CONTENTS

TABLES

ILLUSTRATIONS

5 DEMAND, USE AND EXPLOITATION OF NATURAL RESOURCES

The execution of projected activities in the construction and assembly stages, and operation of the draft; they will demand the use and / or use of the following natural resources:

- Subsoil and soil: Construction materials, excavations and surface fillings of soil, and disposal of surface waste.

- Surface water: Collection of water, and discharges of domestic wastewater and industrials.

- Flora: Forest exploitation and removal of vegetation cover.

- Atmosphere: Generation of atmospheric emissions and noise.

The detailed information on the supply, demand, use and / or use of these resources is presented below. Input also used to determine environmental management presented later in chapter No. 8 Environmental Management Plan (PMA by its initials in Spanish).

5.1 EXPLOITATION OF CONSTRUCTION MATERIALS

Construction materials will be used for the works of physical locative installations, from of quarries with due mining and environmental authorizations, Table 5-1 contains the contracts of concession and holders of licenses for construction materials near the project area the fish for sands, gravels and clays. Annex 5.1 contains the mining concessions granted in the area of influence of the project for the use of construction materials.

Table 5-1. Concession contracts for the use of stone aggregates in the area of influence of the project.

Concession contract	Headline	Object
LCQ-14081	MIDRAE GOLD S.A.S., NEW GRANADA MINERALS S.A.S, TRIDENT GOLD SAS, TRIDENT GOLD NORTH-EAST ANTIOQUIA S.A.S.	SANDS AND NATURAL GRAVES AND SILICEAS, GOLD MINERALS AND ITS CONCENTRATES
LJ5-080012X	MIDRAE GOLD S.A.S.	SANDS AND NATURAL GRAVES AND SILICEAS
LJ5-08004	MIDRAE GOLD S.A.S, NEW GRANADA MINERALS S.A.S.	SANDS AND NATURAL GRAVES AND SILICEAS
LJQ-080011X	TRIDENT GOLD SAS	SANDS AND NATURAL GRAVES AND SILICEAS, GOLD MINERALS AND ITS CONCENTRATES
IKK-08003X	MINERALS OTU S.A.S. GUSTAVO JOSE KOCH HERRERA. LAS ACACIAS S.O.M..	CLAY. SAND. MINERAL METAL. ROCKS

Concession contract	Headline	Object
LJ5-08004	JOAQUIN GUILLERMO RUIZ MEJIA. MIDRAE GOLD S.A.S. NEW GRANADA MINERALS S.A.S.	SANDS AND NATURAL GRAVES AND SILICEAS.
NGU-16522	CARLOS JOSE QUINTERO ESCOBAR. UNION TEMPORAL ICESGA	SANDS AND NATURAL GRAVES AND SILICEAS

5.1.1 EXCAVATIONS AND / OR SUPERFICIAL FILLS

9.14 ha illustrated in orange (see Illustration 5-1) will be used as cutting material or excavations of soil to make full, leveling and / or adaptation of land.

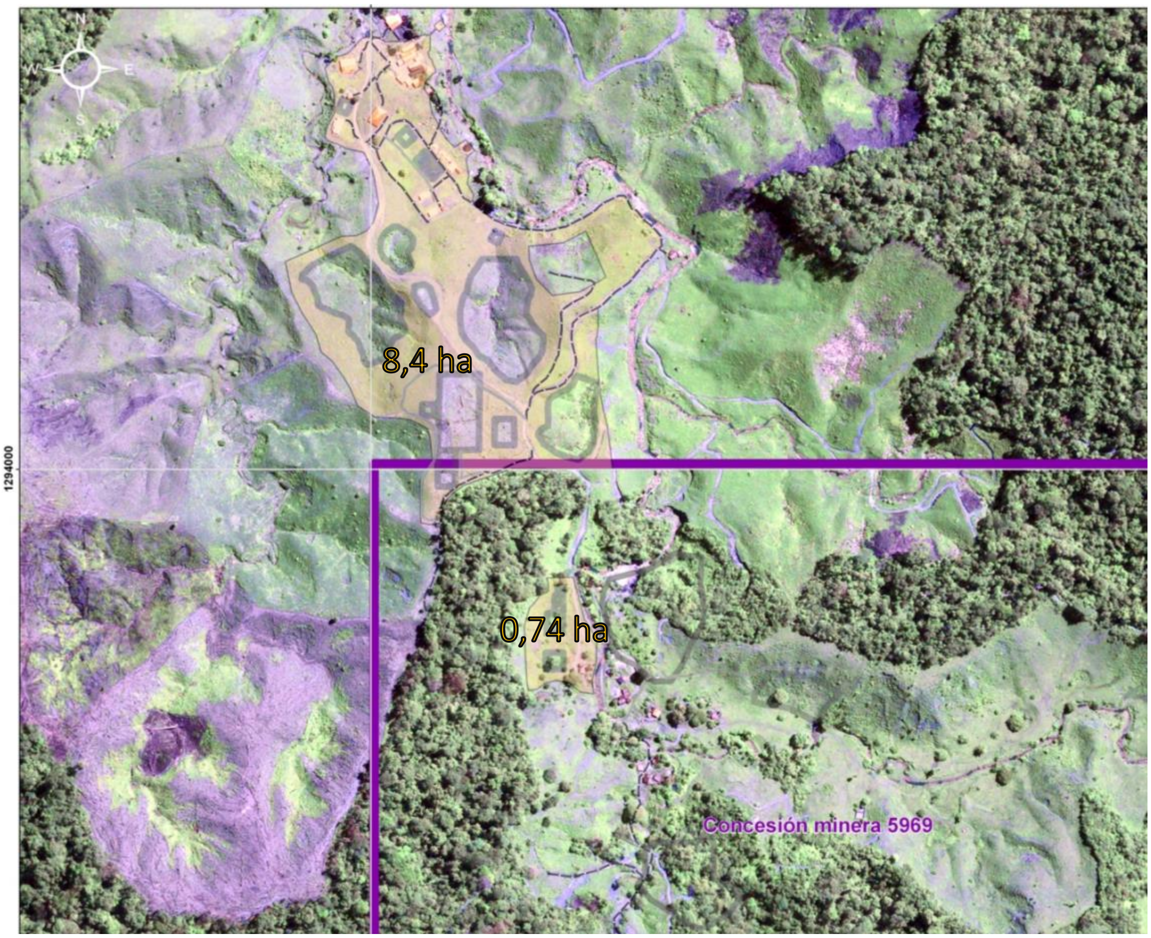

Illustration 5-1. Area for filling, leveling and/or adaptation of land.
Source: INGEX, 2016.

5.1.2 WASTE

In compliance with the regulatory decree 1713 of 2002 in relation to the Integral Management of Residues Solids (hereinafter GIRS) and its amending regulations decree 1505 of 2003, resolution 1045 of 2003, resolution 0477 of 2004 and decree 838 of 2005, establish the processes and activities necessary for proper waste management, guaranteeing strategic planning and efficient administration.

The generation, separation or classification, storage and disposal are detailed below final, according to the type of waste.

5.2 SOLID WASTE

5.2.1 GENERATION

Per capita production (hereinafter PPC) or per capita daily production of solid waste domestic consumption is 0.45 kg / inhabitant / day, corresponding to Colombian municipalities belonging with low complexity (RAS 2000, title F), applicable to the number of workers in this project. In the stage of operation of the project, an approximate generation rate of 34kg / day is estimated from 75 people. While in the construction stage, they will be generated approximately 14kg / day for 30 [jarm2] people.

5.2.2 SEPARATION OR CLASSIFICATION

These will be classified as biodegradable, ordinary and recyclable. They will be generated mainly in the dining room of the camp and other physical locative facilities. The waste on each front of work may vary in characteristics and quantities.

For front of work or physical installation, three (3) containers will be located (See Illustration 5-2) to make the proper separation of waste, classifying them as follows:

Illustration 5-2. Dumps sorting of domestic waste.
Source: ESTRA.

- ✓ Green Dump: Non-recyclable waste, such as sweep and any impregnated or dirty object of a substance, such as food wraps and napkins, that prevent its reuse or recycling.
- ✓ Gray Dump: Recyclables (Paper and cardboard).
- ✓ Blue Dump: Recyclables (Plastics).

On the other hand, the biodegradable waste generated in the kitchen will be temporarily disposed of in another cream-colored container (See Illustration 5-3).

Illustration 5-3. Dumps sorter of organic domestic waste.
Source: ESTRA.

5.2.3 STORAGE AND FINAL PROVISION

This waste will be stored in 55-gallon containers at a covered site, isolated from weathering.

Ordinary waste will be managed with the collection and disposal service company municipal, to perform the correct final disposal in an authorized sanitary landfill.

The classified biodegradable waste will be taken to the composter placed in the camp, in order to supply fertilizer to the green areas, the nursery, internal vegetable gardens and other revegetation activities of the project.

The recycled waste will be sold in the municipal capital of Segovia, La Cruzada or Machuca.

5.2.4 INDUSTRIAL WASTE

These correspond to the category of Special and Hazardous Waste (hereinafter RESPEL), which they can be liquid and / or solid, presented below.

5.2.5 GENERATION OF HAZARDOUS INDUSTRIAL WASTE

Present one or more of the characteristics CRETIB (Corrosive, Reactive, Explosive, Toxic, Flammable and infectious Biological), conformed by:

- Batteries for vehicle.
- Batteries.
- Luminaires - fluorescent lamps.
- Packages, tow, garments and containers impregnated with fats, oils and fuels.
- Laboratory chemical waste.
- Hydraulic motor oil.
- Hydraulic oil for machinery.
- Engine lubricant.
- Oils for vehicular transmission.
- Oils for pump transmission.
- Packaging impregnated with raw materials: HCl, $NaOH$, etc.
- Packings of sodium cyanide tablets ($NaCN$).

5.2.5.1 Generation of special industrial waste

They are characterized by being inert or not to contaminate, but they occupy high volumes as the material sterile.

5.2.5.2 Storage and final disposal

The following is the storage and final disposal form of the main hazardous and special industrial waste, generated by the project.

5.2.5.3 Chemical residues from the laboratory

Residuals of chemicals used in laboratory tests and purged glassware (rinsed) with water prior to washing, will be placed in the same containers of origin or containers of greater capacity according to the chemical affinity. Then they will be stored in zones temporary with spill containment measures; avoiding soil contamination and water bodies. Later they will be delivered to certified companies before the authority environmental, that are providers of the collection, handling, treatment and final disposal service.

5.2.5.4 Cyanide residues

The residues impregnated with cyanide (as packaging), it’s handled according to the international code for the handling of cyanide, for each of the following stages of handling:

- During the importation, cyanide is properly packed in bags and boxes Hermetically sealed and water resistant, using the best industry standards and appropriate for transport to its final destination.
- The boxes will be appropriately marked and labeled with rhombuses, signs, safety sheet and security panels that indicate the danger.
- Upon arrival in Colombia, they will be loaded onto trucks, in the original container in which they arrived and will transport in convoy with permanent supervision and will be escorted by vehicles provided with the equipment of response to primary incidents.
- In the storage place, large corridors are left so that the forklift can circulate internally comfortably, the unloading and storage of boxes containing cyanide sodium will only be carried out by trained personnel.
- The boxes will be placed in a specially conditioned tank for this purpose, following all internationally accepted safety and control standards.
- The floor of the building is made of reinforced concrete. This will help keep the bags free of dust, mud or other foreign material, so that they can be inspected before being transported to ensure that there is no sodium cyanide on the outside of the box. The concrete floor in addition to facilitating the detection of spills, it will facilitate cleaning procedures in case of a rupture of the bag or box and to prevent soil contamination with cyanide.
- When the product arrives at the mine, it is unloaded from the containers using a forklift mechanized or manual.
- In the warehouse the boxes will be stacked in a maximum of three, paying close attention to the alignment from the same.
- Operators will move the boxes containing sodium cyanide to the preparation area and they will be placed in a place where the hoisting crane can reach them. It should be verified that the pH of the solution is equal to 12.
- At the end of the task, the preparation area of sodium cyanide with sterile solution will be cleaned.

- All empty cyanide bags or boxes at the facility will be collected by the company conveyor of the compound and deposited in a safe place.

The configuration of the deposits and / or tailings was made based on the amounts of tailings and sterile provided (Table 1). The deposits were designed considering final slopes of 3H: 1V.

Table 5-2. Annual configuration of tailings deposits.

BOTTLE	HEIGHT (m)	VOLUME (m^3)	USEFUL LIFE (Years)	DESCRIPTION
1	14	70,439	19	Dam of solids for Cyanidation 2
2	3,2	10,300	3	Dam of solids for Cyanidation
3	15	15,556		Dump
4	12	91,860	3	Dam of solids for Floatation

Source: INGEX, 2016

The approximate configurations of the tailings deposit presented in the previous section do not they discern between the tailings and the sterile ones of the mine. The expected method of deposit is for transport in dump trucks from the filtering and placement area at different levels of compaction depending on the moisture content obtained during the filtration process. The Illustration 5-4 to Illustration 5-7 show the preliminary recommendations for distribution and compaction of tailings.

The slope area below the deposit (indicated by the number 1 in the illustration) extends vertically down from the crest of the slope requires the highest degree of compaction possible so that a containment structure is created to resist static and dynamic forces within of the tailings deposit. A second area (indicated by number 2 in the illustration) will be formed with tailings that have been sufficiently filtered but do not require the same level of compaction, and finally, a third area (indicated by number 3 in the illustration) will be used to store tailings that did not reach the moisture content specified with compaction minimal.

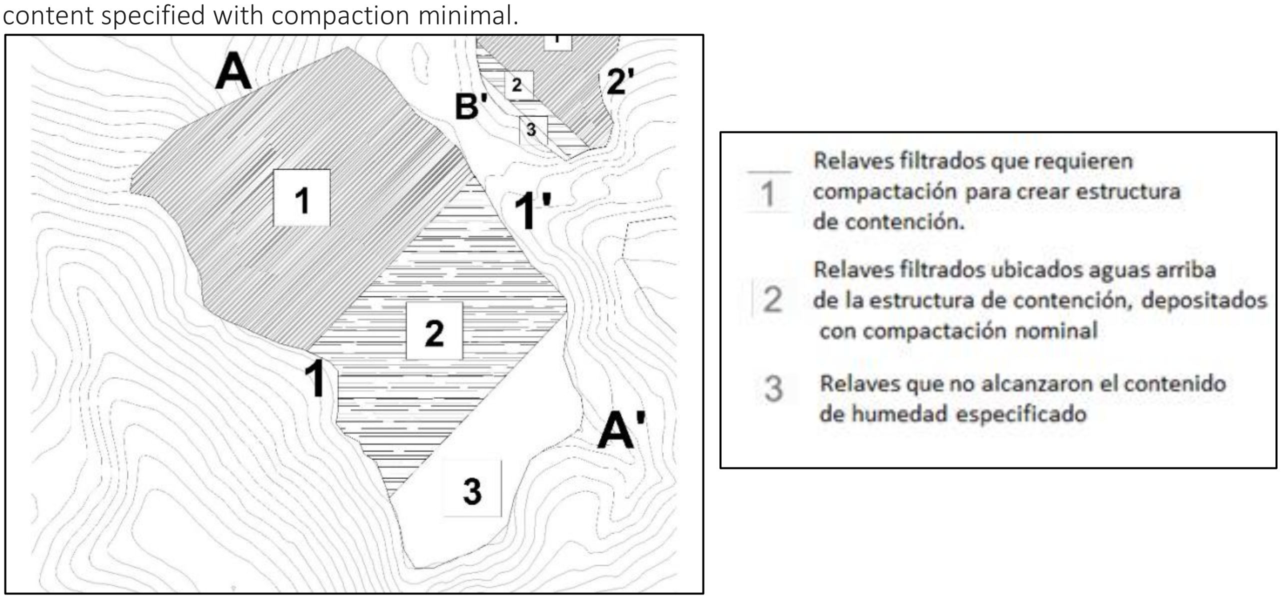

Illustration 5-4. Recommended compaction areas for tailings deposit No. 1.
Source: INGEX, 2016

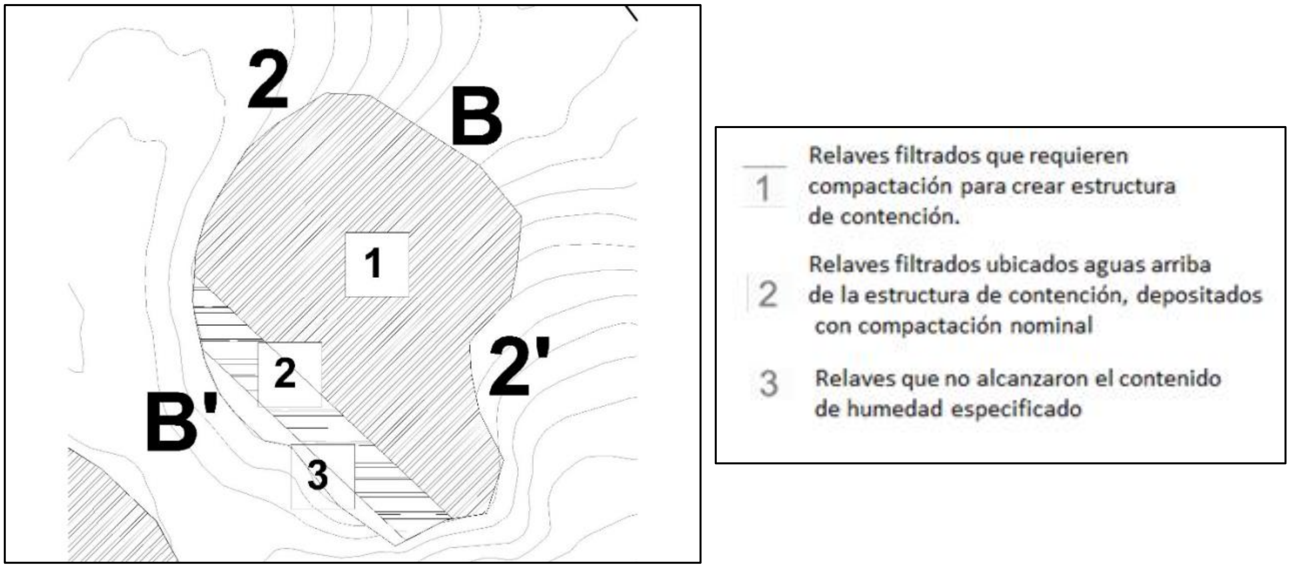

Illustration 5-5. Recommended compaction areas for tailings deposit No. 2.
Source: INGEX, 2016

