, where the average is from 126.6 hours to 150.7 hours. The month that on average has the greatest amount of sunshine is August, considered to be the least rainy month

· **Cloud Cover**

Based on the records from the stations analyzed for the project's area of influence, the average monthly cloud cover varies from 3 to 6 oktas, with an average annual value of 5 oktas.

According to the median estimated from the histogram for the project's area of influence, a continuous trend can be seen in average cloud cover of 5 oktas, and therefore a partially cloudy sky is expected in the area of the project.

· **Wind**

Wind was analyzed in the zone of study based on the information at the Apto. San Luis station, bearing in mind that the other stations used in the climate characterization of the project area do not measure this parameter. Based on this and on the historical records at the station, reliable information on wind on a regional scale was obtained.

According to the records at the station analyzed in the project's area of influence, the average monthly wind speed varies from 2 m/s to 3.2 m/s, and therefore, on average, the average monthly wind speed in the zone is on the order of 2.5 m/s, classifying it as a light breeze according to the Beaufort scale.

It was estimated, on average, that in the area of influence of the project, the periods with greater wind speed correspond to low precipitation and low temperature periods, also associated to cold winds (July to September), with average monthly values of 2.96 m/s to 3.26 m/s, with August being, on average, the month with greater speed; the high precipitation and high temperature periods are characterized by lower wind monthly speed, with average values of 2.0 m/s to 2.3 m/s in October and November, and 2.14 m/s to 2.38 m/s for the first quarter in the year, with November being the month with the lowest wind speed.

· **Atmospheric Stability and Mixing Height**

The atmospheric stability and the mixing height were estimated in a simplified manner using the wind speed and the degree of insolation (Spadaro, 1991). The behavior of the height over the year for the Alto San Luis station. It is evidenced that in days of high insolation, the mix height is at 1200 m, with slight variation in times of low precipitation, in mid-August; in days of low insolation, the mix height can be around 800 m, with decreased mix height in mid August, when the mix height could be at 560 m; at night, when the thermal layers

are reversed, the mix height usually at around 200 m and in times of low precipitation it can reach up to 320 m.

· **Atmospheric Pressure**

The atmospheric pressure calculated for the zone, making the conversion to mmHg, oscillates from 520 to 585 mmHg. The Del Comun and Funes weather stations are the points with the lowest and highest pressure, respectively. The average for this variable with respect to the stations analyzed in the project's area of influence is approximately 549 mmHg.

· **Water Balance**

The results show that the annual potential evapotranspiration in the area of study is 668.8 mm, a value that is below the 1053.7 mm of average annual precipitation recorded by the stations in the zone. It can be concluded from the results obtained that for 10 of the 12 months of the year there is a surplus. The months where there is no surplus are August and September, but the deficit is low.

· **Climate Classification**

For the effects of classification by life zones, the two parameters were used that have the most importance for conditions in the tropics: temperature and precipitation. According to the inter-institutional methodology developed by the IDEAM, IAvH, Invemar, I.Sinchi, IIAP and IGAC in the document called "Ecosistemas continentales, costeros, y marinos de Colombia," in which the ecosystems map was developed along with a group of thematic maps on a scale updated to 1:500,000, including maps of precipitation, temperature, and climate zones, it was found that the main temperature classification in the project area is Cold, although in some zones, mainly close to Pedregal, there are temperate and warm zones. Relative to the classification for precipitation, the rain pattern analysis showed that the area is in the range of values associated with dry, being in the range of 1020 to 1050 mm/year.

Adding together the two classifications, we find that in the project area the predominant classification is Cold Dry.

· **Identification of Emissions Sources**

Three classes of sources of atmospheric emissions were identified in the project area: Stationary point sources, scattered, and mobile.

o **Stationary Emissions Sources**

The stationary sources in the project's area of influence are those coming from agro industrial activity involved in planting crops such as potatoes, cabbage, and onions, etc., due mainly to crop fumigation.

Controlled open air burning, a recurring practice in agriculture, and burning solid waste as a method of disposal, are other stationary sources of atmospheric pollution. This activity is periodic and extensive, which causes its impact to be moderate.

It was also found that domestic activities in the rural area, such as cooking food, constitute a stationary source of emissions, due to the use of wood as a source of heat. But because these emissions are scattered and the population is low, the impact is slight.

Another common source of stationary emissions in the area of study comes from quarries.

Stationary emission sources come from industrial activities such as the brick making industry, sanitary fills, and duty-free zones. They also come from common activities among the inhabitants of the rural districts and townships, where emissions can be seen from chimneys (smoke) that are generated by domestic activities that use firewood for cooking. The practice of burning garbage, leaves, grass, and dry plants is also common.

o **Mobile Emissions Sources**

In the area there are several emission sources of particulate matter and gases due to the continuous movement of all types of vehicles, mostly circulating on the Panamericana road, which include cars, trucks, truck-tractors, motorcycles and buses designed to roll on public highways; said vehicles contribute to a large extent to CO emissions, NOx, SOx and particulate matter, and to a lesser extent, the vehicles that run on roads leading to the municipal seat of the municipalities of Contadero and Iles and the rural roads connecting these two municipalities.

· **Air Quality**

The quality of the air in the study area was evaluated, taking into account a total of six (6) stations and six (6) parameters - particulate matter (TSP, PM10, PM2.5, NOX, SO2 and CO) – and the results obtained from the monitoring were compared with the current regulations relative to the thresholds for each parameter.

It was determined that the concentrations of total suspended particles (TSP) and particulate matter as PM10 and as PM2.5 obtained in each monitoring station, are below the thresholds in the national air quality regulations. The high PM2.5/PM10 ratio, however, indicates that a significant proportion of these fine particles make up the particulate matter of less than 10 µ.

In all of the stations the results of the concentrations obtained are in line with the fact that the quantity of suspended particles is greater in relation to particulate matter of less than 10 µ (PM 10). The high PM 10/TSP ratio indicates that the greatest proportion of the total particles comes from vehicle traffic, the pavement, and civil works.

It was also determined that the contamination from particulate matter is more representative than that coming from gases (NO2, SO2 and CO). Although traces of these compounds are seen in the air, the concentrations are not higher than the threshold values permitted.

· **Noise**

The sound pressure level in the assessment area was evaluated considering a total of six (6) stations, performing day and night monitoring in business days and holidays, comparing the results obtained from the monitoring with the current regulations on the maximum allowed for each scenario.

According to the classification issued by the Ministry of the Environment, Housing, and Regional Development in Resolution 627 of 2006 and in accordance with the location of the measuring points for the area of influence of the Rumichaca – Pasto Divided Highway Project San Juan - Pedregal Segment project, the activities observed and the identification of human settlements, there are several sectors in the zone with noise restrictions, including sector C with intermediate restricted noise applicable to the main road between Ipiales and Pedregal, sector B with tranquility and moderate noise applicable to residential zones, and sector D rural zone of peace and moderate noise applicable to residential suburban and rural zones inhabited and dedicated to agriculture and livestock farming.

During the daytime, at all the measuring points, during 90% of the measurement period, the noise levels were below the thresholds established in the current environmental regulations for each noise restriction sector

identified. This indicates the low impact from noise of the anthropogenic activities of the people living in the zone and the low noise emissions from small industries and linear sources.

At night, at all the measuring points (except at the site called Campamento Mikel in the El Porvenir rural district in Iles) during 90% of the measurement period, the noise levels were below the thresholds established in the current environmental regulations for each noise restriction sector identified.

During the daytime, the greatest noise levels were associated with vehicle traffic on the road between Ipiales and Pedregal, reaching levels between 64.1 dB and 68.9 dB. The lowest levels were recorded in the zone farthest from towns and main roads, with values between 47.1 dB and 48.8 dB, specifically at the site called Campamento 31+100 in the Urbano rural district of the municipality of Iles.

5.2 BIOTIC ENVIRONMENT

5.2.1 Ecosystems

5.2.1.1 Terrestrial Ecosystems

5.2.1.1.1 Flora

This section of the chapter describes the biogeographic regions, biomes, life zones, and strategic ecosystems present in the project's area of influence.

- **Biogeographic Provinces and Districts**

According to the classification proposed by Hernández et al., 1992, the project's area of influence is located in the IX. Norandina Biogeographic Province, which groups together a set of biogeographic units corresponding to the three mountain ranges and the inter-Andean valleys in the Great Andes Mountains in Colombian territory. All the isothermal zones are represented here, and the mountain's biota is derived basically from elements coming from the low Amazon lands, which progressively began processes of adaptation and speciation (Latorre, 2005). In this province there are forty five (45) biogeographic districts; in the specific case of the project, the Andean Forest Distric Nariño Western Cordillera is located, which is described below:

Andean Forests District Nariño Western Cordillera: this district is made up of ecosystems at an altitude between 1800 masl and 3600 masl, in soils with abundant organic matter and forest plant formations, present in conditions of continuous high humidity due to the influence of fog. They are called montane forests and they are differentiated according to their altitude in the orobiome of the High Andean Forest and the Orobiome of the Middle Andean Forest (CORPONARIÑO, 2009).