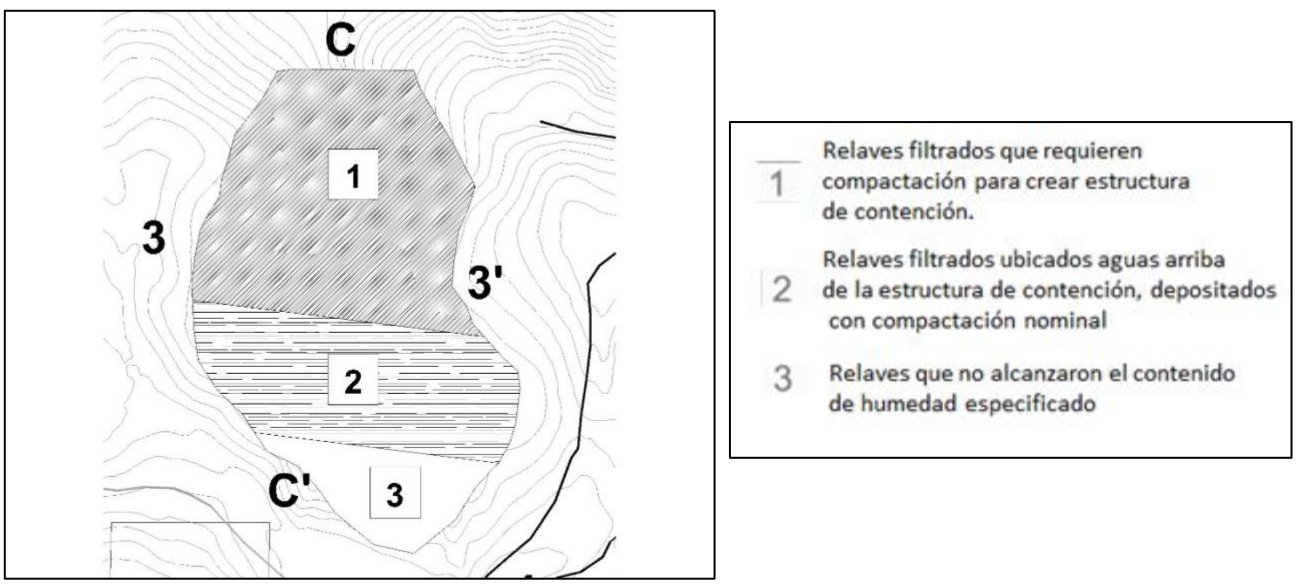

Illustration 5-6. Recommended compaction areas for tailings deposit No. 3.
Source: INGEX, 2016

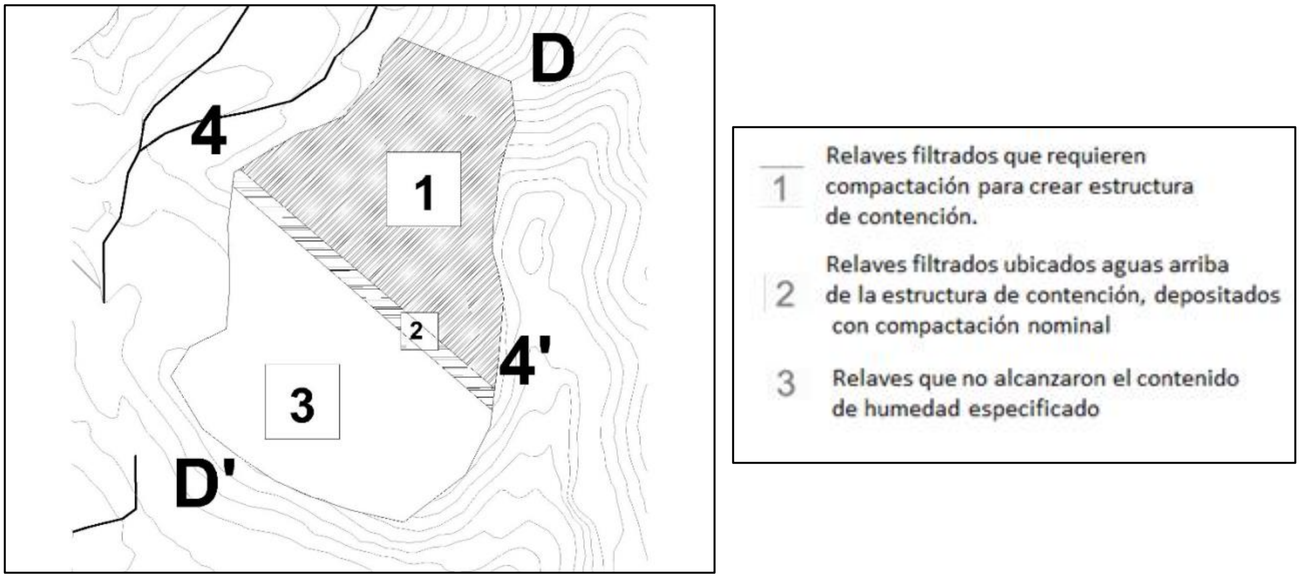

Illustration 5-7. Recommended compaction areas for tailings deposit No. 4.
Source: INGEX, 2016

The construction of a start dam will allow the tailings to be compacted and will improve the stability conditions of the tailings deposit and / or sterile, especially during the first years of construction, in which the behavior of the in-situ soil is controlled by the conditions not drained and there is potential to generate excess pore pressure. The dike proposed start for the four dumps has 3 m high, 3 m crest and is composed by crushed rock from the area (Illustration 5-8).

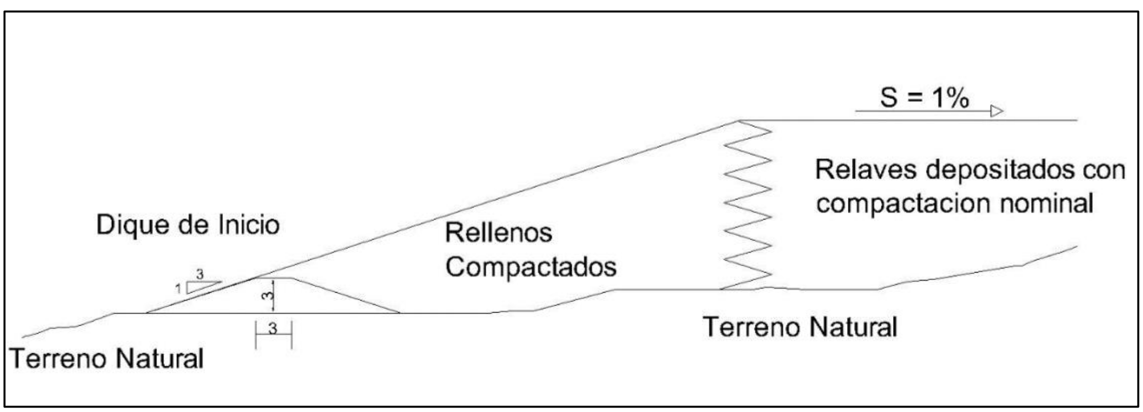

Illustration 5-8. Start dike.
Source: INGEX, 2016

The slope downstream of the tailings and / or sterile will be covered to minimize erosion, using rock from the mine or a geotextile before compaction of saprolite or residual soil as part of the closing activities. In addition, drains will be built in castling along the natural drainages located in the footprint of the deposit, which will guarantee an effective drainage of infiltrated water.

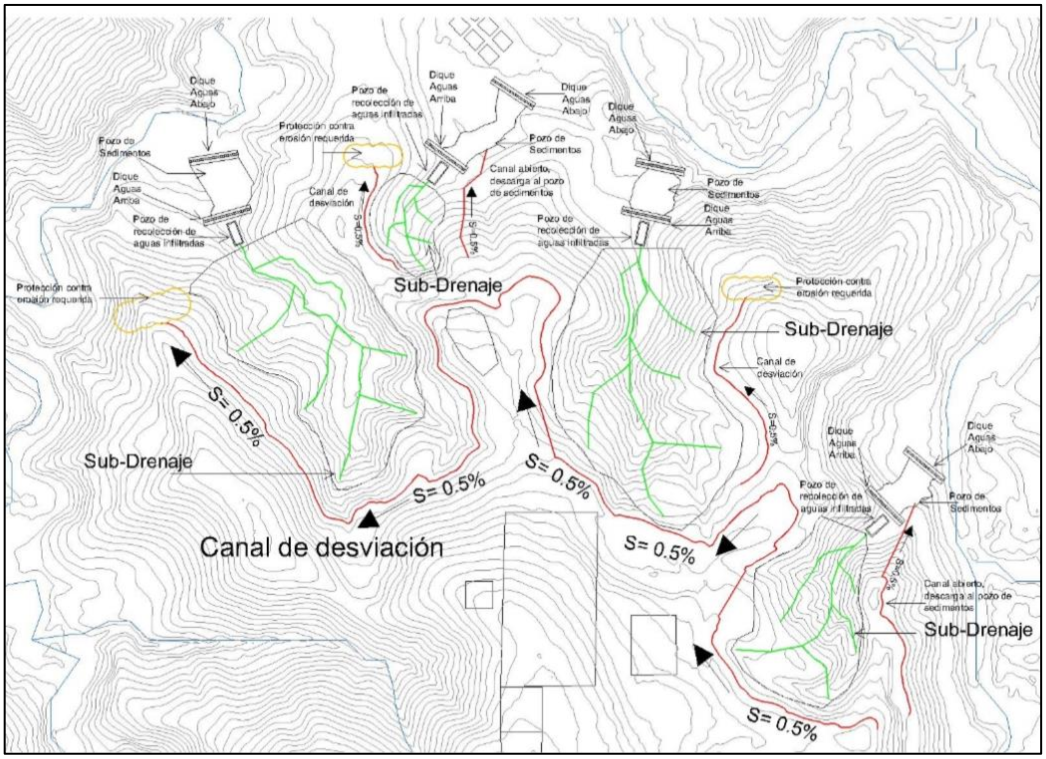

Illustration 5-9. Water management of tailings and/or sterile tanks.
Source: INGEX, 2016

The tailings will be deposited maintaining a slope of 1% upstream on the surface end to lead the runoff and direct precipitation to the side upstream of the deposit, in this way the compacted tailings located near the slope downstream will maintain conditions not saturated. In addition, the final surface of the deposit will be inclined towards the natural terrain to that the distance that the water of run-off must travel is smaller.

- **Stability analysis of tailings deposit.**

The mechanical properties of the filtered tailings are not available during the preparation of this document; therefore, the values of resistance were assumed. The following tables indicate the values used for these analyzes:

Table 5-3. Soil mechanics properties of tailings.

PROPERTIES OF RELAYS	
Friction angle	30°
Cohesion	0 kPa
Unit weight	17 KN/m^3

Source: INGEX, 2016.

Table 5-4. Soil mechanics properties of residual soil.

RESIDUAL SOIL PROPERTIES (Based on results of laboratory tests)			
Deposits	Angle of friction (°)	Cohesion (KPa)	Unit weight (KN/ m^3)
N°1	22,06	25	17,15
N°2	24,43	100	17,15
N°3	21,96	400	17,24
N°4	20,80	12,50	16,76

Source: INGEX, 2016.

Table 5-5. Soil mechanics properties of the saprolite.

PROPERTIES OF SAPROLITE (Based on results of laboratory tests)			
Deposits	Angle of friction (°)	Cohesion (KPa)	Unit weight (KN/ m^3)
N°1	22,03	100	17,15
N°3	21,06	200	17,24
N°4	20,53	12,50	16,76

Source: INGEX, 2016.

The residual soil thickness, the saprolite, the depth of the rock and the water table were defined as from the direct and indirect tests that were carried out in the field. These thicknesses were used to estimate an approximate soil profile for the stability analyzes presented in this document.

Considering the slope change of 3H: 1V, a safety factor of 1.7 to 1.5 was obtained under static conditions, and 1.28 under pseudo-static conditions using an acceleration coefficient horizontal equivalent of 0.11g, using the methods of Bishop Simplified, Janbu Simplified and Spencer (Table 5-6). These safety factors meet the minimum criteria used in projects of this magnitude.

Table 5-6. Values of the safety factors for each of the evaluated conditions.

Conditions	Static			Pseudo-static		
Methods	Spencer	Janbú	Bishop simplified	Spencer	Janbú	Bishop simplified
Profile of AA	1,776	1,777	1.778	1.282	1.281	1.280
Profile of BB	1,777	1,777	1,777	1,280	1,280	1,280
Profile of CC	1,777	1,777	1,777	1,280	1,280	1,280
Profile of DD	1,653	1,585	1,657	1,280	1,280	1,280

Source: INGEX, 2016.

The following illustrations indicate the static and pseudo-static analysis of tailings deposits of the El Pescado project.

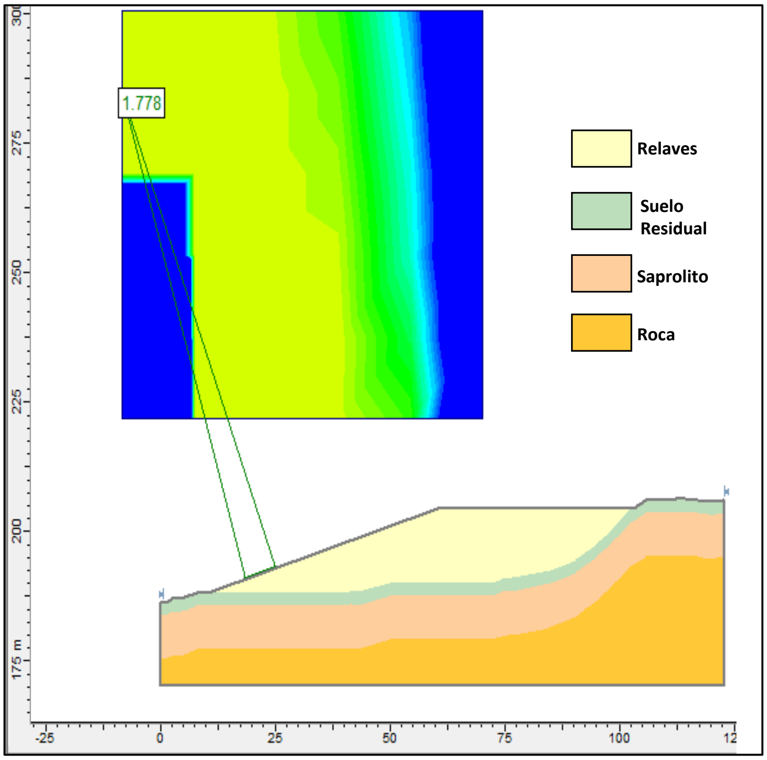

Illustration 5-10. Results of stability analysis under static conditions, Section A-A.
Source: INGEX, 2016.

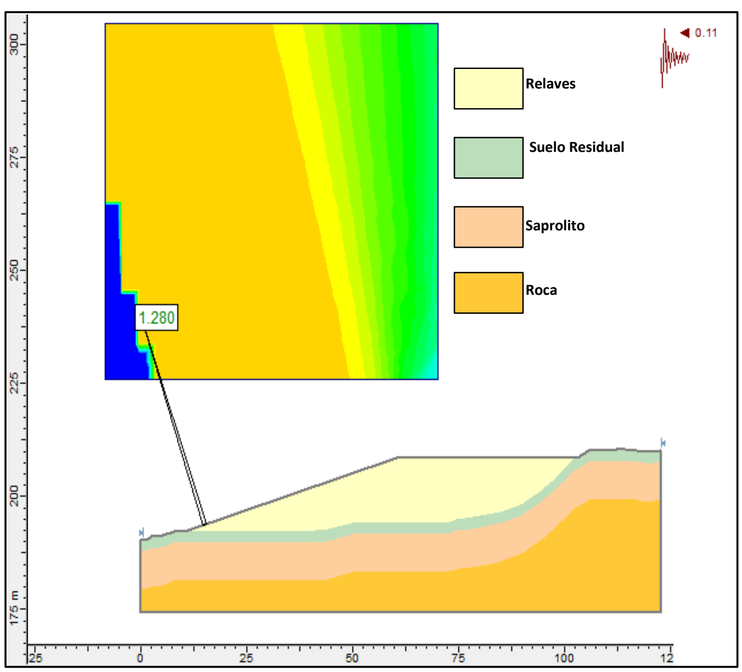

Illustration 5-11. Results of stability analysis under pseudo-static conditions, Section A-A.
Source: INGEX, 2016.

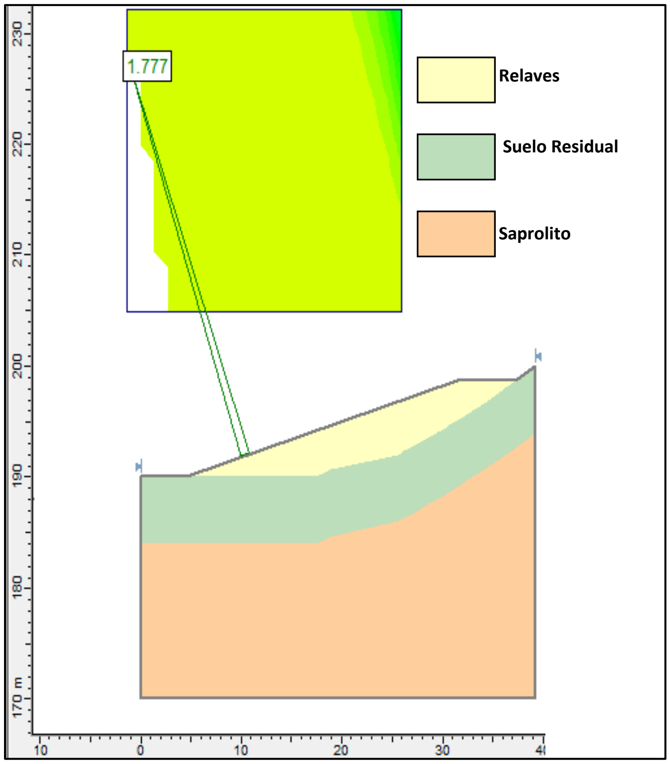

Illustration 5-12. Results of stability analysis under static conditions, Section B-B.
Source: INGEX, 2016.

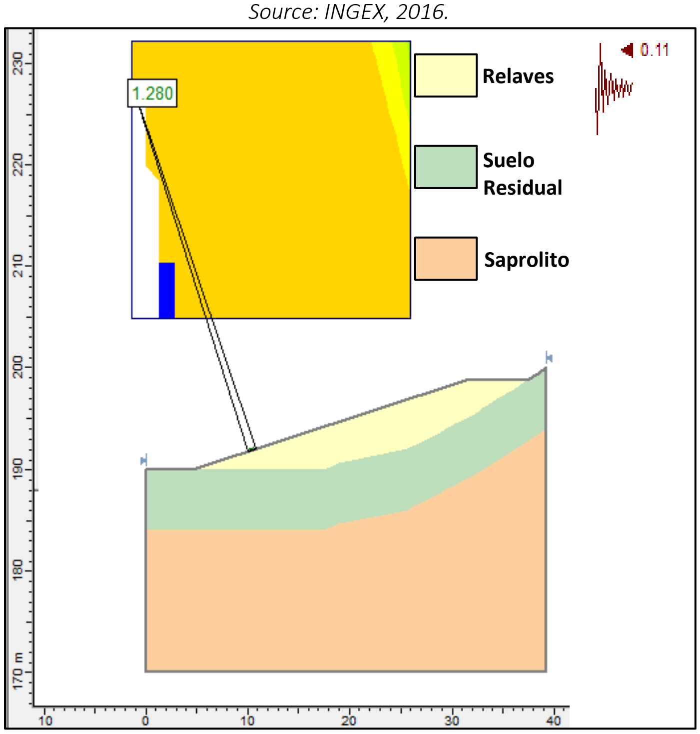

Illustration 5-13. Results of stability analysis under pseudo-static conditions, Section B-B.
Source: INGEX, 2016.

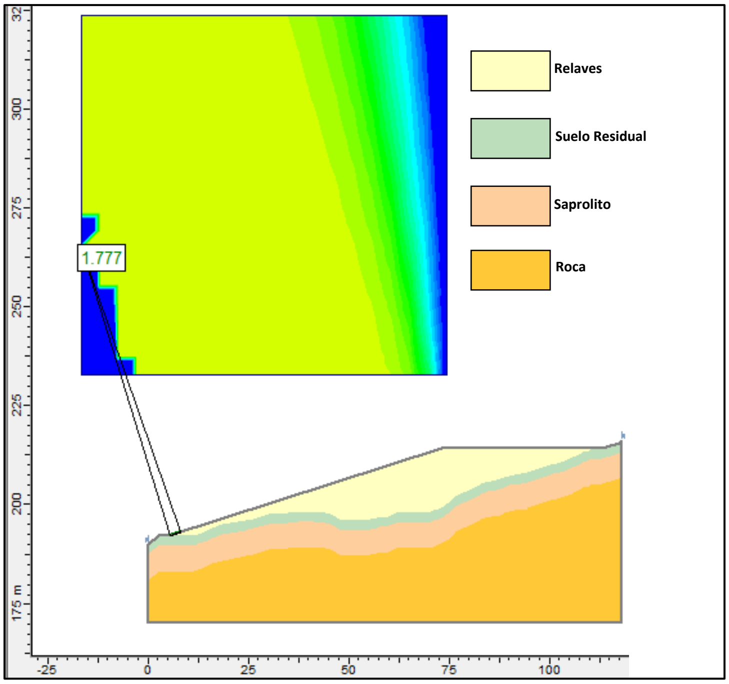

Illustration 5-14. Results of stability analysis under static conditions, Section C-C.
Source: INGEX, 2016.

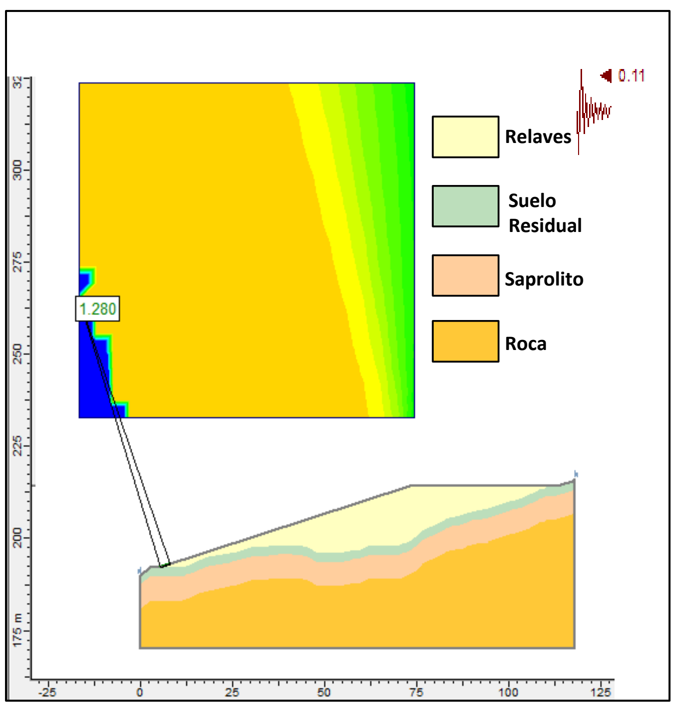

Illustration 5-15. Results of stability analysis under pseudo-static conditions, Section C-C.
Source: INGEX, 2016.

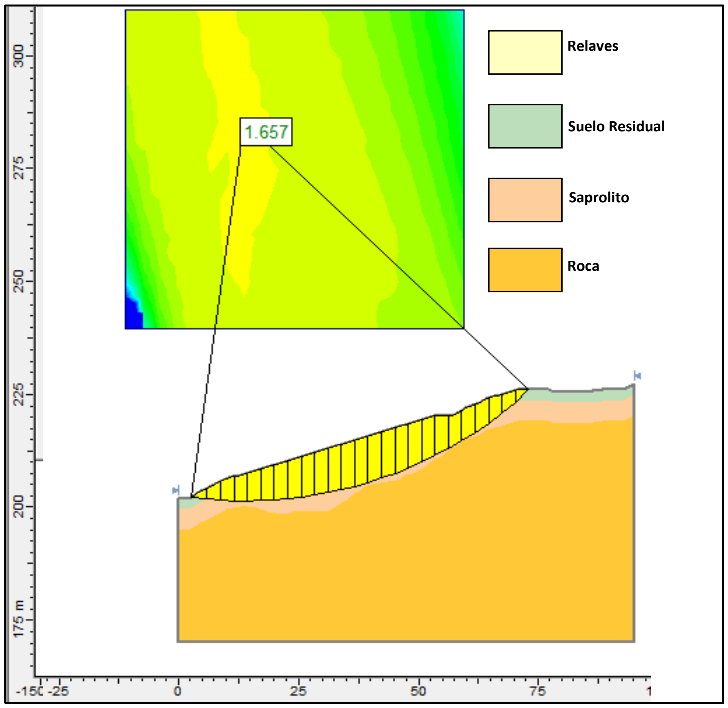

Illustration 5-16. Results of stability analysis under static conditions, Section D-D.
Source: INGEX, 2016.

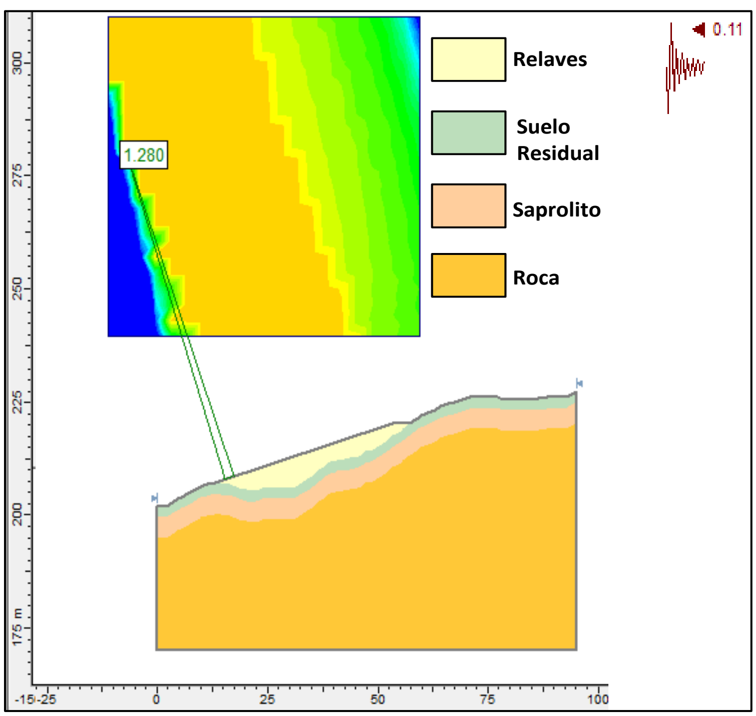

Illustration 5-17. Results of stability analysis under pseudo-static conditions, Section D-D.
Source: INGEX, 2016.

In the same way, the methods for the respective maintenance of the sediments generated by the tailings are described below:

5.2.5.4.1.1 Sediments of flotation tailings

The flotation tailings will carry a dike or dam for hydrostatic containment and a geotextile waterproof that prevents liquid infiltration to the ground and contamination of water sources. Guaranteeing a closed and controlled circuit, where there is no danger of external contamination.

The flotation tailings this, will always operate except that it is required to rehabilitate by accumulation of sediments that reach the maximum geotechnical limits. This through the temporary replacement with the west flotation tailor, in order not to suspend the operations of the benefit plant.

Wastewater treatment will be treated as the sub numeral will be presented later corresponding to the water resource.

5.2.5.4.1.2 Cyanidation tailings sediments

The cyanidation reactor will also carry a dike or dam for hydrostatic containment and a waterproof geotextile that prevents liquid infiltration to the ground and contamination of water sources. Guaranteeing a closed and controlled circuit, where there is no danger of external contamination.

When accumulation of sediments that reach the maximum limits also occurs geotechnical, will be rehabilitated through the removal, transport and final disposal generated by TOUCHSTONE.

Wastewater treatment will be treated as the sub numeral will be presented later corresponding to the water resource.

5.2.5.4.1.3 Other hazardous waste

The remaining hazardous waste will also be classified and grouped in the same containers of origin in order not to contaminate others and will be stored in temporary zones with the measures spill containment; avoiding contamination of soil and bodies of water. Later will be delivered to certified companies before the environmental authority, which are providers of collection service, handling, treatment and final disposal of these.

5.2.5.4.2 Sterile

According to the method of underground extraction of cut and fill, the sterile material will be returned to the underground chambers that were developed to reach the deposit under conditions suitable geotechnical Therefore, no sterile material will be deposited on the surface. Annually tons will be returned. However, this material may be used for roads and other uses.

5.3 DUMPING

Below is the demand, use and/or use of the water resource, excluding the groundwater, because it is not possible to take advantage of or intervene due to the absence of static or null presence, according to the hydrogeological characterization of the LBSA. Annex 5.3 shows the dumping simulation of the study area.

According to the water requirements of the project, it is required to request one (1) water concession and five (5) discharge permits (See Table 5-7, Table 5-8 and Illustration 5-18), included in this EL on request, through the respective forms completed in Annex 5.1

Table 5-7. Location of catchment or intake of the project

TYPE OF USE	FLOW (m^3/Day)	WATER SUPPLY AVAILABLE FOR NEW ACTIVITIES, PRESERVING ECOLOGICAL FLOW (m^3/day)	SOURCE OF WATER	COORDINATES		HEIGTH (m.a.s.l)
				EAST	NORTH	
Domestic e industrial	DOMESTIC *Staff demand of the personal: 20 m^3/day. *Demand for others uses: 0,3 m^3/day. *Laboratory Demand for metallurgy: 3 m^3/day. Subtotal: 23,3 m^3/day. INDUSTRIAL BENEFIT AREA Subtotal: 2050 m^3/day INDUSTRIAL MINING AREA Subtotal: 24m^3/day **TOTAL: 2097,3 m^3/day**	3157	SN #8 more SN#5	930.296	1’294.151	192

Source: INGEX, 2016.

Table 5-8. Shedding Location of the project.

SOURCE OF DUMPING	TYPO OF USE	FLOW (m^3/day)	SOURCE OF WATER	COORDENADAS		HEIGTH (m.a.s.l)
				EAST	NORTH	
Shedding tails No. 1 of flotation	Industrial	200	SN#9	930.189	1’294.290	180
Shedding tails No. 2 de cyanidation		150	SN #8 more SN#5	930.331	1’294.208	188
Shedding tails No. 3 de flotation		200	SN#2	929.870	1’294.264	186
Subtotal industrial		**550**				
Shedding of camp together with laboratory waste water	Domestic	16	Downstream SN#2	930.058	1.294.524	174
Dumping of other hydro-sanitary units		4		929.954	1’294.480	178
Subtotal domestic		**20**				

Source: INGEX, 2016.

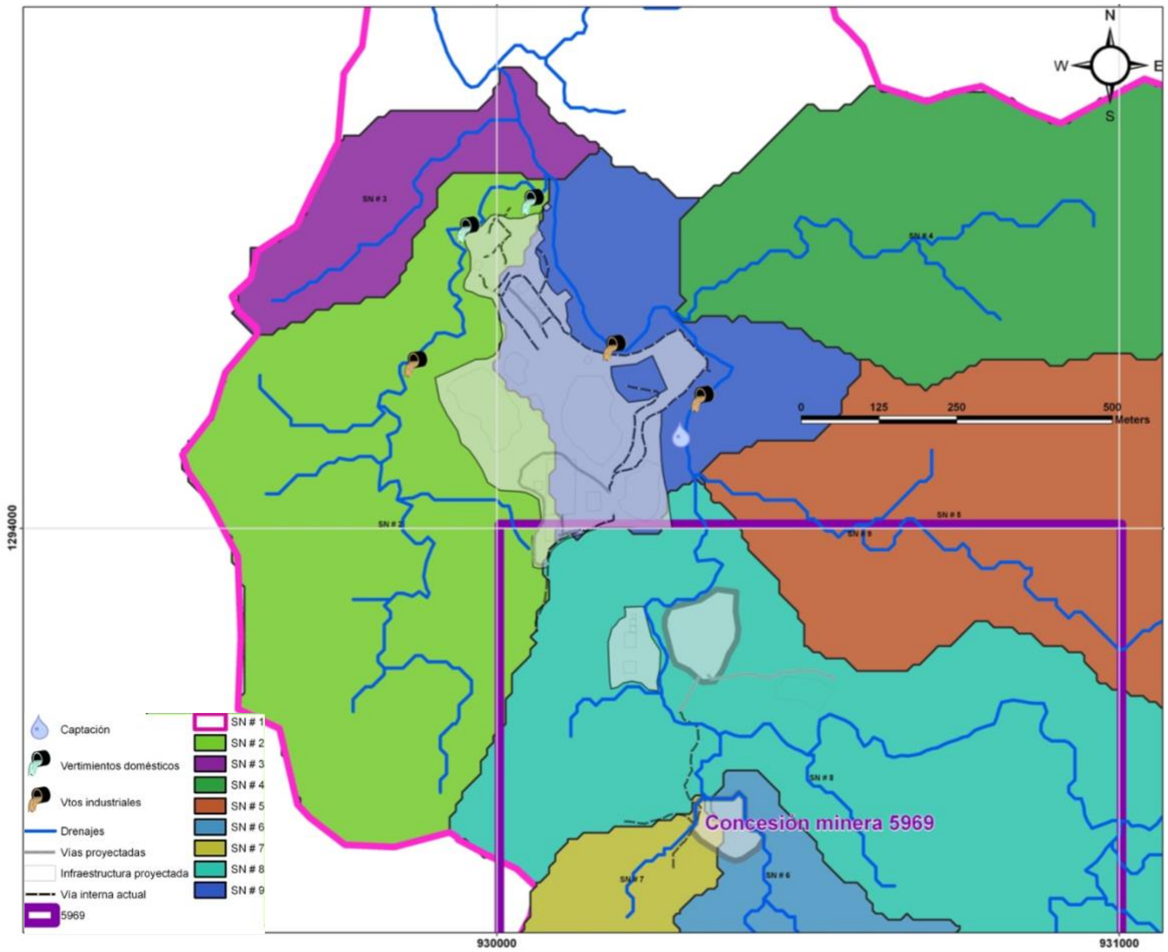

Illustration 5-18. Location of catchment and dumping of the project.
Source: INGEX, 2016.