- **Biomes**

The project's area of influence belongs to the Great Biome of Tropical wet forest, specifically the middle Andean orobiome and the High Andean Orobiome. Taking into account the high level of anthropogenic intervention in the zone, the ecosystems have not conserved their natural characteristics. The forests have been intervened, and the agricultural frontier has been growing with great strength, and the natural vegetation has been replaced by areas dedicated to pasture and agriculture.

· **Life zones**

For the identification and description of the life zones in the area of study, the classification system proposed by Holdridge (1987) was used, which uses bioclimatic factors such as the average annual bio temperature (on a logarithmic scale), annual precipitation in millimeters (on a logarithmic scale), and the ratio of potential evapotranspiration (PET). The combination of these factors defines certain ranges where particular plant formations can exist. These zones can be imagined as a group of associations related among themselves through the effects of temperature, precipitation and humidity.

Consequetnly, the Holdridge methodology was used to identify life zones, finding in the project's area of influence lower montane wet forest (LMWF), premontane wet forest (bh-PM) and Lower montane dry forest (bs- MB) (See **Table 5.7)}**

Table 5.5 Distribution of Life Zones in the Area of Influence of the Project

N°	LIFE ZONE	SYMBOL	PRECIPITATION (MM/YEAR)	TEMPERATURE (° C)	HEIGHT(MASL)	AREA (HA)	%
1	Lower Montane Wet Forest	bh-MB	2016 to 2019	2016 to 2019	2000-2500	2988,65	74,46
2	Premontane wet forest	bh-PM	2016 to 2019	2016 to 2019	1000-2000	206,71	5,15
3	Lower montane dry forest	bs-MB	2016 to 2019	2016 to 2019	2000-2500	818,16	20,39
TOTAL						4013,52	100

Source: GEOCOL CONSULTORES S.A., 2017.

· **Ecosystems**

For the area of influence of the project, 21 ecosystems were identified, which were named following the aforementioned ranking; the most representative ecosystem is the Pasture and Crops Mosaic, in the medium orobiome of the Andes, it covers an area of 2.078,76 ha, which correspond to 51.79% of the total area of influence of the project, and in the High orobiome of the Andes, 852.65 ha, equivalent to 21.24%; next is the low secondary vegetation in the Western Norandina Cordillera, medium Orobiome of the Andes, which covers 286.23 ha, representing 7.13%, followed closely by high secondary vegetation in the Western Norandina Cordillera medium Orobiome of the Andes, with 145.37 ha, representing 3.62%; riparian forest in Western Cordillera medium Orobiome of the Andes, with 142.15 ha, equivalent to 3.54% and, Forest Plantation in Western Norandina Cordillera medium Orobiome of the Andes, with 131.75 ha.

Other ecosystems identified have areas of less than 100 ha, which represent percentages below 3%: this leads us to conclude that the greatest percentage of the area of influence of the project is represented by the mosaic ecosystems in the two orobiomes (Anden medium and high) and, in a smaller percentage by the natural areas ecosystems, whcih is attributed to high anthropogenic intervention that has occurred in the zone, which is increasing and expanding the agricultural boundaries, thus ruining the natural areas.

· **Flora**

o **Indentification and description of the various types of land in the assessment area.**

Initially the intervention area was delimited for the Rumichaca-Pasto divided highway project, San Juan-Pedregal segment. Later, it continued to establish the assessment area and defining the reach of potential impacts associated with the project in the biotic component (particularly in flora). This delimitation was based on aspects related to changes in geomorphology and presence of natural or artificial barriers, vegetation

cover, mobility and distribution of wildlife fauna, distribution of drainage networks and aquatic ecosystems, presence of strategic ecosystems, sensitive and(or protected areas, obtaining the area of influence of the project; the whole area of influence is located in the department of Nariño, immersed in the biogeographical district of Western Cordillera Nariño Andean Forests, more specifically in the municipalities of Ipiales, Contadero, Iles e Imués (4040,72ha).

The identification of coverage in the assessment area consisted in the interpretation at a scale of 1:25.000 of a WorldView image captured on 19 January 2015 with a 4-band spectral and 0.50 m spatial resolution; in the zones where there was no coverage with this image, we relied on four Rapideye images taken on 27 January 2016 (three images) and 21 February 2015 (one image), with a 5 meter spatial resolution and 5-band spectra, which resulted in the **Land Coverage map** where 14 coverages were identified, with only dense and riparian forests, high and low secondary vegetation, and open rocky grasslands were identified as natural vegetation cover, subjected to the characterization. The most representative coverage in the assessment area is the pasture and crops Mosaic, with 73%, followed by low secondary vegetation of 7.63%, and high secondary vegetation 4.16%.

For the vegetation characterization, a total of 74 sampling units were established, distributed in natural ecosystems as follows: 6 UMF for the dense forest in the high Andes orobiome, 8 UMF in the riparian forest in the medium Andes orobiome, 6 UMF in the high secondary vegetation in the high Andes orobiome, 5 in the high secondary vegetation in the medium Andes orobiome, 6 UMF in the low secondary vegetation in the high Andes orobiome, 23 UMF in the medium Andes orobiome, and 19 UMF in the open rocky grasslands in the medium Andes orobiome.

After consolidating the list of species found, we consulted the list of endangered flora species in Colombia, prepared by the Ministry of Environment and Sustainable Rural Development, the Resolution zero 192-2014, and the Red Books of the Humbold and SINCHI Institute, among others, registering two species with some level of threat:

Vegetation endangered species within the area of influence of the project

SPECIES	COMMON NAME	RES. 0192/MADRS	RED BOOKS	RED LIST UICN	CITES	ENDEMISMO
Juglans neotropica Diels.	nogal	EN	-	EN	-	-
Cedrela odorata L.	cedro	EN		EN	III	

Source: GEOCOL CONSULTORES S.A., 2017.

- **Vascular and non-vascular flora of the epiphyte, rock and terrestrial facultative plants**

The composition of the epiphyte, rock and terrestrial facultative species for which the characterization was performed in 13 coverages present in the area of the roadway project, through the establishment of 606 characterization plots, with 215 species represented, 74 of which were vascular and 141 non-vascular species, for a total of 72.390 registers for the two groups of species (abundance for vascular and frequency for non-vascular).

With respect to the biodiversity of the characterized vegetation cover, the index of dominance of Simpson had the highest value of high secondary vegetation cover, with a value of 0.96, followed by low secondary vegetation with 0.95, while the cover with the least value of dominance was exploitation of construction material, with 0.30; additionally, the Shannon equity index had the highest value in high secondary vegetation

cover, with 3.90 (80.6% of the maximum expected diversity for the sample), followed by low secondary vegetation, with 3.7 (75.1), while in coverage with the least Shannon value it was exploitation of construction material with 0.59.

With respect to abundance of vascular species, rock and terrestrial facultative in the area of the project, the species of the family Orchidaceae ***Pleurothallis pulchella*** (Kunth) Lindl. with a total of 4344 registers, that is 19% of total abundance registered for the vascular flora of rock and terrestrial facultative flora; second was ***Elleanthus sphaerocephalus*** Schltr., with a total of 4062 registers, that is 17.8%; third, the terrestrial rock bromelia ***Puya lehmanniana*** L.B. Sm., with 2102 registers, that is 9.2% of total abundance and, fourth ***Pleurothallis lamellaris*** Lindl., with 1264 registers, that is 5.5% of total abundance.

In turn, the floristic composition of non-vascular rock and terrestrial facultative species, which were registered in 11 of the 13 coverages characterized in the area of the project, for which the characterization was performed, was represented by 122 species, distributed in 48 families and 3095 frequency registers; the families with more species wealth were Parmeliaceae with six (6) classes, and 13 species and Lejeuneaceae with seven (7) species, equal to Lobariaceae, Physciaceae and Bryaceae.

Of all the species registered in the project's area, only two (2) vascular species of the Bromeliaceae family, one of terrestrial rock, ***Puya lehmanniana*** L.B. Sm. and the other bromelia of the epiphyte group, ***Tillandsia lajensis*** André., are registered under some type of threat category. It is worth highlighting that all the Orchidaceae family species are registered in the CITES, Appendix II; therefore, their traffic and commercialization are regulated by an international covenant such as the CITES.

5.2.1.1.2 Fauna

The characterization of fauna in the Rumichaca-Pasto divided highway project, San Juan-Pedregal segment, shows a species composition typical of the high lands of the Colombian Andes; the results obtained include 11 species of amphibians belonging to the Aunra order, which are distributed in three genders and three families. For the reptiles, 12 species were identified belonging to five families: Dactyloidae, Corytophanidae, Gymnophthalmidae, Tropiduridae and Colubridae. With respect to birds, a total of 104 species were registered, distributed in 14 orders and 33 families. Bird registers totall3ed 1362, 144 from the fog network capture technique and 1218 of the visual and auditive detection transects. Finally, for mammals, 103 individuals were reported by direct and indirect methods; the reported species were grouped in seven Orers and 13 families; the registers were distributed in seven species of flying mammals (Chiroptera Order), 15 terrestrial and one (1) semi-aquatic.

Within the ecologic relationship of fauna with various land coverages, it was determined that the riparian forest and the high vegetation exhibit the greatest animal diversity; in contrast, pastures and crops, forests and plain grasslands have low diversity. It is worth noting that the area of influence shows high levels of fragmentation and environmental deterioration, which restricts the distribution of species to small native vegetation patches associated with lotic water bodies.

In the area of influence of the project, the presence of 11 species in their endangered category was determined, four amphibians, four reptiles, two mammals and only one bird; in the CITES categories, there are 24 birds and three mammals, in migratory birds 11, and three mammals (vats). Lastly, the number of species with restricted distribution for Colombia is 3 endemic and 21 nearly-endemic.

5.2.1.2 Aquatic ecosystems

The relevance of selected points and representativeness regarding spatial coverage was determined taking into account the following criteria: Location within the area of influence, presence of the main basins and sub-basins identified, water bodies with greater coverage within the area of influence, different types of water bodies, rivers and streams, and Lentic: natural and artificial; however, no water bodies of this type were registered), water bodies of ecosystemic and socioeconomic relevance, and points of interest for the project or subject of exploitation (riverbed occupation and water intake respectively); therefore, some points may coincide in the same water body. Thus, 44 water quality sampling stations were established for the project; said samplings were taken between February 26 and March 21 of 2017.

The hydro-biological characterization of variables aquatic ecosystems present in the area of influence of the Rumichaca-Pasto Divided Highway Project - San Juan-Pedregal segment, said characterization was performed under the collection permit intended for preparation of environmental assessments (Resolution No. 0783 of July 2, 2015). The methodological design is described in chapter 2. General aspects contained in the report presented by the laboratory -MCS Consultoría y Monitoreo Ambiental S.A.S.-which is responsible for the physicochemical, bacteriological and hydro-biological monitoring of this assessment; it is certified in SO 9001:2008 and is accredited with the IDEAN under NTC-ISO/IEC 17025:2005, pursuant to Resolution No. 0896f May 27, 2013.

· **The main findings for the communities in the area of study showed that:**

The periphytic community in the lotic systems assessed is made up of microalgae with different levels of sensibility and/or tolerance relative to organic decaying processes, which confirms the presence of organic matter in these systems, not reaching critical contamination levels, and showing greater density and taxonomic variety of the Ochrophytes as part of this community.

As noted for the periphytic community, the phytoplankton community was mainly represented by Ochrophytes of genders, both sensitive and tolerant to environmental deterioration, which probably are incidental contributions to the periphytic substrata located in adjacent areas.

The zooplanktonic community is known for the presence of hylum Rotifera organisms, a high plasticity taxonomic group to be adapted to different food sources. Similarly, due to greater representativeness of phylum Protozoa, these organisms are abundant in the environments where notification processes are performed.

The benthic community showed more richness and abundance downstream of the Sapuyes River. Inseca was the class contributing the most richness and abundance at the monitored points, followed by Bivalvia and Hirudinea.

Acording to the calculated BMWP/Col, 33 stations were classified very critical, 33.3 critical, and 1 uncertain, a conditions that in some cases results from the lack of categorization for some of the reported families; therefore, these results are to be considered with precaution.

The reported Macrophytes show the presence in the water-land phase a percentage of 99.8, and the rest in the aquatic phase; this proves that the flow is a limiting factor for the establishment of said community.

As regards the Ichthyofauna, no individuals were captured, which can be attributed to system conditions, such a geological characteristics (mineral content and soil nutrients, solids, erosion, etc), rate of water renovation

(velocity, flow), morphometric features (shape or irregularity of river bed, shallow surface:depth ratio), water turbidity and type of river substratum.

The Spearman correlation coefficient determined significant correlations among variables that might favor or not the diversity of the hydro-biological communities assessed, as in the case of macronutrients associated with the growth of communities, or turbidity or metals that could limit the establishment of these communities.

5.2.1.3 Strategic, sensitive ecosystems and/or protected areas

The road project area is located in part of the municipalities of Imués, Iles, Contadero and Ipiales in the department of Nariño. This area and its geography are influenced by the watershed of the Guáitara River, which in turn belongs to the large basin of the Patía River and is under the jurisdiction of the Corporación Autónoma Regional de Nariño – CORPONARIÑO.

To identify the presence of strategic ecosystems and/or protected areas in the area of influence of the highway project, the database was consulted of the National Environmental System (SIAC for the acronym in Spanish), which is run by the Ministry of Environmental and Sustainable Development in coordination with environmental research institutions (IDEAM, SINCHI, HUMBOLDT, IIAP and INVEMAR), the regional environmental authorities (Regional Autonomous Corporations and sustainable development corporations) and local authorities, the academic community, the different sectors, and in general the different providers and users of environmental information. This produced the result that in the studied area *if there are no protected areas declared at the national, regional, or local level*.

Furthermore, the Early Alert Information System, using the tool TREMARCTOS-COLOMBIA 3.0, does not report presence of Forest Reserves as per Law 2, Natural National Parks, restricted areas in the RUNAP System, regional or local Protection areas, for the area of influence of the Rumichaca-Pasto divided highway project, San Juan Segment. Said tool reported low vulnerability for the area of influence of the road project.

The Ministry of Environment and Sustainable Development, through the Directorate of Forests Biodiveristy and Ecosystemic services defines that in the area of study there are no national protection areas such as Biosphere Reserves or Ramsar sites, as well as national protecting areas and AICAS.

The verification in Colombia's Environmental Information System (SIAC)[1], evidences that the project's area of influence is not located in the forest reserve substation area established by Resolution No. 129 of 1996, issued then by INCORA (today INCODER).

In addition, the Corporación Autónoma Regional del Cesar (CORPONARIÑO), declares that the project's area of influence does not overlap with legally declared national or regional protected zones, nor with Law 2 Forest Reserve Zones.

Likewise, the Asociación Red Colombiana de Reservas Naturales de la Sociedad Civil (RESNATUR) and the planning secretariat of the respective mayors' offices, do not determine the presence of local protected natural areas, civil society reserves and/or protected areas in the area of influence of the road project.

[1] Geographic visor: Sistema de Información Ambiental de Colombia. Available in: http://sig.anla.gov.co:8083/

5.2.2 Ecosystemic Services

13 ecosystemic services were identified for the area of influence: six (6) for the provisioning category, (3) in the regulation category, (1) in the support category, and three (3) in the cultural category. Also, three (3) types of beneficiaries of ecosystem services were identified, which correspond to: 1. Rural peasant and indigenous communities, 2. Population settled in urban sectors, and 3. Floating population, who are dependent highly from the support service for upholding their productive systems, surface water provisioning, weather regulation and air quality, oil purification and presence of historical-cultural important sites that contribute to the cultural identity of the communities.

With respect to project dependence, it occurs mostly on provisioning of surface water intake by construction activities (1.95 L/s for each of the eleven planned camps), and the necessary forest use for execution of the planned works (1511.44 ha with a maximum volume of 13.048,24 m3). Lastly, the highest incidence of the project will be on physical support services for establishing agricultural and cattle farming systems, water regulation, weather regulation and maintenance of air quality, offer and maintenance of habitats, enjoyment of landscape beauty and soil purification.

5.3 SOCIOECONOMIC ENVIRONMENT

Considering the M-M-INA-02 Terms of Reference that were approved by Resolution 0751 of March 26, 2015 for the preparation of the Environmental Impact Assessment - EIA, which were used to prepare this study, the area of influence corresponds to that showing significant impact caused by the execution of the project, which varies from one component to the other and, therefore, the socioeconomic area of influence is proposed based on the physical–biotic area of influence.

The definition of the socioeconomic area of influence is also based on a consideration of the impacts that may be caused to the components of the environment, in such a way that the minimum unit of analysis included in the development of this study corresponds to the territorial units in the physical-biotic area of influence, due to the fact that the existence is seen of these units as the minimum political-administrative subdivision of the municipality. Therefore, the potential socioeconomic impacts take place in the demographic, spatial, economic, cultural, and political-organizational components of the groups of these territorial units, each of them having their population, infrastructure, economic activities, and community organization.