In chapter 4.1.5 "Hydrology", the map of the main channels is included of micro-basins that make up the no-name basin SN # 1 (see Illustration 4.1-117).

In agreement with the information presented in the item of uses and users corresponding to the chapter of hydrology, the users are very few and these are located upstream of the project or the basin, therefore, they cannot be affected in terms of availability or quantity by capturing the project, and not in quality due to dumping (See Illustration 5-18).

The risk management plan of the dumping, will be presented within the chapter No. 10 "Plan of Contingency “because it covers all possible risks, both natural and anthropic.

Next, in Illustration 5-19, the supply flow diagram (tributaries, water inputs, demand or concessions) and discharges (effluents, discharges or outlets of water) by project area, based on the following items.

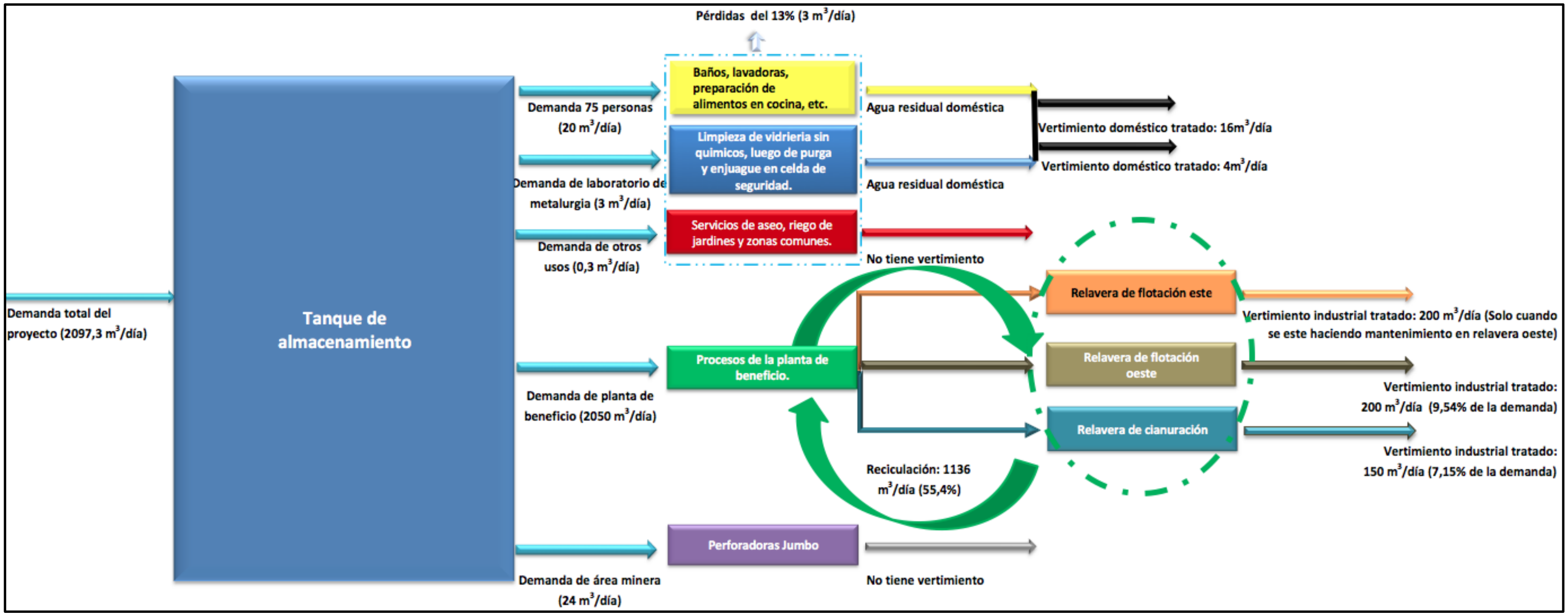

Illustration 5-19. Flow diagram of supply and dumping of the project.
Source: INGEX, 2016.

5.3.1 DOMESTIC WATER SUPPLY AND WATER DISPOSAL

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The flow diagram of domestic supply and discharges, is synthesized in the Illustration 5-20 and specified below.

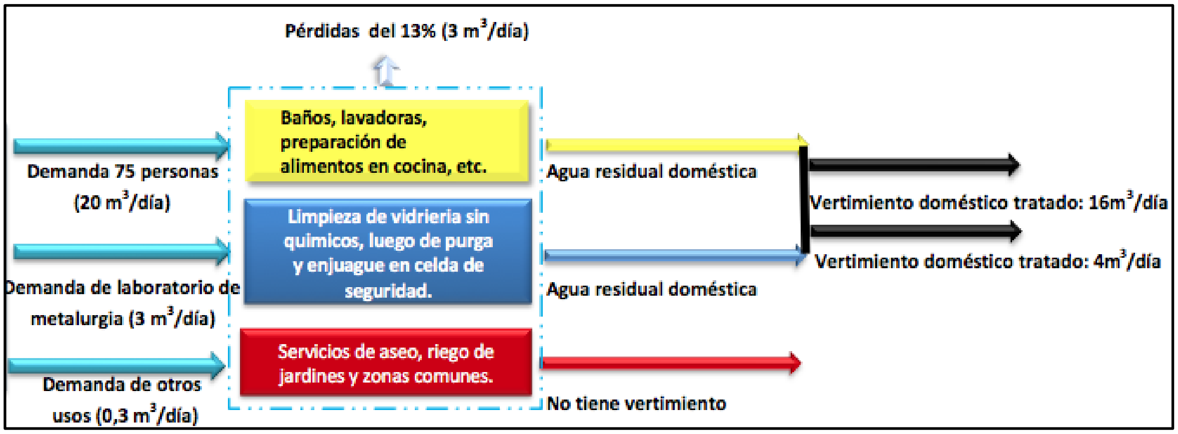


Illustration 5-20. Diagram of flow of supply and domestic discharges.
Source: INGEX, 2016.

5.3.1.1 Domestic water supply

Drinking water for the consumption of personnel, will be provided by purchasing large bottles of water in the region and transported to the camp by the company.

However, the use of this resource is also required for activities of a domestic nature. Amounting to the equivalent of the sum of demands of people between permanent and non-permanent (Value of demand for more personnel in the operation stage) that the units will use hydro-sanitary (bathrooms, washing machines and preparation of food in the kitchen) of the camp, bathrooms of profit and mining areas; plus the demand for other uses (Cleaning services, garden irrigation and other) and the demand of the laboratory, as presented in the following equation, argued in the following sub numerals.

$$\text{Demand}_{\text{camp}} = \text{Personal}_{\text{demand}} + \text{Demand}_{\text{others uses}} + \text{Laboratory}_{\text{demand}}$$

$$\text{Camp}_{\text{demand}} = 20m^3/day + 0,3m^3/day + 3m^3/day = \mathbf{23,3\ m^3/day}$$

Staff demand

Water consumption or demand for project personnel was calculated in accordance with Title B of the RAS 2000, who defines the QMH corresponding to the temporary peaks, in order to guarantee the water supply. In accordance with the following considerations of the level of complexity of the system, the net endowment, the correction for climate and losses.

The demand for water for the hydro-sanitary units, food, personal hygiene and toilet physical facilities, required by the staff, is first conditioned under the considerations of level of complexity of the system. Where the RAS 2000 establishes minimum values and maximums in the net allocation (See Table 5-9).

Table 5-9. Net allocation according to the level of complexity of the system.

LEVEL OF COMPLEXITY OF THE SYSTEM	MINIMUM NET PROVISION (L/hab·day)	MAXIMUM NET PROVISION (L/hab·day)
Low	100	150
Medium	120	175
Medium high	130	-
High	150	-

Source: RAS, 2000.

The level of complexity is low for this water system, because the number of inhabitants is 75, much lower value than that corresponding to an aqueduct of thousands of people as in municipal areas therefore the net daily allowance corresponds to the minimum, that is, 100 L / day (Low level of complexity of the system).

With regard to the net allocation chosen, the numeral B.2.4.4.2 of the RAS was corrected according to climate. 2000, by percentages of proportionality for the effects of climate on the net allocation or in the water supply. Taking into account the level of complexity and the warm climate of the basin, the climate correction is + 15% (See Table 5-10).

Table 5-10. Effect of climate on the net endowment.

COMPLEXITY LEVEL OF THE SYSTEM	WARM WEATHER (MORE DE 28°C)	TEMPERED CLIMATE 20°C and 28°C)	COLD CLIMATE (LOW OF 20°C)
Low	+ 15 %	+ 10%	No Weather Correction allowed
Medium	+ 15 %	+ 10 %	
Medium high	+ 20 %	+ 15 %	
High	+ 20 %	+ 15 %	

Source: RAS, 2000.

Taking into account the previous table, the value of the net allocation corrected by climate was calculated as follows:

$$\text{Net provision}_{\text{Corrected}} = \text{Dotation}_{\text{Net}} * (1 + \text{Correction}_{\text{weather}})$$
$$\text{Net provision}_{\text{Corrected}} = 100 \text{ L/hab·day} * 1.15 = 115 \text{ L/hab·day}$$
$$\text{Net provision}_{\text{Corrected}} = 115 \text{ L/hab·day}$$

Continuing with the numeral B.2.6 del RAS 2000, the gross endowment is equivalent to:

$$D_{\text{gross}} = D \text{ net}_{\text{corrected}} / (1 - \%p)$$

Being:
D gross = Gross endowment
Net D corrected = Net provision corrected
%p = Percentage of losses.

According to the above, a percentage of losses of 10% is established, due to the system of adduction and individual driving that transports the flow.

$$D_{\text{gross}} = 115 \text{ L/hab·day} / (1 - 0.1) = 127.8 \text{ L/hab·day}$$
$$D_{\text{gross}} = 127.8 \text{ L/hab·day}$$

According to the value of the gross endowment and personnel, the average daily flow according to the numeral B.2.7.1 of the RAS 2000, is equal to:

$$Q_{md}= P^* \ d_{\ gross}/ \ 86400$$

Being:
Q_{md} = Average daily flow
P = Population
$D_{\ Gross}$= Gross endowment

Then the result of the average daily flow of the project personnel is:

$$Q_{md}= (75^*127.8. \ L/hab\text{-}day)/86400 \ s= 0.11 \ L/s$$
$$Q_{md}= 0.11L/s$$

Finally, to determine the water demand of the personnel or domestic consumption, we have counted the daily maximum consumption coefficient (K1) (See Table 5-11) and the consumption coefficient maximum time (K2) (See Table 5-12). Where K1 is obtained from the relationship between the highest consumption daily and average daily consumption, while K2 is the ratio between the maximum hourly consumption with the maximum daily consumption (RAS, 2000).

Table 5-11. Maximum daily consumption coefficient, k1, according to the Level of Complexity of the System.

LEVEL OF COMPLEXITY	K1
Low	1,30
Medium	1,30
Medium High	1,20
High	1,20

Source: RAS, 2000.

Table 5-12. Maximum hourly consumption coefficient, k2, according to the level of complexity of the system and the type of network of distribution.

LEVEL OF COMPLEXITY	LOWER DISTRIBUTION NETWORK	SECONDARY NETWORK	RED MATRIX
Low	1,60	--	--
Medium	1,60	1,50	--
Medium High	1,50	1,45	1,40
High	1,50	1,45	1,40

Source: RAS, 2000.

With respect to the aforementioned tables, human consumption or domestic demand of the camp staff, is equivalent to:

$$D_{\ personal}= k1^* \ k2 \ ^*D_{\ total \ gross}$$
$$D_{\ personal} = 1.3^* \ 1.6^* \ 0.11 \ L/s$$
$$D_{\ personal} = 0.23 \ L/s \approx 20 \ m^3/day.$$

Demand for other uses

Based on the previous result, it can be affirmed that in the RAS, numeral B.2.3.5, for the demand average of other uses establishes that the consumption for public use used in the toilet services, irrigation of gardens and public parks, public fountains and others, will be estimated between 0 and 3% of the average daily domestic consumption, as long as there is no data available. For this reason, took a percentage of 3% of the average daily allowance.

Average demand for other uses = Qmd * 3%
Average demand for other uses = 0.11 L/s * 3% = 0.003 L/s ≈ 0,3 m^3/day.

The demand for water for other uses of 0,3 m^3/day, does not imply a shedding because it will be outdoors, occasionally absorbed in the irrigation of gardens, toilet services and others.

Laboratory demand for metallurgy

For the metallurgy laboratory, a flow rate of 3 m^3/day was estimated, in order to be used for the glass cleaning without chemicals or reagents, after the disposal of chemical substances residuals, surpluses and purges (rinse) with water before washing, in the respective safety cell with periodic provision by an authorized company. Therefore, the effluent will pass to the STARD domestic without chemical substances, presenting below.

5.3.1.2 Discharges of water from the camp

After the 75 people and the laboratory have used the 20 m^3/day and 3m^3/day, respectively. A total of 20 m^3/day will be generated / day (After a 13% loss for evapotranspiration) of water with organic matter (black water) mainly in the kitchen and hydro-sanitary units of the different work areas (Benefit, camp and mining), and the soapy water (gray water) with significant amounts of nutrients such as phosphorus, organic matter, fats and bacteria. These are mixed because they are biodegradable, and then enter in two (2) Domestic Wastewater Treatment Systems (hereinafter STARD) conformed by grease traps, a system of filtering sheets with aquatic plant (Phragmites Communis) 288 m^2 (approximately 17m x 17m) for the wastewater of the camp and laboratory (16 m^3/day = 80%), and another of 72 m^2 (approximately 8.5m x 8.5m) for wastewater from bathrooms in the area mining and profit (4 m^3/day = 20%) (See Illustration 5-21 e Table 5-13).

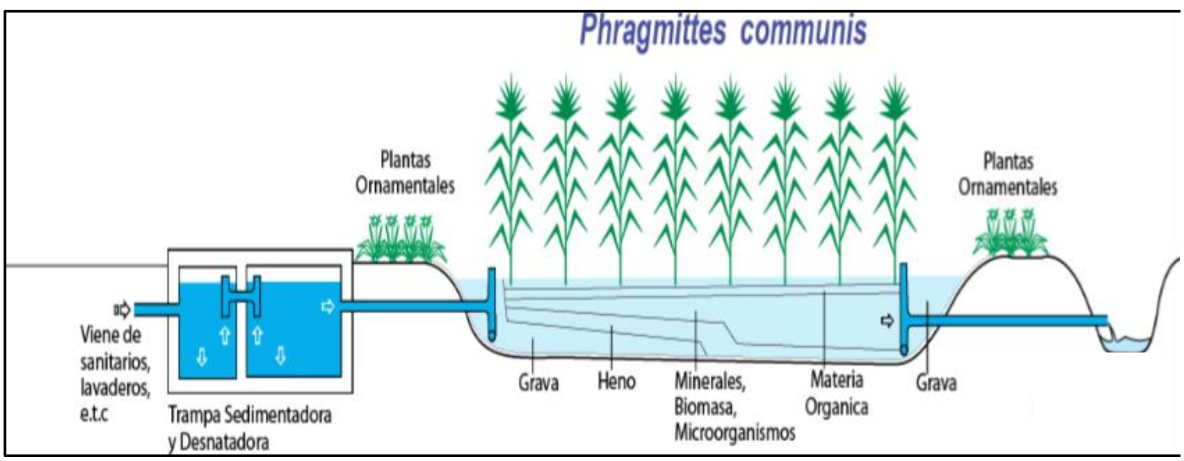


Illustration 5-21. STARD - Filtering sheets with aquatic plant.
Source: Transform Ecoskandia - Scandroots International Group, 2012.

Table 5-13. Design variables of STARDs.

FLOW (m^3/day)	TOTAL AREA (m^2)	STARD DIMENSIONS	No. MODULES
4	72	8,5m x 8,5m	3
16	288	17m x 17m	12

Source: Transform Ecoskandia - Scandroots International Group, 2012.

Subsequently, treated water with a removal efficiency greater than 95% will be discharged downstream of SN # 2, at coordinates 930.058E - 1'294.524N and 929.954E - 1'294.480N (See Illustration 5-18).

The fat traps are responsible for separating these floating films generated mainly by the kitchen and the washing machines and deliver to the laminated filtration systems with plant aquatic.

This natural system of filter sheets can be easily integrated into the natural landscape and does not produce bad smells. It consists of a pool with a depth of 1.5 m whose bottom is coated with a polyethylene membrane to prevent soil contamination. In the pool are installed layers of different composition with certain functions in water filtration: gravel as a first biological filter; hay to increase capillarity; biomass that includes among others, humus and rice husk to promote organic decomposition; black earth mixed with some minerals.

On these layers are planted plants (Phragmites Communis) whose roots have been previously treated with aerobic and anaerobic bacteria cultures. Aerobics survive thanks to the property of this plant to release large volumes of oxygen to its roots. Both types of bacteria digest a large amount of water waste. The water is collected by pipe at the end of the pool and can be reused, for example, for watering gardens and the pool can be decorated with ornamental plants, does not require the addition of chemicals, nor use electrical energy. For being natural process, its duration is unlimited, part of the maintenance consists of extracting the sludge from the sedimentation tank once a year and arrange them as fertilizers in the root area.

The principle of this technology is to activate the capacity of the microbiological processes that stimulate the separation of contaminating components in specific water situations residuals this is possible thanks to the special characteristics of wetland plants such like reeds and rushes that transfer substantial amounts of atmospheric oxygen through their root system, promoting an extraordinary amount and diversity of species of microorganisms that thrive in the soil around their roots. The treatment system with the plants are self-sufficient with an artificial ecosystem of plants. Using combinations particular of plants, floors and hydraulic flow systems to optimize chemical processes and microbiological present in the root zone. The separation of contaminants and treatment of contaminated wastewater are achieved through controlled filtration of the tributaries contaminated through the root zone of plants, these native microorganisms or inoculated (bacteria and fungi) metabolize contaminants found in the tributary turning them into innocuous final products. In this process, contaminants are bio transformed because generally the microorganisms can use them for their own growth as a source of carbon and energy and in case they are not able to grow from of them, they can continue to transform them if they are provided with an alternative growth substrate or co-substrate.

For the growth of microorganisms is necessary the presence of donors and acceptors of electrons, a source of carbon and nutrients (N, P, K, S, Mg, Ca, Mn, Fe, Zn, Cu and trace elements). The most basic process of microbial metabolism is the transfer of electrons from a donor substrate to an acceptor substrate. Electrons are needed to oxidize (or reduce) organic compounds, which are the carbon source, to the chemical form used by cellular constituents and to generate the necessary energy that enables synthesis and biomass maintenance.

Most contaminants, typically aliphatic, contain different functional groups. These compounds, acting as electron donors, are oxidized during metabolism microbial to provide energy for cell growth and in many cases end up being mineralized to carbon dioxide and water. Some of the intermediate products of this oxidation they can be assimilated as a carbon source during cell growth. The groups functional can be used as nutrients or separated from the carbon skeleton when the compound is oxidized or reduced. There are three processes by which microorganisms can biodegrade organic compounds:

- Fermentation.
- Aerobic respiration.
- Anaerobic respiration.

During fermentation, the compounds are degraded by a series of reactions enzymatic that do not involve an electron transport chain and can act as electron donors or as acceptors. During aerobic respiration, microorganisms they use oxygen as an electron acceptor for microbial respiration. When breathing takes place under anaerobic conditions, oxygen is replaced by compounds or elements oxidized organic or inorganic that can be used as electron acceptors alternative, such as nitrate, metal ions (Fe (III), Mn (IV)), sulfate or carbon dioxide. For his in part, organic compounds can be metabolized to methane, carbon dioxide and hydrogen. Aerobic biodegradation has the advantages that aerobic organisms grow faster than anaerobes and can maintain higher degradation rates but requires a constant supply of oxygen that can often limit the process of biodegradation.

Thus, assisted biodegradation accelerates biodegradation reactions by facilitating growth microbial and optimizing the environmental conditions of the area where microorganisms they must carry out their decontamination function. For this approach to work, the pollutant must not be recalcitrant, that is, micro-organisms must have the capacity genetic and physiological enough to degrade the substance.

In a schematic way, this process can be observed in Illustration 5-22.

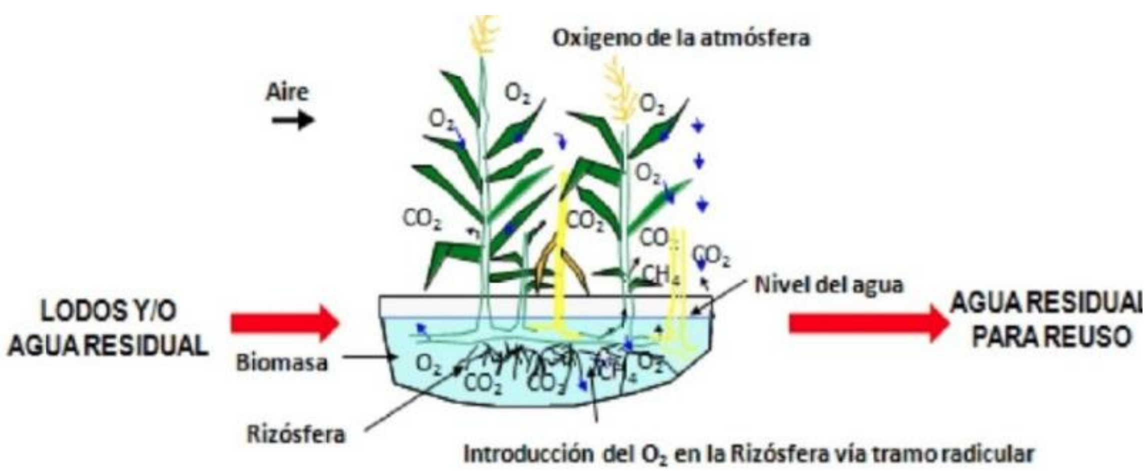


Illustration 5-22. Process of treatment or biodegradation.
Source: Transform Ecoskandia - Scandroots International Group, 2012.

In summary, the following advantages of the filtration sheet system can be mentioned:

- Aerobic and anaerobic conditions.
- No need to add chemical agents.
- There are no water mirrors, no vector growth.
- Minimum energy requirements (electric or fuel).
- Greater efficiency over time.
- Removals up to 98%.
- Flexible to variations in wastewater characteristics.
- Landscaping, does not generate visual impact.
- Minimum maintenance costs.

The operation and maintenance manual are presented in Annex 5.2.

5.3.1.3 Water supply and discharges from the benefit area

The flow diagram of supply and discharges of the benefit area is synthesized in the Illustration 5-23 and specified below.

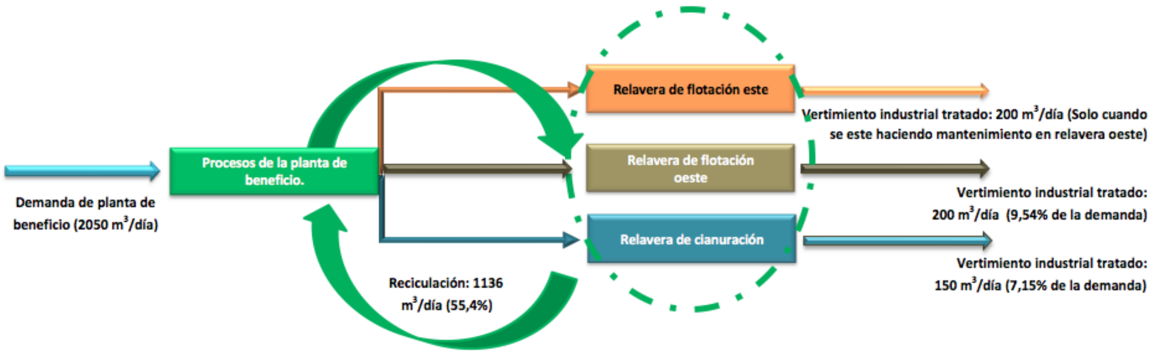


Illustration 5-23. Supply flow diagram and dumping of the benefit area.
Source: INGEX, 2016.

5.3.1.3.1 Water supply from the benefit area

The benefit processes that demand water are presented in Table 5-14

Table 5-14. Demand for water required for the different processes in the beneficiation plant.

PROCESES	WATER REQUIREMENT (m^3/day)	RECIRCULATION (m^3/day)
Milling	302,4	
Magnetic separation	360	
Knelson	600	
Pump 1	144	
Flotation	216	960,96 (46,9%)
Cyanidation	60	115,2 (5,6%)
Gravimetric concentration (Mesa Gemeni)	72	60 (2,9%)
Packer	240	
General service	7,2	
Workshops	48	
TOTAL DEMAND	**2050**	**1136 (55,4%)**

Source: INGEX, 2016.

The process of flotation, cyanidation and gravimetric concentration, will have recirculation of 46.9% (960,96 m^3/day), 5.6% (115,2 m^3/day) and 2.9% (60 m^3/day) respectively. The total of the process benefit will have a recirculation of 55.4% (1136 m^3/day). However, the demand for water the concession is 100% (2050 m^3/day), because the first time the total will be captured and, in any contingency, may be required 100% to not suspend the processes of the plant benefit.

5.3.1.3.2 Industrial discharges of the benefit process

As presented in the demand item of the benefit plant; the flotation processes, cyanidation and gravimetric concentration will have recirculation of 46.9% (960,96 m^3/day), 5.6% (115,2 m^3/day) and 2.9% (60 m^3/day) respectively.

Therefore, the water from the beneficiation process will have a recirculation of 55.4% (1136m^3/day), through one (1) cyanidation tailings pool (70,439 m^3) with a height of 14 m and a service life of approximately 19 years and a flotation tailings pool (91,860 m^3) with 12 m height and one 3-year lifespan (See Illustration 5-18). It will also subsequently operate a second pool of cyanidation tailings (10,300 m^3), which will serve exclusively as a substitute or to replace the operation of the first, while the maintenance and habilitation is carried out with the removal of sediments (Height 3.2 - shelf life 3 years).

The 44.6% (913,4 m^3/day) not recirculated, not fully discharged and less even instantaneously once it has been recirculated 55.4% (1136 m^3/day), because it will first be stored in these pools during the hydraulic retention time and may be 80% of the recirculation, thus giving a cyclical water exchange in the pools and a closed and controlled circuit, where there is a danger of external contamination.

The proposed water management plan for the project considers the management of contacted waters and not contacted within the project. The following elements have been conceptually designed for the El Pescado project in the municipality of Segovia Antioquia. (Illustration 5-24):

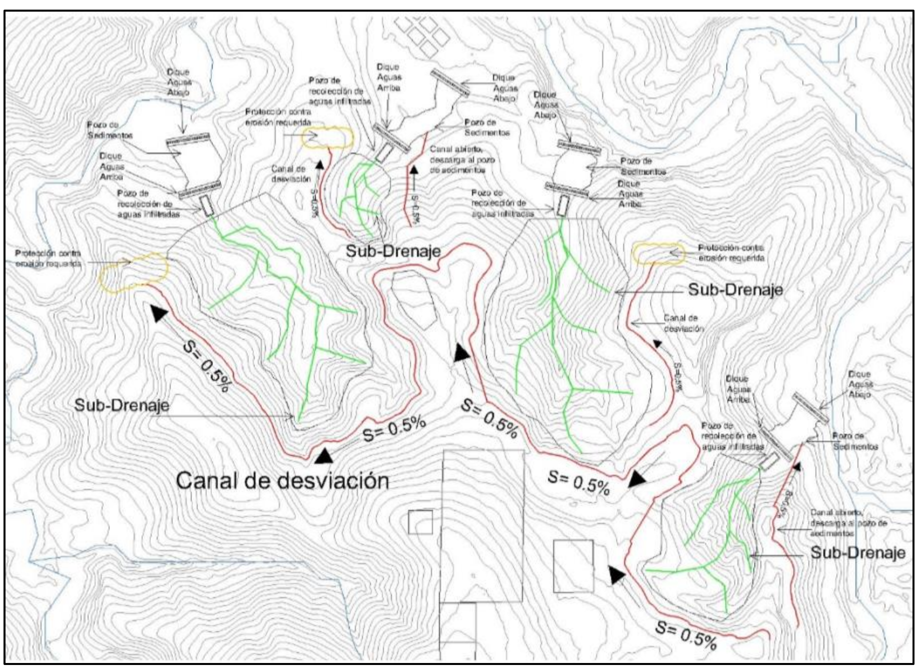


Illustration 5-24. Water management system for tailings and/or sterile deposits.
Source: INGEX, 2016.

- ✓ Open channels parallel to tailings deposits to divert runoff flows and prevent them from entering them. These channels would discharge to a pool or control well sediments waters below the start dams (Illustration 5-25).

- ✓ The system of sub-streams under the tailings deposits would quickly evacuate the waters of infiltration, discharging it in an infiltration water well.

- ✓ For the infiltration water collection well, it is recommended to locate it in the lower part of the foot of the tailings deposits, which will capture the flow of the sub-system, under the deposits and their stored volume will be pumped to the processing plant.

- ✓ The sediment control well downstream of the infiltrated water collection well for handle unconnected flows and reduce the sediment load when discharged to the ambient.

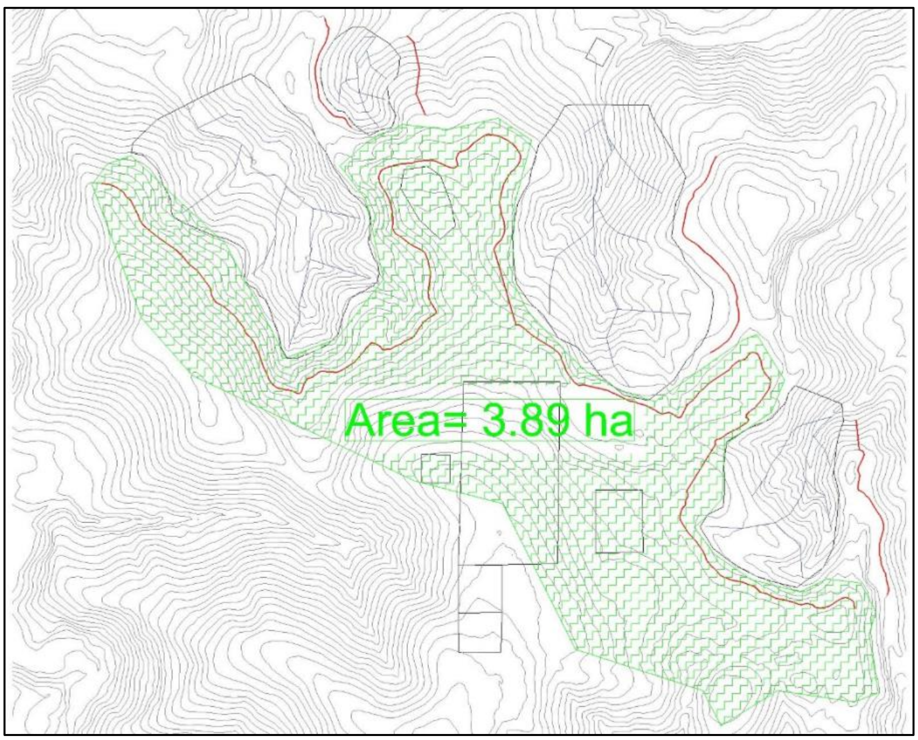


Illustration 5-25. Afferent area for the design of the channels for the tailings and/or sterile deposits.
Source: INGEX, 2016.

• Design of diversion channels

For the diversion of uncontacted waters, open channels excavated in the natural soil were designed for uniform flow using the Manning equation. A roughness coefficient of 0.020 He was employed in the analyzes. The channels have trapezoidal sections with 1H: 1V slopes.

The characteristics of the channels are presented in Illustration 5-26 and Table 5-15. The average flow for a wet year in the plant area it is approximately 307 l/s. For this initial phase of design, the channels have been designed for a flow of 0.8 m^3/s, so you can join higher flows for uncertainties in calculations and return events greater than those used in this stage.

Table 5-15. Characteristics of diversion channels of tailings and/or sterile deposits.

FLOW (l/s)	FLOW OF THE DESIGN ($m^{3/s}$)	COVERING	TALUD LONGITUDINAL (m/m)	WIDTH (m)	HEIGHT (m)
307	0.8	Excavation in soil	0.005	0.5	0.5

Source: INGEX, 2016

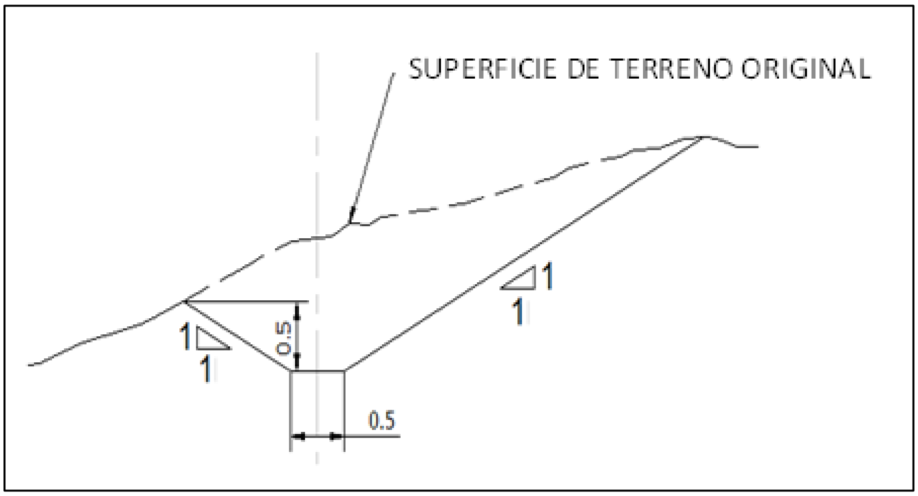


Illustration 5-26. Cross section for diversion channels.
Source: INGEX, 2016

5.3.1.3.2.1 Drainage design in rockfill

Tailings and / or sterile deposits require a subdrainage to maintain a surface low water table inside the tanks, in order to guarantee stability. The designed system will collect the base flow emerging from the channels that will be covered by the deposits and the direct precipitation on the surface of them.

The highest value of runoff to the deposits (3.5 l/s) was selected to evaluate the capacity required of the drain. As for the design flow, it was calculated from the capacity and having in how much a safety factor of 15 (Saliba et al., 2010). The cross section of the drain was designed under turbulent flow conditions using the Wilkins equation (in LEPS, 1973). The average slope of the channels in the basin occupied by the tailings and / or sterile deposits is the 3%, varying between 1.0 and 5% (Table 5-16).

Table 5-16. Design parameters for subheadings in castings for tailings and / or sterile deposits.