It should be noted that for the definition of the socioeconomic area of influence, a preliminary area of influence was initially established, based on the information on the scope of the project, the transcendence of its impacts, and the information on the region filed in the archives of the Concesionaria Vial Unión del Sur, and information consulted in official sources such as Basic Regional Development Plans, Municipal Development Plans, certificates from the Ministry of the Interior regarding the presence of ethnic communities (434 and 432 on May 9, 2017), and the National Department of Statistics (DANE). Subsequently, after approaching the municipal authorities and the communities of influence, the definitive socioeconomic area of influence was specified and defined, with the territorial units that are listed in **Table 5.8.**

Table 5.6 Territorial Units of the Project's Area of Influence

MAJOR TERRITORIAL UNITS	MINOR TERRITORIAL UNITS	AREA (ha)	CRITERION TYPE OF INTERVENTION
IPIALES		3292.87	ZODME and Road Layout

MAJOR TERRITORIAL UNITS	MINOR TERRITORIAL UNITS	AREA (ha)	CRITERION TYPE OF INTERVENTION
	San Juan Indigenous Reserve (El Rosal, Boquerón and San Juan)		Layout and camp
			Layout, ZODMES and camp
CONTADERO	Aldea de María	2264,28	Route and ZODMES
	El Capulí	1865,74	Route and ZODMES
	El Culantro	1241,19	Route and ZODMES
	El Juncal	3917,16	Physical - biotic influence
	El Manzano Creek	1020,74	ZODMES
	Rosal de San Francisco Rural District	491,94	ZODMES
	I.P. IP Ospina Pérez	1898,57	Layout and ZODMES
	Iscuazán	2409,42	ZODME
	La Providencia	1548,01	Route and ZODMES
	Las Cuevas	980,50	ZODMES
	Las Delicias	1828,68	Layout and ZODMES
	San Andrés	897,75	Layout and ZODMES
	San Francisco Creek	898,54	Layout and ZODMES
	San José de Quisnamuez Rural District	2738,31	Layout and ZODMES
	Urban perimeter	288,82	EIA 1B intervention area and physical-biotic area of influence
ILES	Alto del Rey	2046,46	Layout
	Capulí	2073,69	ZODMES
	El Porvenir	2611,91	Camp, Layout and ZODMES
	El Rosario	6876,46	Route
	La Esperanza	2435,04	ZODMES
	Loma Alta	2752,77	Physical - biotic influence
	Tablón Alto	6062,98	Route and ZODMES
	Tablón Bajo	1846,64	Route and ZODMES
	Tamburán	5078,96	ZODMES
	Urban	4896,44	Camp, Route and ZODMES
	Yarqui	2034,58	Physical – Biotic Area of Influence.
IMUÉS	La Recta Rural District	4992,03	Route and ZODMES
	Pilcuán Viejo		Layout
	Silamác	3354,73	Physical – Biotic Area of Influence.

Source: Geocol Consultores S.A 2017.

Given the characteristics of the project and having defined the area of influence, the guidelines for participation were developed through a process of sharing information with the municipal authorities of Ipiales, Contadero, Iles and Imués, and with representatives and the general community residing there. The socioeconomic characterization was also done of each major and minor territorial unit identified in the area of influence of the Rumichaca – Pasto divided Highway project, San Juan - Pedregal Segment.

6 ENVIRONMENTAL ZONING

Environmental zoning is produced by an environmental description and characterization of the area of influence and area of intervention of the Rumichaca – Pasto Divided Highway Project, Ipiales – San Juan Segment. A synthesis was obtained from the diagnosis of the baseline for the study and an overall vision of

the conditions of the ecosystems and natural resources found there. Environmental zoning basically consists of overlaying thematic layers (abiotic, biotic, and socioeconomic) obtained from the environmental characterization, analyzing and rating each component separately to subsequently categorize and prioritize those factors that determine the sensitivity of a place. Said zoning determines the degree of environmental sensitivity in each one of the ecosystems in a determined area.

The elements classified as areas of Very High Sensitivity are found in patches of dry forest, and at headwaters and their protective buffer zones, with the purpose of ensuring their protection during the execution of the project. With respect to the zones considered to have *High Sensitivity*, these are areas that have environmental and/or legal limitations. Carrying out projects, works, or activities is not definitively excluded in these areas; through reaching a consensus, engaging in consultations, and proper management, they can be used to execute projects. These type of terrains include the following: Social infrastructure (municipal seats, towns, scattered homes, health posts, and community meeting rooms), infrastructure for the provision of water, hand-dug wells, productive infrastructure associated with homes, infrastructure corresponding to the generation of income and providing subsistence to the people, and areas for recreational use.

Protective forest areas, which are lands that may or may not have a forest aptitude, constituted in forests, that are an integral part of and support for biological, ethnic, and environmental biodiversity, where knowledge of the forests and their management must be safeguarded under the principles of sustainability and that should be continuously conserved as forest; areas that are the headwaters of many rivers that flow out in different directions (*estrellas fluviales*), water production, forests in areas that supply urban or rural water systems, and buffer zones around creeks. Buffer zones for rivers and creeks, where the buffer zones for water courses are strips of land parallel to the creeks and rivers, which have the purpose of isolating and protecting the water currents. Due to their importance, a strip of 30 m is taken on each side of the maximum contour line for flooding by the body of water.

The zones corresponding to mosaics of crops and pasture, artificial territory, etc., are considered to have *Moderate to Low Sensitivity*. These elements have environmental and socioeconomic conditions that can be used for the development of the project, through the implementation of environmental management measures, in accordance with the impacts generated by the intervention and the negotiations carried out with the owners of these areas. Likewise, those elements were considered in the intermediate zoning (physical, biotic, and social) presented in **Table 6.1 and Figure 6-1.**

Table 6.1 Environmental Zoning for the Area of Influence and Intervention of the Rumichaca – Pasto Divided Highway Project, San Juan - Pedregal Segment

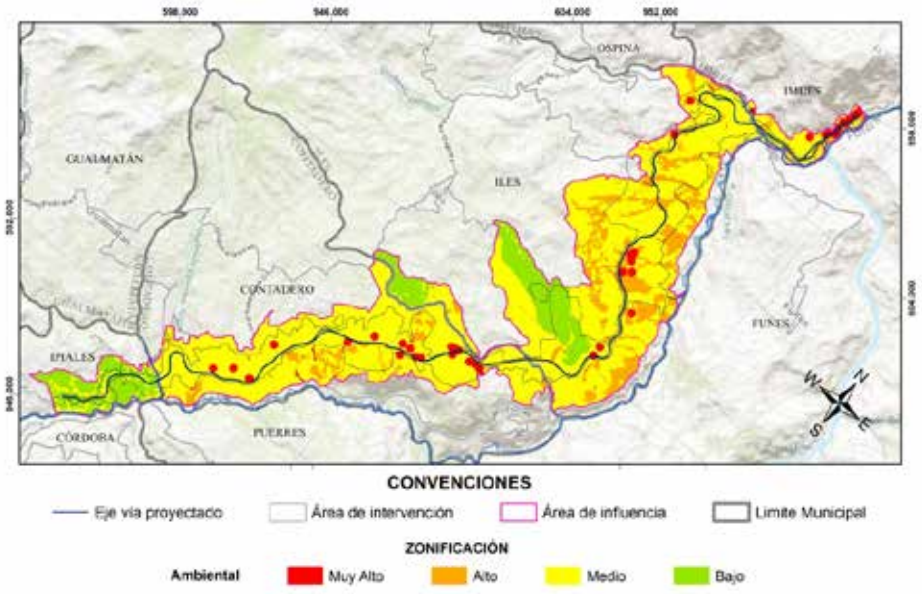
ENVIRONMENTAL SENSITIVITY	AREA OF INFLUENCE		AREA OF INTERVENTION	
	Area (ha)	%	Area (ha)	%
VERY HIGH	114,39	2,8	75,81	4,7
HIGH	546,07	13,5	181,11	11,1
MEDIUM	2.898,50	71,7	1207,49	74,1
LOW	481,69	11,9	164,27	10,1
TOTAL	**4040,66**	**100**	**1628,68**	**100**

Source: GEOCOL CONSULTORES S.A., 2017.

The percentages for the different degrees of sensitivity determined in the consolidated environmental zoning for the project's area of intervention showed that 74.1% (1207.49 ha) is made up of zones of Medium

Sensitivity, 11.1 % (181.11 ha) of the area consists of zones of High Sensitivity, 10.1% (164.27 ha) of Low Sensitivity, and 4.7% (75.81 ha) are zones with Very High Sensitivity.

Figure6-1Environmental Zoning for the Area of Influence and Intervention of the Rumichaca – Pasto Divided Highway Project, San Juan - Pedregal Segment.



Source: GEOCOL CONSULTORES S.A., 2017.