DESCRIPTION	UNITS	VALUE
Design flow	l/s	3.5
Porosity	--	0.34
Hydraulic radius	m	0.007
Starting surface efficiency rate	--	1.2
Dominant particle diameter	m	0.13
Empirical constant of Wilkins	--	6.69
Hydraulic gradient	m/m	0.03
Relation of voids	--	0.54
Security factor	--	15

Source: INGEX, 2016.

The theory used to estimate the flow through a castling material is the Wilkins equation (Ferris, 2009). This is valid for a wide range of particle sizes and hydraulic gradients. The equation is applicable to turbulent flow conditions and is described below:

$$Q = n\,A\,W\,m^{0.5}\,i^{0.54}$$

Where:
Q: Flow (m^3/s)
n: Porosity (dimensionless)
A: Transverse flow area (m^2)
W: Wilkins empirical constant
m: Hydraulic radius (m)
i: Hydraulic gradient (dimensionless)
The hydraulic radius is estimated according to Hansen's theory:

$$m = \frac{e\,d}{6\,r_e}$$

Where:
e: Relation of voids (dimensionless);
d: "Dominant" grain size (m); and
r_e: Particle surface efficiency rate, typically 1.3.
The following Table indicates the characteristics of the designed drain, and Illustration 5-27 shows the designed cross section.

Table 5-17. Results subgrades in castling for tailings and / or sterile deposits

FLOW (l/s)	FLOW OF THE DESIGN (l/s)	HEIGHT (m)	WIDTH IN THE FUND (m)	MINIMUM AREA (m)
3.5	58.98	0.7	2.0	1.56

Source: INGEX, 2016.

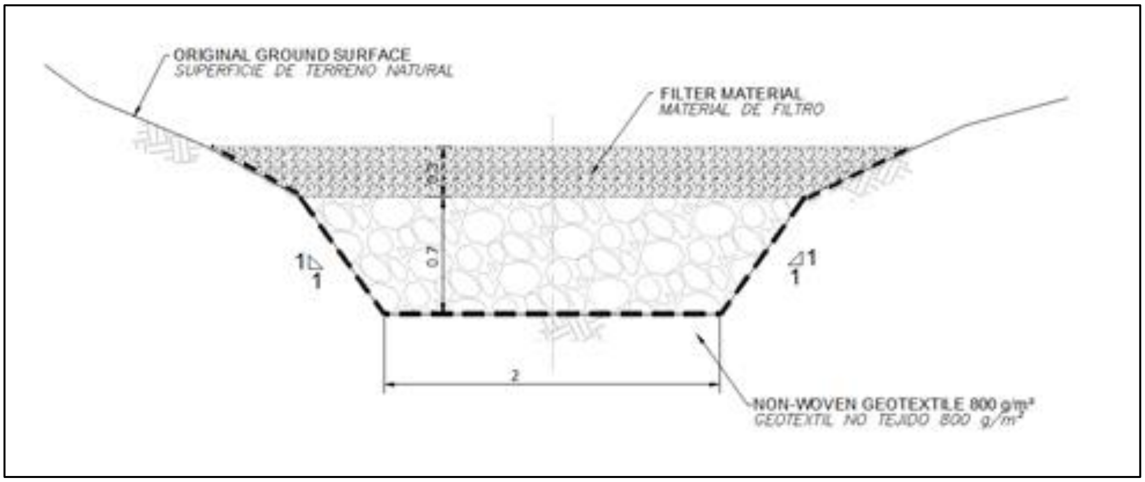


Illustration 5-27. Transverse section of the subdrainage in castling for tailings and / or sterile deposits.
Source: INGEX, 2016

The drain will be built along the bottom of the natural depressions that form channels or streams and the migration of natural soil to the casting material will be prevented using a non-woven geotextile of 800g/m^2 in the bottom and drain slopes. The migration of tailings to the rock casting material will be avoided by using a filter layer on the subgrade.

5.3.1.3.2.2 Infiltration and sediment handling wells

Two (2) wells will be built under the deposits to handle contacted water and will not contacted. The contacted flows (coming from the sub-drainage system under the deposits of tailings and / or sterile) will flow out of the subdrain to an infiltration well, the which consists of an excavation of approximately 402 m3 whose walls will be waterproofed with a HDPE membrane or cast concrete. The volume requirement for this well was estimated assuming 24 hours of storage capacity of the flow derived from the system of subdrainage. The entrance of sediment to this well must be minimized by a continuous closure from the face of the tailings and / or sterile deposits, or by installing a geotextile and castling in the face of the slope.

For the infiltration collection well, downstream, a control well is required. Sediments to reduce the sediment load being discharged into the environment. The well will be separated from the water well contacted by a small dam in compacted soil, and the Required volume (1537 m^3) will be contained by another dam approximately 100 m waters below, which will have two landfills: an operational landfill composed of a "low exit" for allow the output of the base flow at all times; and an emergency dump that will allow Evacuate flows from a storm with a determined return period. The detailed design of these elements will be realized during future phases of the project. The location and conceptual design of these elements is shown in Illustration 5-28 through Illustration 5-31.

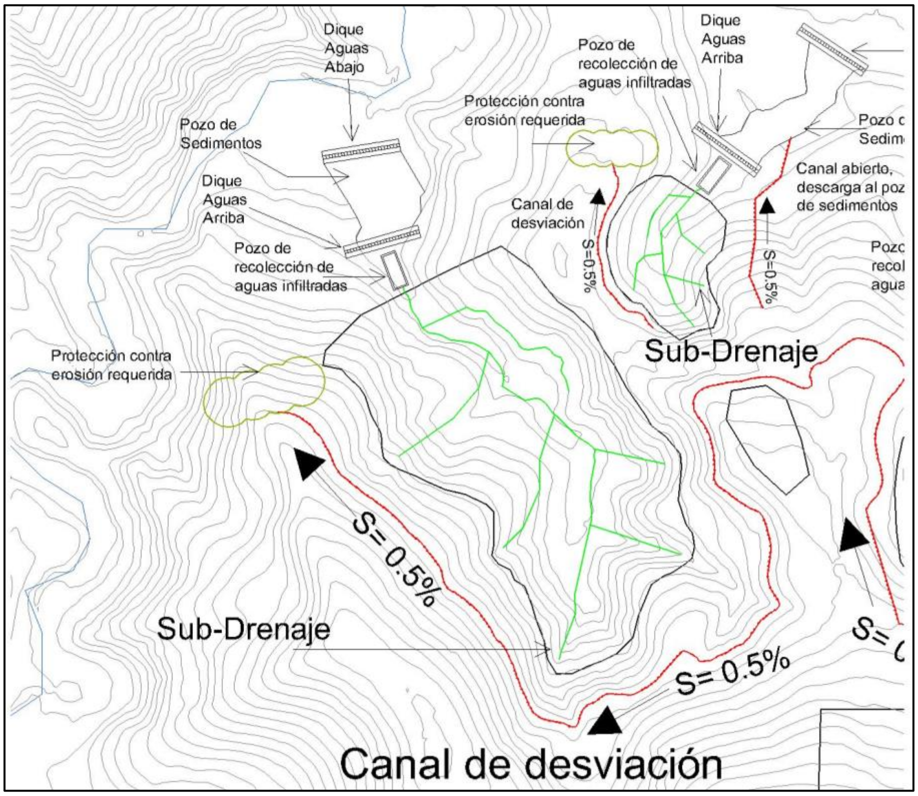


Illustration 5-28. General plant for water management wells for deposit No. 1.
Source: INGEX, 2016.

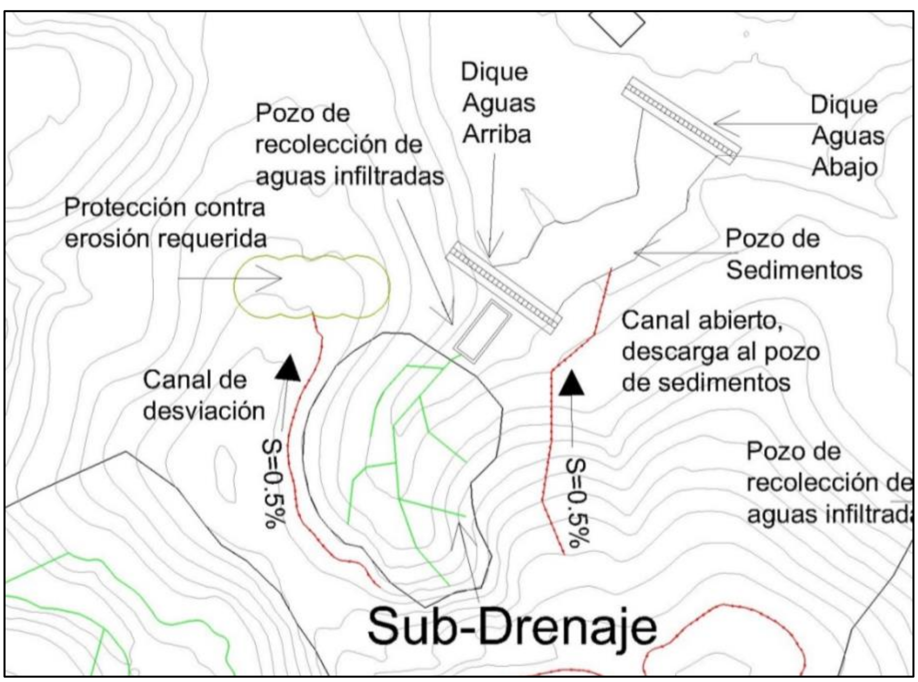


Illustration 5-29. General plant of water management wells for deposit No. 2.
Source: INGEX, 2016.

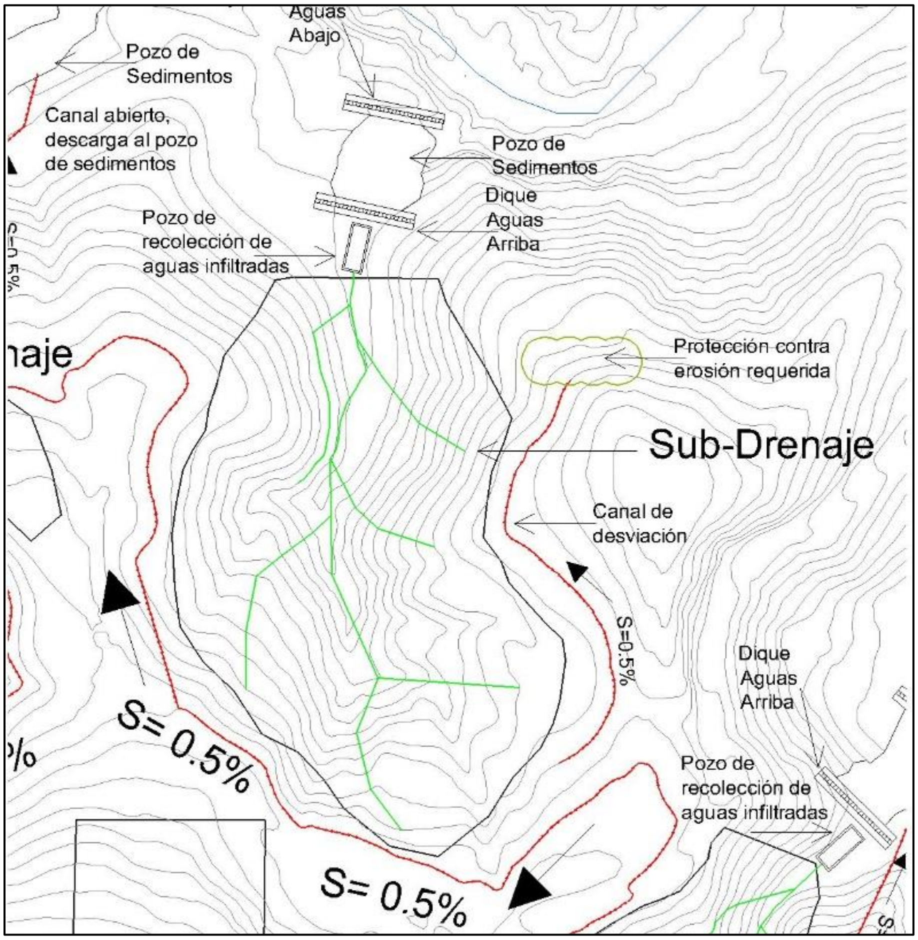


Illustration 5-30. General plant for water management wells for deposit No. 3.
Source: INGEX, 2016.

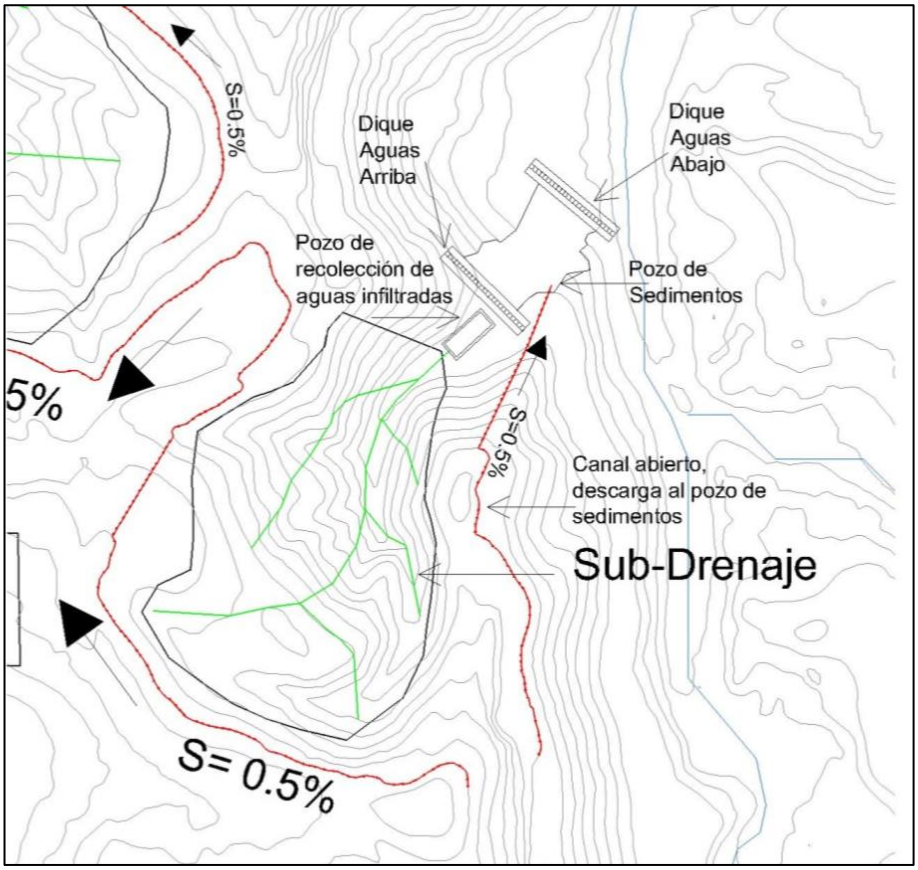


Illustration 5-31. General plant of water management wells for deposit No. 4.
Source: INGEX, 2016.

The following table indicates the volumes for each well.

Table 5-18. Wells under the tailings and/or sterile deposits.

WELL	DESIGN FLOW (l/s)	REQUIRED VOLUME (m^3)
Infiltrations	3.5	402
Sediment control	76.8	1537

Source: INGEX, 2016.

To avoid the overflow of the water level in the pools and discard non-reusable water in the processes, discharges or controlled and intermittent discharges will be made, with the flows and in the coordinates of Table 5-8. But previously they will be treated and / or detoxified in the Systems of Treatment of Industrial Wastewater (hereinafter STARI) as presented below.

5.3.1.3.2.2.1 Management of cyanide and other chemicals in water treatment and beneficiation processes industrial waste

To achieve a treatment of cyanide solutions and solid waste from the process of cyanidation, first presents the chemical reactions involved in the process, it is described the process and handling of cyanide and other chemical products used, in order to adequately support the treatment and / or detoxification of industrial wastewater.

The cyanide will be used in four (4) agitation tanks, in order to leach gold (dissolution of gold in leaching solution of sodium cyanide from the flotation concentrates previously the soluble dissolution of gold occurs). This dissolution reaction of gold will demand oxygen (contributed by the agitation and supply of air under pressure through special nozzles), as shown in the following stoichiometric equation.

$$4Au + 8NaCN + O_2 + H_2O \rightarrow 4\,NaAu(CN)_2 + (4NaOH)$$

In order to perform the separation of the gold-rich cyanide solution (NaAu (CN) 2), the System of Decantation in backflow (DCC), which consists of the use of a series of three (3) Thickeners, where the solid-liquid separation is carried out. In these thickeners, a hindered sedimentation that allows the solution to be separated by overflow while the pulp Thickened is discharged through the bottom of the tanks. The solution rich in precious metals is stored in tanks provided for it, from where the next process will be fed. Next, the gold and silver precipitation process known as the process is carried out Merrill-Crowe. This process involves the addition of zinc powder to the rich solution to get the precipitation of gold.

$$Zn + 2NaAu(CN)_2 \rightarrow 2Au + Na_2Zn(CN)_2$$

The solution is filtered through a filter press to capture the precipitate and excess zinc. The solution stripped of the values is pumped and stored in tacks provided for this end. From there, this solution is fortified in cyanide concentration and then reused in the process. Another important volume of this solution is used in the DCC system to perform the washing of the solids. Finally, the thickened and filtered solid wastes are taken to a reactor in which another considerable portion of poor solution is added to start the process of degradation of cyanide.

The process of destruction of cyanide, consists of the addition of hydrogen peroxide, spreading of air and copper sulfate solution as catalyst, until obtaining the maximum concentration allowable mentioned above, as presented in the following chemical equation.

$$CN^- + H_2O_2 \rightarrow CNO^- + H_2O$$

$$CNO^- + H_2O \rightarrow NH_3^- + HCO_3$$

The cyanide removal rate is very effective, varying from hour to minutes, depending on the nature of cyanide (if complexed or free), the treatment conditions (pH and temperature) and the presence of other components in the wastewater (See).

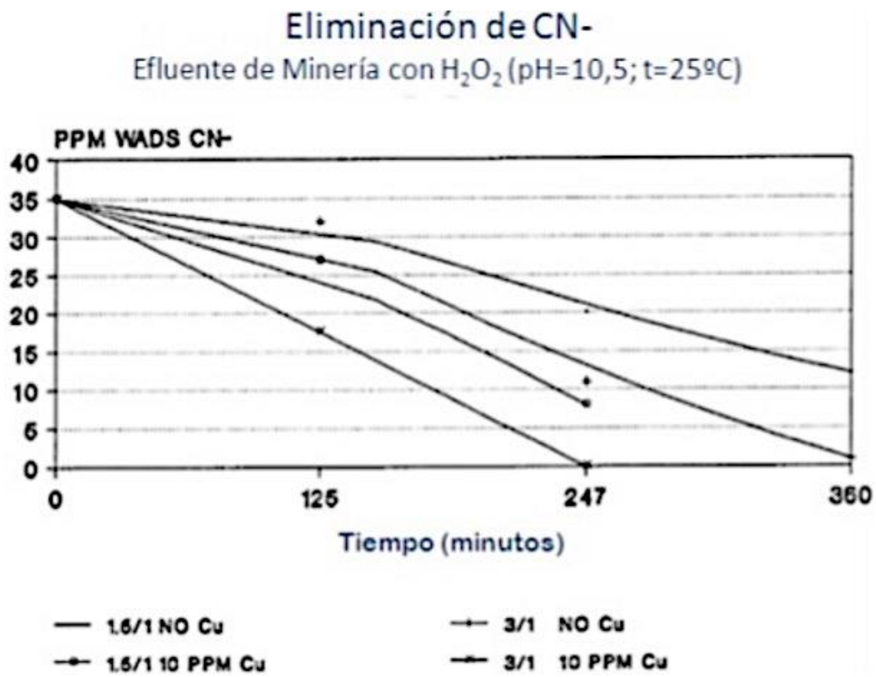


Illustration 5-32. Cyanide removal rates.
Source: FMC, FORET S.A.

However, this water cannot be discharged, after having eliminated the ammonia through the recovery of ammonia or biological nitrification.

The water treated in this system will be reused in the process avoiding the generation of shedding.

After this cyanide removal, the tails will be discharged to a compensation tank and then they will be pumped to a second compensation tank. The combined capacity between the two Compensation tanks will be minimum of 24 hours and maximum 48 hours.

The press will operate in a cycle that consists of closing the filter and holding, feeding the filter, air blowing, cake discharge and finally cloth washing. Water with prior elimination of cyanide, is used to wash the fabrics before starting a new filtration cycle. He filtrate is collected in a filter tank and pumped into a clarifier system (consisting of a small clarifier and lower flow pump) to then also recirculate to the benefit.

These filtered tails will be transported through conveyor belts to a drying bed to Remove moisture and take advantage of this fine inert material, and decontaminated or detoxified.

5.3.1.4 Water supply from the mining area

The supply flow diagram of the mining area is summarized in Illustration 5-23 and specified below.

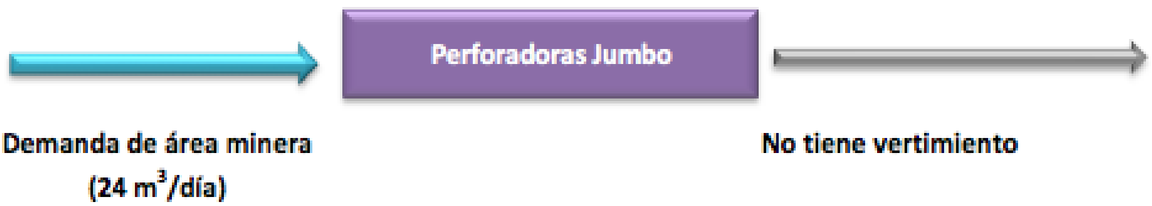


Illustration 5-33. Supply flow diagram and dumping of the mining area.
Source: INGEX, 2016.

5.3.1.4.1 Water supply from the mining area

This demand for surface water is conformed by the demand for drilling.

The drilling is used in the advancements of the exploitation fronts, as well as the construction of chimneys and shafts. This operation is performed wet to maintain air quality, minimizing the risk of occupational diseases. The addition of water, also allows the sweep of the ground mineral, the cooling of the bars and the sealing of the walls of the shot in lands fractured, avoiding the sticking of the bars.

Drilling hammers are hydraulic to achieve higher power than tires, running at broken percussion: the auger rotates continuously while exerting an impact on the drill background. Therefore, it needs a contribution of water to drag the detritus and to cool the mouth of drilling.

Also, in order to strictly comply with the regulations on safety for underground mining, where in Article 50 it requires textually "All mechanized drilling of drill holes in rock, must be done with water injections".

As described in the project description chapter, two (2) drills will be used "Jumbo" to make the blast holes of the blast.

Each Jumbo drill consumes 1 L/s and has a 3-hour shift per day. Therefore, the consumption or daily water demand is 10,8 m^3/day (0.023 L/s), as illustrated in the following equation:

$$Demand_{1\ jumbo\ driller} = \frac{1L}{s} x \frac{1m^3}{1000L} x \frac{3600s}{hour} x \frac{3horas}{1\ day\ journey} \text{x1,1 (\% hydraulic losses)}$$

$$Demand_{\ 1\ jumbo\ driller} = \frac{11{,}9m^3}{day\ journey}$$

In the same way, it would be for the second Jumbo drill, for a total demand for the two (2), 24 m^3/day.

5.3.1.5 Catchment

The total water demand of the 2097,3 m^3/day (24,274 L/s), will be captured at the union of the water sources SN#8 y SN#5, specifically in the coordinates 930.296 E – 1'294.151 N (See Illustration 5-18). This by means of a hydraulic pump with revolutions graduated at this flow to grant, until driving it to a storage tank designed to also control the flow with a free-hole weir design and additionally avoid the overflow of the water level and wasted by float system (See Illustration 5-34).

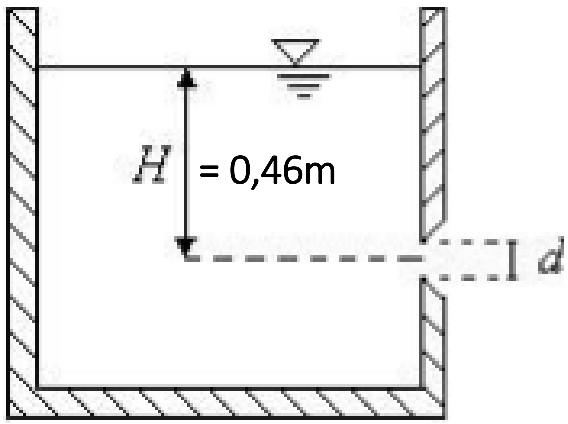


Illustration 5-34. Design work of recruitment.
Source: INGEX, 2016.

The design of this free-hole weir work determines the vertical location of the orifice with regarding the level of the sheet of water; by the Torricelli equation in terms of the flow, the cross-sectional area of the pipeline and gravity.

$$Q = A * \sqrt{2.g.H} \quad \rightarrow \quad H = \frac{(\frac{Q}{A})^2}{2\, x\, g}$$

H = 0,46 m

Where:

Q= 24,274 L/s. A= 0,0081073 m^2. (for a 4 "pipe")
g= 9,81 m/s^2. H= 0,46m (Height of the sheet of water starting from the hole)

From design calculation, it is determined that the pipe or orifice is 4 "and must be located at 0.46m below the water level, which will be controlled with the float.

5.3.1.6 Modeling of shedding

In order to perform the environmental assessment of domestic wastewater discharges and industries associated with the operation of the "El Pescado" mining project (Concession 5969), located in the municipality of Segovia in the department of Antioquia, modeling is presented below of water quality considering the maximum permissible limits in the discharges made on surface water currents in accordance with the provisions of Resolution 0631 of 2015; The behavior of the influence length of the dumping is analyzed, taking into account the hydrological conditions referred to the periods of low water and the wet periods in the study zone; which was analyzed through the implementation of the water quality model QUAL2Kw®.

The main objective of the modeling of water quality in the section of interest of each source recipient, is to determine the current status of water quality, and how does dumping influence domestic and industrial wastewater in it. The characteristics are considered constant physical, chemical, microbiological and hydraulic of the main tributaries (sub-basins).

In the QUAL2Kw, the main current is segmented based on its hydraulic characteristics (slope, width, depth and roughness.) In each spreadsheet of the graphic interface, you enter the data corresponding to the main current, tributaries, point and diffuse sources.

5.3.1.6.1 Geometry of the section (Segmentation)

Based on the spatial location of wastewater discharges, the definition was made of two (2) sections of water quality simulation in basins afferent to the area of influence of the 5969 Concession. The simulation sections considered, in addition to the points of Water quality monitoring and wastewater discharge are presented in the Illustration5-35.

In Table 5-19 and Table 5-20, the segmentation scheme of the simulation sections is related implemented in the QUAL2Kw water quality model. In accordance with the results obtained, in the case of simulation section N° 1, a total of 11 segments were defined (including Border condition or Headwater), with lengths of each segments of the order of 0.053 and 0.322km for a global length of the analysis section of 2.17km. The modeling of water quality in the simulation section N° 2 was made from 7 segments, discretized between 0.038 and 0.117km, with global analysis length of 0.573 km.

In general, within the simulation section N ° 1, the main discharges were identified as associated with tailings N° 1 of flotation and tailings N ° 2 of cyanidation (V1 and V2, respectively), with the water quality monitoring points P - 04, P - 08, P - 10 and P - 11 along the segment analyzed.

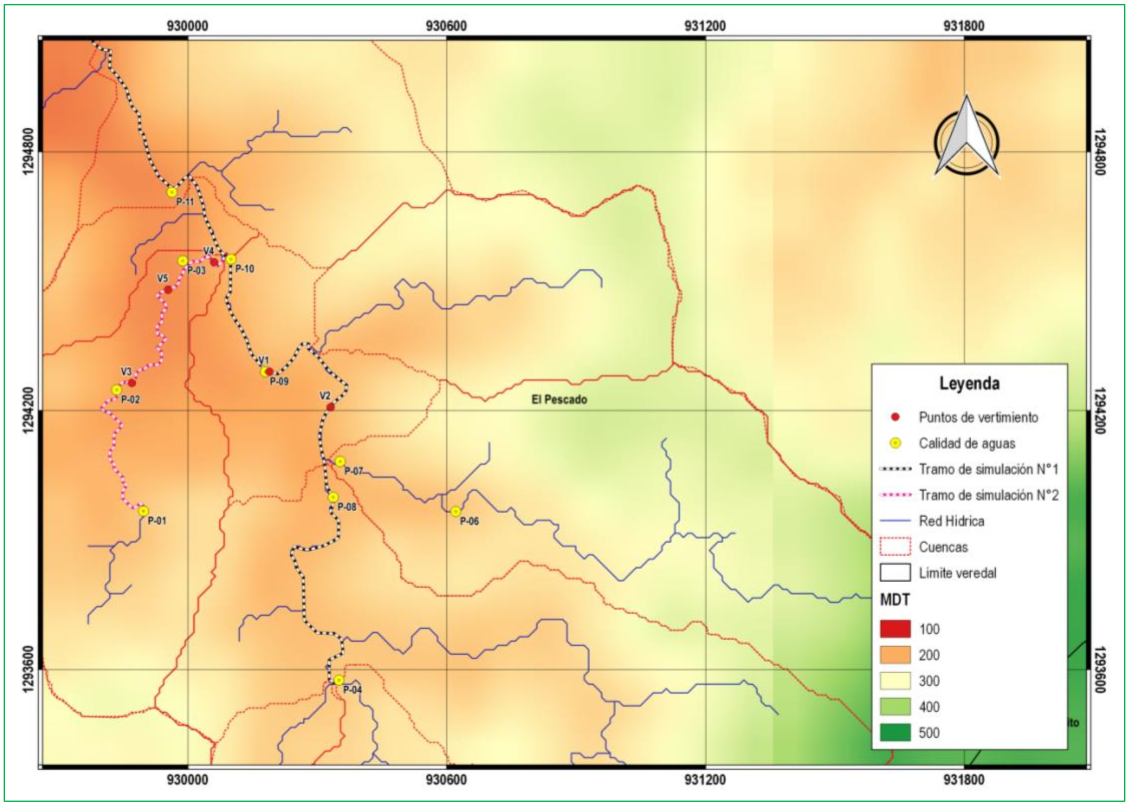


Illustration 5-35. Simulation stretches, water quality monitoring points and dumping points.
Source: INGEX, 2016

Discharges of flotation tail No. 3, in addition to effluents from treatment systems of wastewater from the camps and other water-sanitary units (V3, V4 and V5, respectively), are performed in simulation section N ° 2, which presents as points representative of the water quality of the stream, ID P - 02 and P - 03.

Table 5-19. Segmentation scheme - Simulation Section No. 1 (EPSG-WGS 84)

Segment (N°)	Water quality	Shedding - Taxes	Segment length (km)	Geographical coordinates		Location (km)
				Latitude (N)	Length (W)	
0	P - 04		Headwater	7.2504	-74.7081	2.166
1			0.053	7.2507	-74.7083	2.114
2			0.173	7.2518	-74.7089	1.941
3	P - 08		0.165	7.2533	-74.7092	1.776
4		V2 -- P - 07	0.184	7.254	-74.7083	1.592
5		V1	0.108	7.2549	-74.7084	1.484
6			0.193	7.2565	-74.7081	1.291
7	P - 10	TS N°2	0.303	7.2569	-74.7094	0.988
8			0.163	7.2582	-74.7104	0.825
9	P - 11		0.32	7.2606	-74.7111	0.505
10			0.322	7.2624	-74.7124	0.183
11			0.183	7.2637	-74.7132	0.000

TS N°2: Simulation section N°2

Source: INGEX, 2016.

Table 5-20. Segmentation scheme - Simulation Section No. 2 (EPSG - WGS 84)

Segment (N°)	Monitoring point	Shedding - Taxes	Segment length (km)	Geographical coordinates		Location (km)
				Latitude (N)	Length (W)	
0	P - 02		Headwater	7.2566	-74.7128	0.573
1		V3	0.117	7.2571	-74.7121	0.456
2			0.094	7.2577	-74.7119	0.362
3			0.097	7.2583	-74.7118	0.265
4			0.038	7.2586	-74.7119	0.227
5	P - 03	V5	0.056	7.2588	-74.7116	0.171
6			0.089	7.2593	-74.7111	0.083
7		V4	0.083	7.2594	-74.7107	0.000

Source: INGEX, 2016.

Discharges of flotation tail No. 3, in addition to effluents from treatment systems of wastewater from the camps and other water-sanitary units (V3, V4 and V5, respectively), are performed in simulation section N ° 2, which presents as points representative of the water quality of the stream, ID P - 02 and P - 03.The hydraulic characteristics of each one of the segments defined in the simulation sections evaluated, were obtained from the hydraulic calibration of surface water sources, receiving wastewater discharges from the "El Pescado" mining project, for which used the HEC RAS ® Software - Hydrologic Engineering Center - USA

5.3.1.6.2 Simulation section

In Illustration 5-36, the conceptual model that describes the segmentation scheme is presented implemented in the simulation section N ° 1, considering the main discharges and tributaries associated with each section, in addition to the representative monitoring point of the physical characteristics, chemical, microbiological and hydraulic thereof.

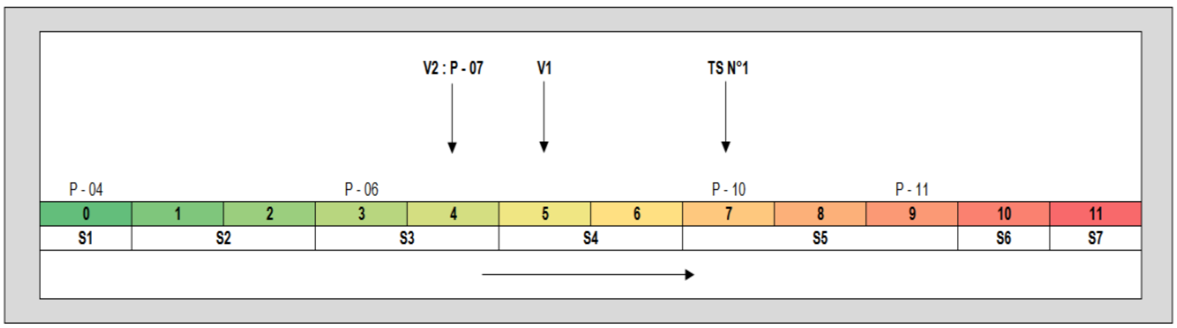


Illustration 5-36. Conceptual model of the segmentation scheme of simulation section No. 1.
Source: INGEX, 2016.

From Illustration 5-37 to Illustration 5-43, the results of the calibration of the cross sections associated to the segmentation scheme of simulation section N° 1. The hydraulic calibration curves of each of the cross sections associated with the segments of the simulation section N° 1 are shown from Illustration 5-44 to Illustration 5-57, these were obtained considering the return periods of 2.33, 5, 10, 25 and 50 years.