7 USE AND EXPLOITATION OF RENEWABLE AND/OR NON-RENEWABLE NATURAL RESOURCES

As a summary, included below in **Table 7.1**, is that related to the various types of use and exploitation of renewable and non-renewable natural resources for the Rumichaca – Pasto Divided Highway Project, San Juan - Pedregal Segment.

Table 7.1 Demand of natural resources applicable to the project

REQUIRED NATURAL RESOURCES	DESCRIPTION	DEMAND/USE
SURFACE WATERS	The Concesionaria Vial Unión del Sur requests as intake sources the concession of surface waters on water sources listed herein below. It plans to carry out water intake at the following points, with mobility of 100 m upstream and 100 m downstream, as per the following coordinates. **Rumichaca-Pasto Divided Highway project, San Juan - Pedregal segment.**	Intake of Surfce Waters on a maximum estimated flow of 1.95 L/s per camp • 0.45 L/s for domestic use.

<table>
<tr><th>REQUIRED NATURAL RESOURCES</th><th>DESCRIPTION</th><th>DEMAND/USE</th></tr>
<tr><td></td><td>
<table>
<tr><th rowspan="2">ID</th><th rowspan="2">SOURCE</th><th colspan="2">WEST ORIGIN MAGNAS SIRGAS COORDINATES</th><th rowspan="2">MOBILITY RANGE</th></tr>
<tr><th>EAST</th><th>NORTH</th></tr>
<tr><td>1</td><td>Guáitara River</td><td>948503</td><td>590762</td><td rowspan="11">A mobility range of up to 200 m is requested, 100 m upstream and 100 m downstream of the proposed points.</td></tr>
<tr><td>2</td><td>Boquerón River</td><td>948589</td><td>590972</td></tr>
<tr><td>3</td><td>La Humeadora Stream</td><td>955074</td><td>597201</td></tr>
<tr><td>4</td><td>Moledores Stream</td><td>956019</td><td>598991</td></tr>
<tr><td>5</td><td>San Francisco Stream</td><td>953962</td><td>601557</td></tr>
<tr><td>6</td><td>El Macal Stream</td><td>954870</td><td>603721</td></tr>
<tr><td>7</td><td>Sapuyes river</td><td>954844</td><td>605090</td></tr>
<tr><td>8</td><td>Yamurayán Stream</td><td>949128</td><td>592258</td></tr>
<tr><td>9</td><td>San Francisco Stream</td><td>949976</td><td>593121</td></tr>
<tr><td>10</td><td>Culantro Creek</td><td>950642</td><td>594577</td></tr>
<tr><td>11</td><td>El Manzano Creek</td><td>951631</td><td>595174</td></tr>
</table>
In turn, Concesionaria Vial Unión del Sur requests, if necessary for domestic use, purchasing water from third parties who have permits in place granted by the competent environmental authority.
</td><td>• 1.5 L/s for industrial use.</td></tr>
<tr><td>GROUND WATER</td><td colspan="2">No ground water concession is requested, given that the demand of water for the construction of the Rumichaca-Pasto divided highway project, San Juan-Pedregal segment, will be covered with the sites requested form surface water sources and water purchased from authorized companies that provide water with optimal characteristics for human consumption.</td></tr>
<tr><td>DISCHARGES</td><td>
The Concesionaria Vial Unión del Sur requests alternatives for disposal of industrial and domestic residual water, as listed below:
1. Sprinkling or infIltration field in areas adjacent to the camps, with surfaces up up to XX (X) hectares.
2. Discahrge on surfave wagter bodies at the sites and flows shown in the following table, with mobility range of up to 100 m upseran and downstream of the proposed points, in accordance with Resolution 631 of March 17, 2015.

Rumichaca-Pasto Divided Highway project, San Juan - Pedregal segment.
<table>
<tr><th rowspan="2">ID</th><th rowspan="2">SOURCE</th><th colspan="2">WEST ORIGIN MAGNAS SIRGAS COORDINATES</th><th rowspan="2">FLOW RATE (L/s)</th></tr>
<tr><th>EAST</th><th>NORTH</th></tr>
<tr><td>1</td><td>Boquerón River Camp 31 + 100</td><td>948589</td><td>590972</td><td>0.44</td></tr>
<tr><td>2</td><td>La Humeadora Stream Camp 31 + 100</td><td>955074</td><td>597201</td><td>0.44</td></tr>
<tr><td>3</td><td>Guáitara River Camp 31 + 100</td><td>956508</td><td>600552</td><td>0.44</td></tr>
<tr><td>4</td><td>Sapuyes river Camp 31 + 100</td><td>954844</td><td>605090</td><td>0.44</td></tr>
</table>
3. Delivery to an authorized third party who has the respective permits for management and disposal of waste water.
</td><td>The volumes planned for disposal are:

Discharge volume into the soil: 0.44 L/s, per camp, for periods of up to X hours/day.</td></tr>
<tr><td>RIVER BED OCCUPATION</td><td colspan="2">Concesionaria Vial Unión del Sur requests the construction and conditioning of river bed occupations at the crossings of surface water ways for the Rumichaca-Pasto Divided Highway Project, San Juan-Pedregal segment, with a mobility range of 50 m upstream and 50 m downstream related to the requested point, in the coordinates and points listed in Table 7.2
Table 7.2 Location of river bed occupation points.</td></tr>
</table>

REQUIRED NATURAL RESOURCES	DESCRIPTION	DEMAND/USE

ID	NAME OF WATER BODY	PROJECT CHAINAGE	DATUM COORDINATES MAGNA SIRGAS ORIGIN 3 WEST		PROPOSED WORK
			EAST	NORTH	
OC1	NN1	KP16+120	946811.93	589397.70	Box culvert 2 x 2 m
OC2	NN2	KP16+503	947121.83	589603.72	Box culvert 3 x 2 m
OC3	Yamurayán Stream	KP20+831	949114.02	592065.11	Box culvert 3 x 3 m
OC4	NN3	KP22+428	950054.08	593102.63	Box culvert 3 x 3 m
OC5	Guayarín Stream	KP23+157	950212.94	593774.90	Box culvert 2 x 2 m
OC6	NN4	KP23+370	950321.61	593956.90	Box culvert 1.5 x 1.5 m
OC7	NN5	KP24+136	950636.07	594629.81	Box culvert 3 x 2 m
OC8	NN5	KP24+136	950617.38	594684.56	Box culvert 3 x 2 m
OC9	NN6	KP24+315	950764.62	594725.77	Box culvert 2 x 2 m
OC10	NN7	KP24+525	950967.72	594782.47	Box culvert 2 x 2 m
OC11	NN8	KP25+529	951686.27	595151.47	900 mm Culvert
OC12	Manzano Stream	KP25+589	951906.14	595274.20	1200 mm Culvert
OC13	Brigada Stream	KP25+952	952253.56	595420.32	1200 mm Culvert
OC14	NN9	KP26+440	952669.62	595499.39	900 mm Culvert
OC15	NN1 Tributary to the La Humeadora Stream	KP28+516	954206.18	596624.50	900 mm Culvert
OC16	NN2 Tributary to the La Humeadora Stream	KP28+516	954290.20	596720.59	900 mm Culvert
OC17	NN10	KP28+677	954363.00	596797.00	900 mm Culvert
OC18	Los Arrayanes Creek	KP29+212	954729.44	597199.25	Box culvert 3 x 2 m

REQUIRED NATURAL RESOURCES	DESCRIPTION						DEMAND/USE
	OC19	Manzano Stream	KP29+437	954925.68	597342.18	Box culvert 3 x 2 m	
	OC20	NN11	KP29+593	955050.07	597431.63	Box culvert 3 x 2 m	
	OC21	Urbano Creek	KP29+756	955178.38	597501.33	Box culvert 3 x 2 m	
	OC22	NN12	KP30+040	955429.67	597508.01	900 mm Culvert	
	OC23	NN13	KP30+880	955776.28	598034.29	900 mm Culvert	
	OC24	NN14	KP31+746	955959.13	598715.59	1200 mm Culvert	
	OC25	Moledores Stream	KP32+103	955961.93	598913.93	900 mm Culvert	
	OC26	El Tablón Creek	KP32+729	954964.97	600264.24	900 mm Culvert	
	OC27	NN15	KP33+863	954928.86	600362.86	1200 mm Culvert	
	OC28	NN16	KP34+018	954892.74	600499.78	Box culvert 1.5 x 1.5 m	
	OC29	NN17	KP34+107	954867.24	600605.07	1200 mm Culvert	
	OC30	NN18	KP34+350	954841.74	600838.89	Box culvert 1.5 x 1.5 m	
	OC31	NN19	KP35+732	954860.08	601994.55	Box culvert 2 x 2 m	
	OC32	NN1 Tributary to the San Francisco Stream	KP35+917	954632.16	602074.88	900 mm Culvert	
	OC33	San Francisco Stream	KP36+000	954609.64	602099.98	Box culvert 1.5 x 1.5 m	
	OC33	NN20	KP36+751	954134.22	602589.08	Box culvert 2 x 2 m	
	OC35	NN21	KP36+878	954020.90	602661.87	900 mm Culvert	
	OC36	NN22	KP37+959	954012.69	603620.06	Box culvert 2 x 2 m	
	OC37	NN23	KP39+700	953918.82	604516.47	Box culvert 2 x 2 m	
	OC38	NN23	KP40+085	953963.00	604813.00	Box culvert 3 x 3 m	
	OC39	NN24	KP44+013	956818.81	605952.00	900 mm Culvert	
	OC40	NN25	KP44+425	956886.56	606301.41	Box culvert 2 x 2 m	

REQUIRED NATURAL RESOURCES	DESCRIPTION	DEMAND/USE
	Type designs for riverbed occupation are outlined in section 7.4 Riverbed Occupation**,** of **this** chapter	
CONSTRUCTION MATERIAL	Concesionaria Vial Unión del Sur requests permission for the acquisition of materials in existing sources, through third parties, in extraction sites having the respective mining permits and / or environmental licenses granted by the competent entities and authorities. Also, Concesionaria Vial Unión del Sur requests the reutilization of materials derived from excavation and7or demolition activities, which can be used as land filling material in order to save unnecessary earth moving and thus reduce the volume of material to be disposed of in the Zodmes.	
FOREST EXPLOITATION	Concesionaria Vial Unión del Sur requests forest exploitation of **13048.25 m³**in an area of **1629.23ha** for performance of activities in the Rumichaca – Pasto divided highway project, San Juan - Pedregal segment. To determine the volume, forest plot surveys were conducted on the natural covers that are susceptible of forest exploitation (dense forest, riparian forest, high secondary vegetation). This survey meets the statistical requirements set out in the terms of reference. For human origin covers (pasture and crop mosaics, crop mosaics, forest plantation and clear pastures) census was performed (100% of riding crop individuals), 47% (662,63ha) of the maximum area to be intervened; based on this census, the forest exploitation for these covers was calculated. Listed below are the maximum areas and volumes requested for forest exploitation:	
Atmospheric emissions.		

Rumichaca-Pasto Divided Highway project, San Juan - Pedregal segment.	**TYPE OF COVER**		
	Maximum area to intervene (ha)	**Average volume per hectare(m³/ha)**	**Maximum volume to intervene (m³)**
Dense forest in the high Andes orobiome	*3,1*	*196,45*	*608,99*
Riparian forest in the medium Andes orobiome	*50,69*	*61,5*	*3117,43*
High secondary vegetation in the Andes orobiiome	*21,18*	*53,17*	*1126,14*
High secondary vegetation in the medium Andes orobiiome	*27,1*	*31,92*	*865,03*
Human origin covers (pasgture and crop mosaic, crop mosaic, clean pasture and forest plantation)	*1409,37*	*5,20*	*7330,65*
Natural covers that are not susceptible to exploitation (rocky open grasslands and low secondary vegetation)	*117,78*	-	-
TOTAL	***1629,23***	***N/A***	***13048,25***

Source: GEOCOL CONSULTORES S.A., 2017.

8 ENVIRONMENTAL IMPACT ASSESSMENT

8.1.1 Scenario without the project

Considering the primary and secondary information collected, in general terms, 195 impacts among the assessed activities and natural environment were assessed and they are positive and negative, the agricultural activity (transitory crops) being the one with the highest number of impacts equivalent to 12%, followed by burning activities and livestock activities equivalent to 11.8% each.

The activities that have produced the highest number of negative impacts are the burning activities (9 mild or irrelevant impacts and 13 moderate impacts for a total of 22 impacts), the livestock activities (14 mild or irrelevant impacts and 8 moderate impacts for a total of 22 impacts) and agriculture (2 mild or irrelevant impacts and 17 moderate impacts and 2 severe impacts for a total of 21 impacts).

In general, the activities that generate a higher number of positive impacts are the ones of forest protection and conservation plantations (7 mild or irrelevant impacts and 12 moderate impacts); followed by agriculture and tourism each one with 3 impacts (1 mild or irrelevant and 2 moderate)

In the discrimination of the group of interactions that caused negative impacts in the activities developed by the community, 43% mild or irrelevant (70 impacts), 53% Moderate (87 impacts) and 4% corresponding to Severe (6 impacts) for a total of 163 negative impacts equivalent to 84% of all the impacts identified.

Likewise, as regards positive impacts, there are eleven (11) mild or irrelevant impacts and twenty-one (21) moderate impacts, corresponding to 34% and 66%, respectively. Total positive impacts correspond to 16% of all the impacts identified

The environmental elements that have been the most affected, both positively and negatively, by the activities assessed in the scenario without the project according to the assessment of the impacts identified and considering the activities and environmental elements analyzed. It is evidenced that the environmental element with the highest number of negative impacts is the one of surface waters (17 mild or irrelevant impacts and 15 moderate impacts for a total of 37 impacts), followed by the fauna (13 mild or irrelevant impacts and 15 moderate impacts for a total of 28 impacts), while the element with the highest number of positive impacts is the one of the economic and productive structure (5 mild or irrelevant impacts and 7 moderate impacts for a total of 12 impacts), followed by surface waters with (3 mild or irrelevant impacts and 3 moderate impacts for a total of 6 impacts).

8.1.2 SCENARIO WITH PROJECT

Considering the scope of the project and the state of the Area of Influence of the highway project, in general terms, 252 impacts were identified among the activities assessed and the current conditions of the area, which would be of positive and negative character, vegetation cover removal, topsoil stripping and cleaning being the activity that would have the highest number of impacts with 24 impacts equivalent to 10%, followed by building and operation of area of management of debris and excavation material (ZODME) with 22 impacts, that is, 9%; then, there is the earth moving activity (excavation and fillings) with 19 impacts equivalent to 8%.

The activities that have had the highest number of negative impacts are removal of vegetation cover, topsoil stripping and cleaning (9 mild or irrelevant impacts, 11 moderate impacts and 4 severe impacts for a total of 24 impacts); followed by building and operation of areas of management of debris and excavation material

(ZODME)} (5 mild or irrelevant impacts, 9 moderate impacts and 8 severe impacts for a total of 22 impacts); and in third level, earth moving (excavation and fillings) (6 mild or irrelevant impacts, 9 moderate impacts, 4 severe impacts for a total of 19 impacts).

In general, the activities with the highest number of positive impacts are restoration of vegetation cover and revegetation with 17 impacts (4 mild or irrelevant, 12 moderate and 1 severe), landscape management with 8 impacts (3 mild or irrelevant, 3 moderate and 2 severe); and treatment of slopes with 7 impacts (5 mild or irrelevant, 1 moderate and 1 severe).

The group of interactions that had negative impacts was broken down as follows: 56 % mild or irrelevant (111 impacts), 32% moderate (63 impacts) and 12% corresponding to severe (25 impacts) for a total of 199 negative impacts equivalent to 79% of all the impacts identified.

As regards interactions that would have positive impacts, they are broken down as follows: 34% mild or irrelevant (18 impacts), 53% moderate (28 impacts), and 13% corresponding to severe (7 impacts) for a total of 53 impacts equivalent to 21% of all the impacts identified.

For the scenario of negative impacts, according to the activities to be developed, the air element has the highest number of possible impacts (34 mild or irrelevant, 13 moderate and 2 severe for a total of 49 impacts), followed by the element of surface waters with 47 impacts (33 mild or irrelevant, 13 moderate, and 1 severe) and in third place, there is the soil element with 19 impacts (6 mild or irrelevant, 6 moderate and 7 severe).

For the scenario of positive impacts, the most benefited elements are surface waters with 11 impacts (8 mild or irrelevant and 3 moderate); this is directly associated to the seeding of grass and revegetation and slope conditioning; second is the economic and productive structure element with 8 impacts (5 moderate and 3 severe), associated with he working dynamism derived from the project.

9 ENVIRONMENTAL MANAGEMENT ZONING

The Environmental Zoning for the Area of Influence of the Rumichaca Pasto Divided Highway Project, San Juan-Pedregal segment was developed based on the information described in Chapter 5. Characterization of the area of influence, allowing to establish the sensitivity of the ecosystems and natural resources with respect to the highway project activities, in order to obtain the units for use, recovery and conservation.

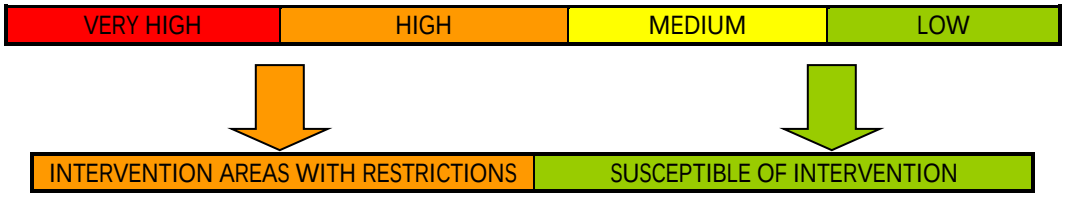
The Environmental Management Zoning results from the interaction between the Environmental Zoning and the environmental assessment, considering the levels of vulnerability and sensitivity of each environmental component, and the socioenvironmental significance of the ecosystems and natural resources concerning the level of intervention or impact.

Next, the areas considering Environmental Management Zoning are defined:

- Excluded Area
- Intervention areas with restrictions
- Susceptible of intervention

It is worth making clear that, as a result for the area of influence of the highway project, two environmental management zoning categories were considered, which are shown in **Figure 9-1**

Figura 9-1 Description of activity management zoning - Level of sensitivity, relevance



Source: GEOCOL CONSULTORES S.A., 2017.

· **Intervention areas with restrictions**

It considers the sites that by their nature, condition or magnitude require that the activities to be performed restrict or implement special or specific environmental management and control to prevent their being affected. For this classification, it is necessary to consider those areas whose environmental sensitivity is classified a very high and high.

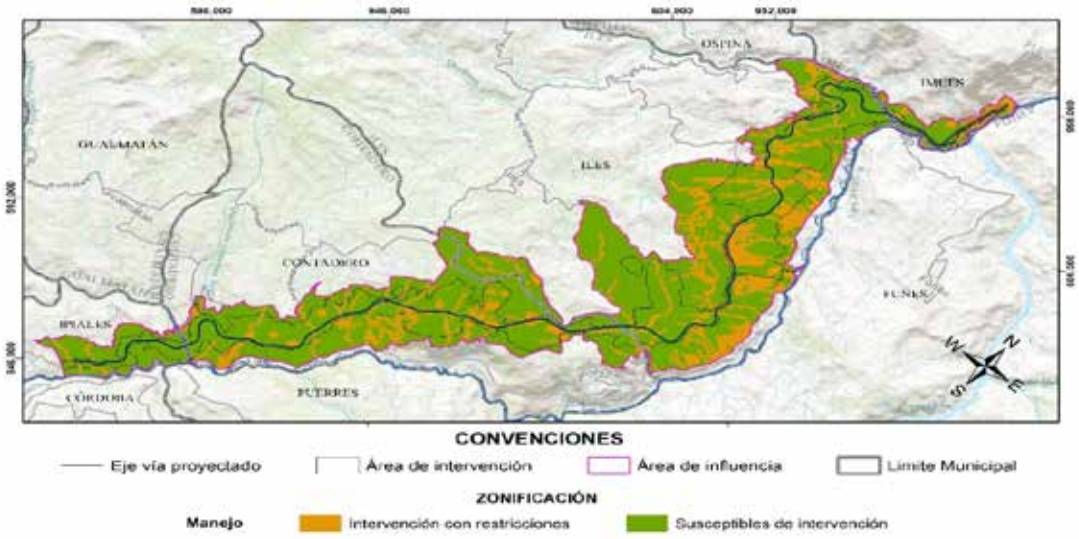
· **SUSCEPTIBLE OF INTERVENTION**

These are areas that have high potential for development of the project and are defined in the environmental zoning in the medium and low categories.

9.1.1 Results

The interrelation of elements in the environmental zoning regarding the level of sensitivity of each ecosystem with respect to the activitie4s that are to be performed in the area of influence of the project, the impacts generated from the various activities, are shown below in **Figure 9-2 and Table 9-1**

Figura 9-2 Zoning map for mangemetn of project activities



Source: GEOCOL CONSULTORES S.A., 2017.

Table 9.1 Environmental mangement zoning for project activity

MANAGEMENT ZONING	PROJECT AID		PROJECT INTERVENTION AREA		DESCRIPTION	PERMITTED ACTIVITIES
	AREA (ha)	%	AREA (ha)	%		
Intervention with restriction	1.056,64	26,15	394,91	24,24	- Headways, springs and 100 m protection strip - Water ways or sources and their 30 m protection strip on each side of the maximum flooding level.	Water intake Riverbed occupation
					Protective forest areas that correspond to lands that may or may not have forest aptitude, constituted in forests, which are an integral part and support of the	It is possible to develop some project activities, implementing special care and restrictions in accordance with

MANAGEMENT ZONING	PROJECT AID		PROJECT INTERVENTION AREA		DESCRIPTION	PERMITTED ACTIVITIES
	AREA (ha)	%	AREA (ha)	%		
					biological, ethnic and environmental offer biodiversity. These must be preserved with forest permanently; fluvial stars are identified therein as well as water production, forests on areas of urban or rural aqueduct supply, stream rounds.	the activities and the environmental sensitivity of the site.
					Social infrastructure (municipal seats, populated centers, scattered dwellings, health posts, community rooms) and its 100 m protection strip. - Water supply infrastructure, wells and 100 m protection strip. - Productive infrastructure associated with dwellings, corresponding to generation of income and living of the population	It is possible to access services in said zones, namely accommodation, food, health service, but these cannot be intervened by the project works or activities.
SUSCEPTIBLE OF INTERVENTION	2.984,02	73,85	1.234,32	75,76	Areas with cover of crop mosaics, pasture, artificial territories, etc.	Conditioning and construction of civil works are permitted. All activities will be performed in

MANAGEMENT ZONING	PROJECT AID		PROJECT INTERVENTION AREA		DESCRIPTION	PERMITTED ACTIVITIES
	AREA (ha)	%	AREA (ha)	%		
						accordance with management measures set forth in Chapter 11.
TOTAL	**4.040,66**	**100**	**1.629,23**	**100**		

Source: GEOCOL CONSULTORES S.A., 2017.

11 ENVIRONMENTAL MANAGEMENT PLAN

The Environmental Management Plan – EMP is prepared taking into account the technical guidelines and the legal requirements established in the Terms of Reference for the preparation of the Environmental Impact Study for the road and/or tunnels construction project M-M-INA-04 (ANLA, 2015) adopted by means of Resolution 751 of 26 March 2015 by the Ministry of the Environment and Sustainable Development (MADS).

11.1.1 Environmental Management Programs

The content and description for each of the management datasheets proposed, are shown in the following Table 11.1.

Table 11.1 Content of management data sheets

ITEM	DESCRIPTION
PURPOSE	Explains in a specific and precise manner the objective it purports to put in place with the environmental management strategy.
TARGET	Presents targets to reach, indicating the objective it purports to put in place with the environmental management strategy.
PHASE	Explains the timing of the project and where the proposed environmental management measures should be conducted.
SOCIOENVIRONMENTAL IMPACTS TO MANAGE	Relates to the impact generated by the different stages of the project, indicating its type, causes, affectation and implicit environmental risk of the activity.
TYPE OF MEASURE	It defines the nature of the measure, namely: prevention, mitigation, correction and compensation.
ACTIONS TO BE DEVELOPED	It corresponds to the description of measures to be developed for adequate impact management.
INDICATORS	It corresponds to the setting of indicators that will show the effectiveness, efficiency and/or success of the measure.
PLACE OF APPLICATION	Indicates the place(s) in which environmental management measures should be implemented.
EXECUTION TIMETABLE	Establishes the phase in which the measures will be executed.
QUANTIFICATION AND COSTS	Establishes unit of measure, quantity, unit cost, and total cost.

Source: GEOCOL CONSULTORES S.A., 2017.

Table **11.2** shows the structure established by the Environmental Management Plan of the road project breaking up each of the datasheets that comprise the different management programs.

Table 11.2 Structure of the Environmental Management Plan

MEDIUM	PROGRAM	No.	NAME OF MANAGEMENT DATASHEET
ABIOTIC ENVIRONMENT	Soil Management	1	Management and Disposal of Debris and Excavation Material
		2	Management of Slopes and Hills
		3	Erosion management and control
		4	Management and Use of explosives
		5	Management and transport of construction material
		6	Runoff Management
		7	Landscape Management
		8	Management of Solid and Special Wastes
	Management of the Water Resource	9	Management of crossings over water ways
		10	Management of ground water, springs, water source
		11	Management and intake of surface water
		12	Management of Domestic and industrial liquid wastes
	Management of the Air resource	13	Management of Emission and Noise Sources
	Management of soil resource	14	Soil recovery project
BIOTIC EENVIRONMENT	Management of biodiversity and ecosystem services	15	Topsoil stripping and land cover management
		16	Protection of Fauna
		17	Protection of Flora
		18	Protection of Sensitive Ecosystems
		19	Management of revegetation in intervened area
		20	Management for compensation for impact on vegetation cover and wildlife species.
SOCIOECONOMIC ENVIRONMENT	Socioeconomic Management	21	Information and Community Participation
		22	Attention to users
		23	Accompaniment on property social management
		24	Education and training of personnel hired by the project
		25	Training, education and awareness building among the community on the project's surroundings
		26	Road Culture
		27	Institutional Support

Source: GEOCOL CONSULTORES S.A., 2017.

According to the identification, description and valuation of impacts, as a result of the environmental assessment, it determines the mechanism for the prevention, mitigation, correction and compensation of impacts to be generated during the different project phases.

11.1.2 Follow up and monitoring plan

The Follow-up and Monitoring Plan is intended to verify compliance with the environmental management measures set out in each program of the Environmental Management Plan (**Chapter 11.1.1**), to monitor and confirm the effectiveness of said projects, and identify potential improvement opportunities for the proposed actions.

The content and description of each follow up and monitoring file cards proposed are shown below in **Table 11.3.**

Table 11.3 Content of the follow up and monitoring file cards

ITEM	DESCRIPTION
PURPOSE	It shows in a specific, precise manner the objective of actions aimed at accomplishing the purposes and goals established.
TARGET	It shows the targets to be achieved through follow-up and monitoring actions, stating the intended purpose of the environmental management strategy.
TYPE OF MEASURE	It defines the nature of the measure, namely: prevention, mitigation, correction and compensation.
ACTIONS TO BE DEVELOPED	It corresponds to the description of measures to be developed for adequate impact management.
LOCATION OF THE FOLLOW-UP FOR MONITORING SITE	Site, area or route where the follow up and monitoring measures will be implemented
INDICATORS	It corresponds to the setting of indicators that will prove the effectiveness, efficiency and/or success of the measure.

Source: GEOCOL CONSULTORES S.A., 2017.

The plan's structure includes monitoring programs of management measures related to the file cards:

Table 11.4 Table 11.1 Structure of the Follow-up and Monitoring Plan

PROGRAM	FOLLOW UP AND MONITORING PLAN	FILE CARD No.
ABIOTIC ENVIRONMENT FOLLOWUP AND MONITORING PROGRAM	Water intake, occupation and domestic and industrial waste water	1
	Solid waste management, treatment and disposal of solid waste	2
	Atmospheric emissions, air quality and noise	3
	Soil	4
BIOTIC ENVIRONMENT FOLLOWUP AND MONITORING PROGRAM	Topsoil stripping and Vegetation Cover	5
	Wildlife fauna	6
	Flora	7
	Protection of Sensitive Ecosystems	8
	Revegetation of intervened areas.	9
	Compensation for impact on vegetation cover and wildlife species.	10
	Follow-up of 1% investment plan	11
SOCIOECONOMIC ENVIRONMENT FOLLOWUP AND MONITORING PROGRAM	Management of project's social impact	12
	Management and Impact Indicators of each EMP program on the socioeconomic environment	13
	Effectiveness of socioeconomic and environmental programs	14
	Management of concerns, requests or claims from the communities	15

PROGRAM	FOLLOW UP AND MONITORING PLAN	FILE CARD No.
	Participation and timely information to the communities	16

Source: GEOCOL CONSULTORES S.A., 2017.

11.2 OTHER PLANS AND PROGRAMS

11.2.1 1% Investment Plan

This chapter contains the proposal for investing 1% of the resources corresponding to the construction activities of the Rumichaca – Pasto Divided Highway Project, San Juan – Pedregal Segment, in compliance with article 43 of Law 99 of 1993 and its regulatory decrees.

Once the project's area of influence is characterized and the sources of the water resources are defined from which the water will be taken, a technical and economic proposal will be presented for the investment of the 1%, in accordance with current laws. Therefore, the following scopes are proposed:

Coordinate the activities proposed in this plan with the environmental authorities, local authorities, and companies in charge of the protection and conservation of the water resource from which water is being obtained.

In order to comply with the actions and activities in favor of the recovery, conservation, preservation, and monitoring of the defined watersheds, resources will be invested according to prioritized activities, defined amounts, and tentative areas and timing.

After reviewing the water resource development and management plans for the Boquerón, Sapuyes and Guaítara Rivers, in which basins are located the 11 water intake points for the project. Therefore, and bearing in mind the project baseline, where a high level of deforestation is evident along with the reduced area of natural land cover, the choice was made for projects that favor protection, conservation, and preservation through ecological restoration, rehabilitation, and recovery.

Based on the above determinations, some tentative areas were defined for the execution of the works or activities proposed. In accordance with the above, the activities to be conducted in the tentative areas for the protection and conservation of water resources are: Reforestation, isolation of hydrological rounds, property purchase, incentives to land owners who undertake revegetation and conservation actions.

11.2.2 Compensation Plan for Biodiversity Loss

Compensation for loss of biodiversity for the Rumichaca – Pasto Divided Highway Project, San Juan - Pedregal Segment was defined based on the criteria established in the Manual for the Assignment of Compensations for Biodiversity Loss, adopted by means of Resolution 1517 of 2012 by the Ministry of the Environment and Sustainable Development (MADS for the Acronym in Spanish), as well as the Terms of Reference for the preparation of the Environmental Impact Study for highway and/or tunnel projects, adopted by MADS through Resolution 0751 on March 26, 2015.

Through consultation with the TREMARCTOS COLOMBIA 3.0 tool, a preliminary evaluation was conducted to determine sensitive zones according to the variables of ecosystem representativeness, the presence of

protected areas, and sensitive fauna and flora. This suggested that there is no overlapping of the road project intervention area with the sensitive species distribution zone. This contrasts with the results obtained during the characterization completed in the project's area of influence, where some species were recorded in the categories of threatened, endemism, or with migratory behavior.

Relative to possible sites for carrying out the compensation, the TREMARCTOS tool shows that there are no areas with national priorities for conservation that are near the area of intervention of the highway project. Moreover, the TREMARCTOS COLOMBIA 3.0 tool shows that the area of intervention of the highway project does not overlap with national, regional, or local protected areas, forest reserves under Law 2, or natural reserves held by civil society. This information coincides with that reported by Regional and National authorities such as CORPONARIÑO, MADS, National Parks, RESNATUR.

Based on the compensation factors for each ecosystem and the area of intervention required, the formula was used to calculate the compensation area according to the activities and the type of ecosystem to intervene. Table 11.5 presents the maximum area to compensate for each type of ecosystem/ biome/ biogeographic district that are subject to intervention for project performance.

Table 11.5 Maximum Area to compensate according to the type of ecosystem

BIOME	BIOGEOGRAPHIC DISTRICT	ECOSYSTEM	EQUIVALENT LAND COVER	TOTAL COMPENSATION Factor	AREA TO INTERVENE (HA)	total AREA TO COMPENSATE (ha)
Middle Andean Orobiome	Norandina SW W Range	Natural forests	Riparian forest	5,75	48,47	278,70
		Secondary vegetation of more than 15 years	High Secondary vegetation	5,75	27,11	155,88
		Secondary vegetation of less than 15 years	Low secondary vegetation	2,875	113,04	324,99
		Grasslands	Open rocky grassland	6	0,83	4,98
High Andean Orobiome	Norandina SW W Range	Natural forests	Dense high Andean forest	8	3,10	24,8
			Riparian forest	8	2,22	17,76
		Secondary vegetation of more than 15 years	High Secondary vegetation	8	21,18	169,44

BIOME	BIOGEOGRAPHIC DISTRICT	ECOSYSTEM	EQUIVALENT LAND COVER	TOTAL COMPENSATION Factor	AREA TO INTERVENE (HA)	total AREA TO COMPENSATE (ha)
		Secondary vegetation of less than 15 years	Low secondary vegetation	4	3,90	15,6

Source: GEOCOL CONSULTORES S.A., 2017.

According to the results obtained using the Ma.F.E. v.2.0 tool in the area of influence of the project and in the hydrographic subzone, sufficient sized areas are not found to comply with the compensation factors by means of conservation activities. It will therefore be necessary to engage in ecological restoration activities until the areas required are attained. In the case of the Alto de los Andes Orobiome ecosystems, a good option is conservation in the SFF Galeras, which has an area available for natural forests and high secondary vegetation, although in this case, criterion h would not be met regarding giving priority to areas in the municipalities where the project is performed.

11.3 MAIN RISKS IDENTIFIED

The risks that were identified during the thorough assessment of each factor that could give rise to a catastrophic situation during the construction of the Rumichaca - Pasto Divided Highway Project, San Juan-Pedregal Segment, are the following: mass removal phenomena, possible volcanic eruption, electric storms and terrorist attacks or possible alteration of public order.