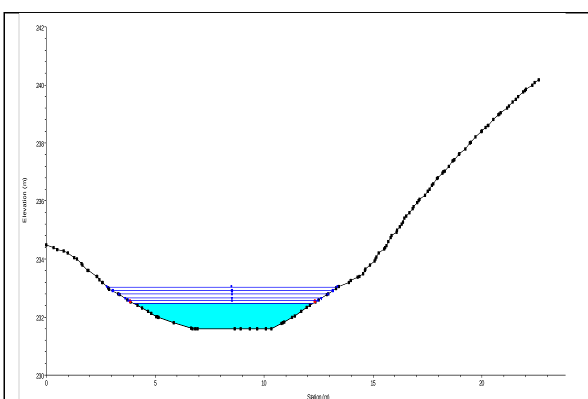


Illustration 5-37. Cross Section S1

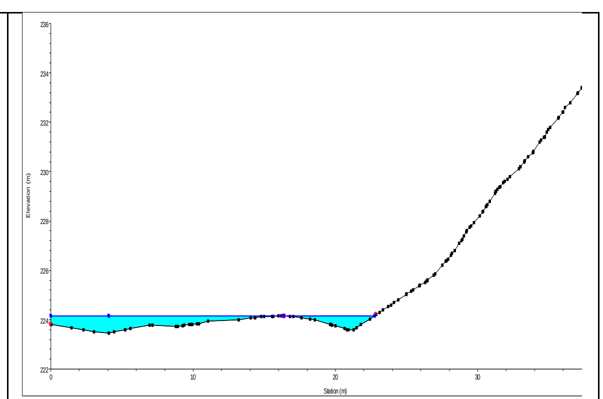


Illustration 5-38. Cross Section S2

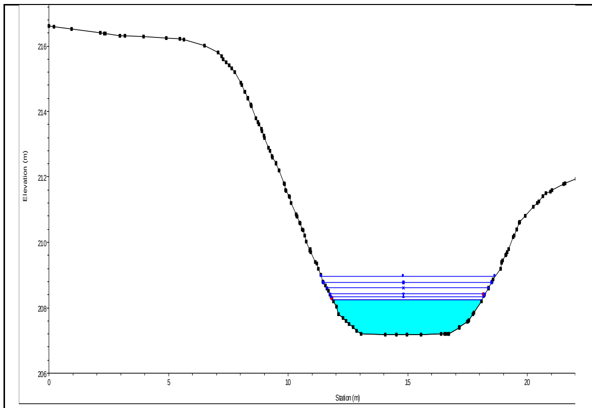


Illustration 5-39. Cross Section S3

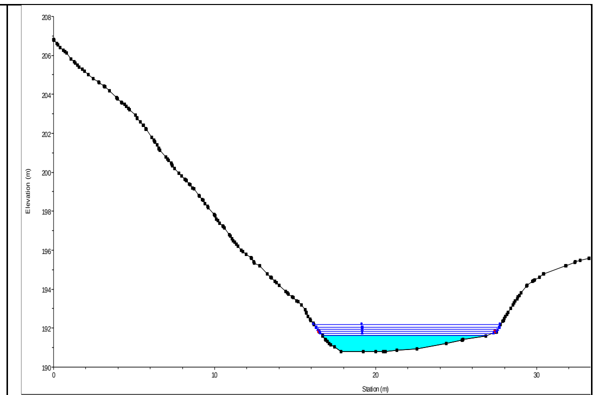


Illustration 5-40. Cross section S4

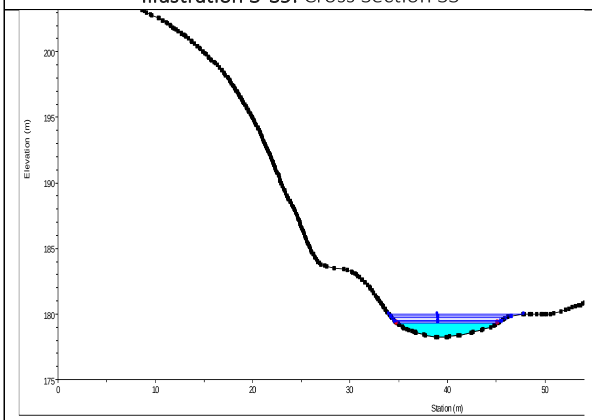


Illustration 5-41. Cross Section S5

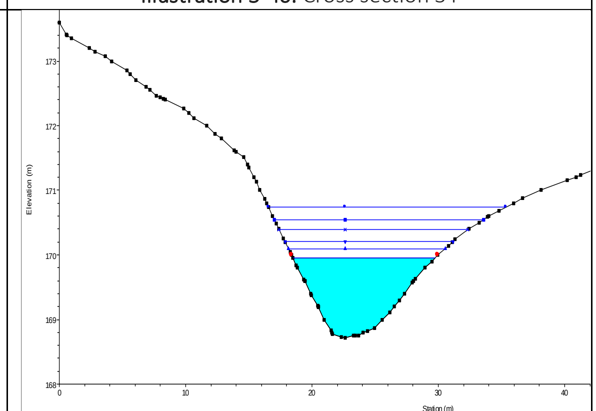


Illustration 5-42. Cross section S6

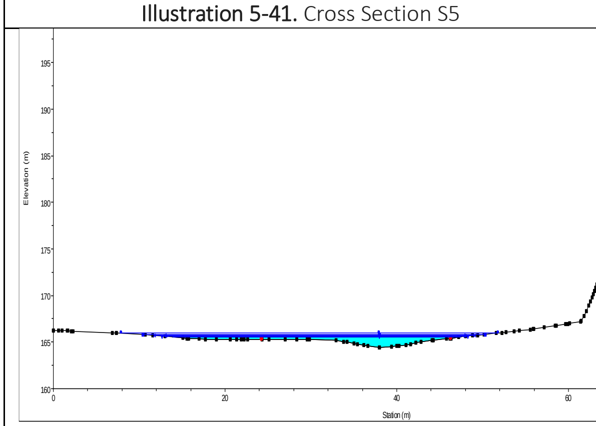


Illustration 5-43. Cross section S7

Source: INGEX, 2016.

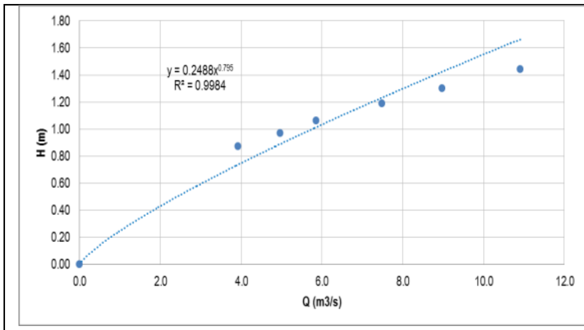


Illustration 5-44. H vs Q (S1)

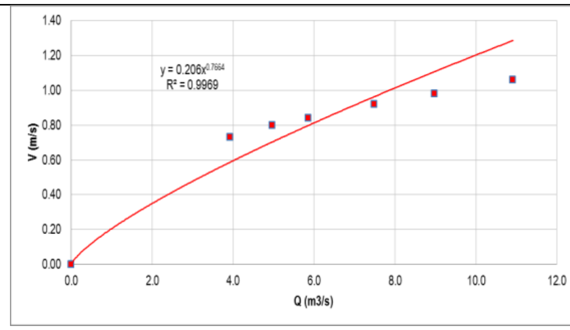


Illustration 5-45. V vs Q (S1)

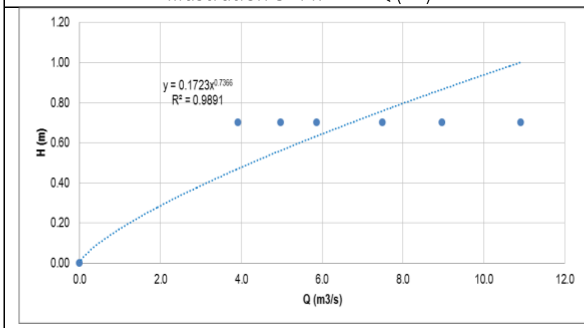


Illustration 5-46. H vs Q (S2)

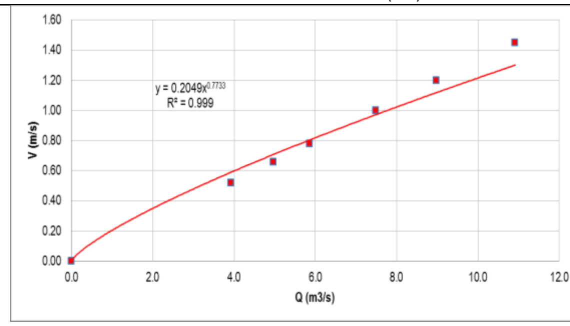


Illustration 5-47. V vs Q (S2)

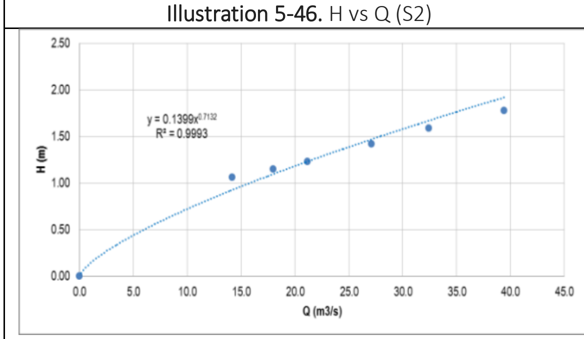


Illustration 5-48. H vs Q (S3)

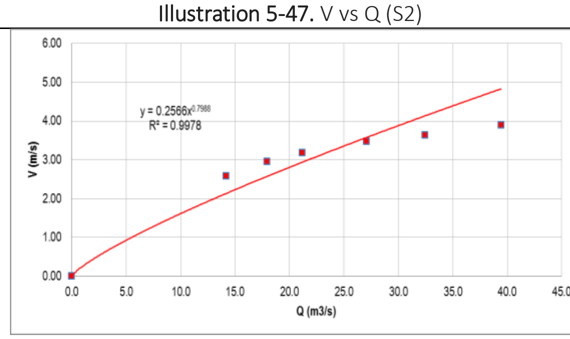


Illustration 5-49. V vs Q (S3)

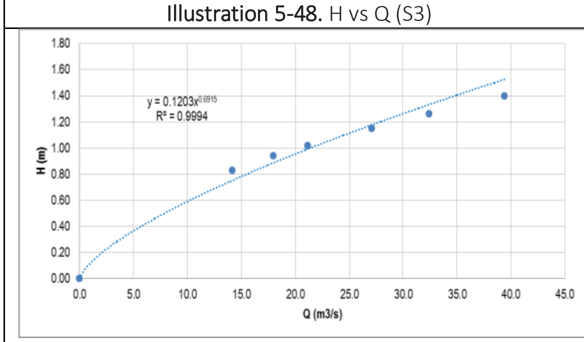


Illustration 5-50. H vs Q (S4)

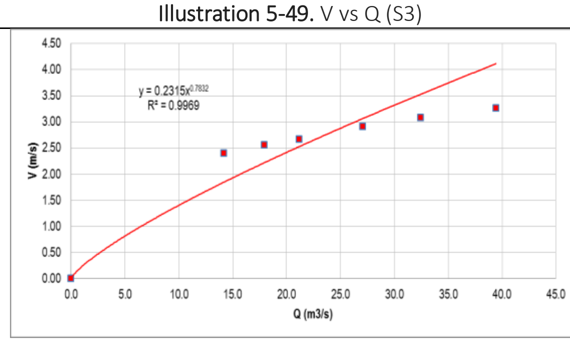


Illustration 5-51. V vs Q (S4)

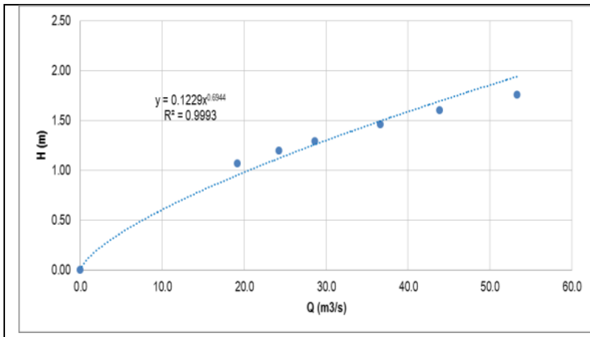


Illustration 5-52. H vs Q (S5)

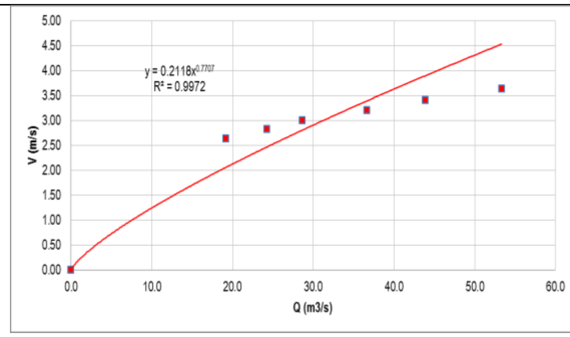


Illustration 5-53. V vs Q (S5)

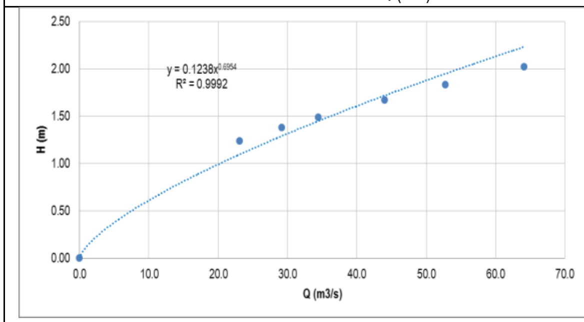


Illustration 5-54. H vs Q (S6)

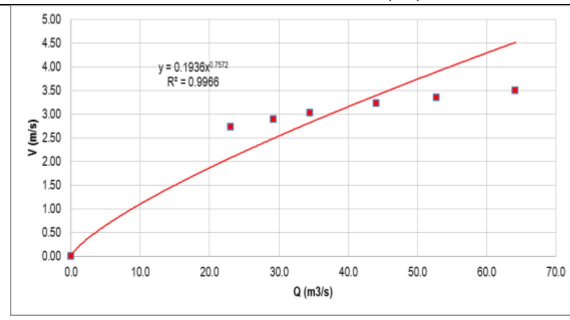


Illustration 5-55. V vs Q (S6)

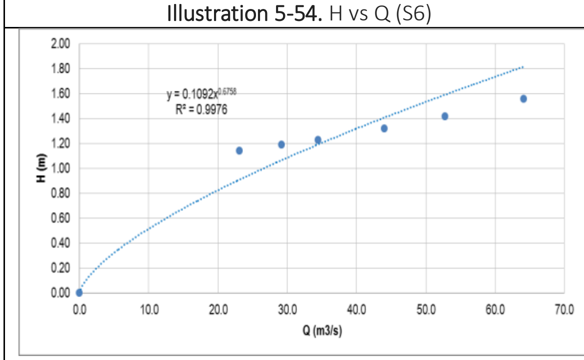


Illustration 5-56. H vs Q (S7)

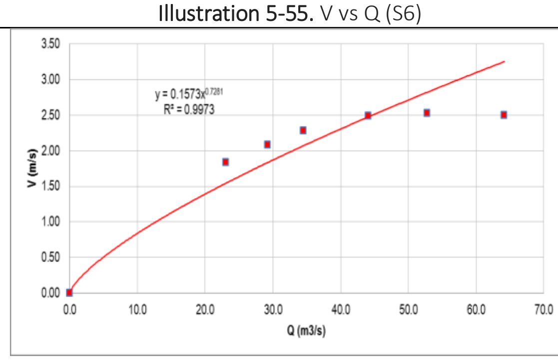


Illustration 5-57. V vs Q (S7)

Source: INGEX, 2016.

Finally, in Table 5-21 the hydraulic characteristics of the simulation section N° 1 are presented.

Table 5-21. Hydraulic characteristics of the simulation section No. 1.

Segment (N°)	Segment length (km)	Elevation N°1 (m)	Elevation N°2 (m)	Speed		Sheet		Slope (m/m)
				Coefficient	Exponent	Coefficient	Exponent	
0			228.0	0.2060	0.7664	0.2488	0.7950	0.0860
1	0.05	228.0	223.5	0.2049	0.7733	0.1723	0.7366	0.0860
2	0.17	223.5	218.0	0.2049	0.7733	0.1723	0.7366	0.0316
3	0.17	218.0	207.2	0.2566	0.7988	0.1399	0.7132	0.0655
4	0.18	207.2	200.0	0.2566	0.7988	0.1399	0.7132	0.0391
5	0.11	200.0	190.8	0.2315	0.7832	0.1203	0.6915	0.0852
6	0.19	190.8	186.0	0.2315	0.7832	0.1203	0.6915	0.0249
7	0.30	186.0	178.2	0.2118	0.7707	0.1229	0.6944	0.0256
8	0.16	178.2	175.0	0.2118	0.7707	0.1229	0.6944	0.0199
9	0.32	175.0	170.0	0.2118	0.7707	0.1229	0.6944	0.0156
10	0.32	170.0	164.4	0.1936	0.7572	0.1238	0.6954	0.0174
11	0.18	164.4	163.8	0.1573	0.7281	0.1092	0.6758	0.0034

Source: INGEX, 2016.

5.3.1.6.3 Simulation section No. 2

In Illustration 5-58, the conceptual model that describes the segmentation scheme is presented implemented in the simulation section N ° 2, considering the main discharges and tributaries associated with each section, in addition to the representative monitoring point of the physical characteristics, chemical, microbiological and hydraulic thereof.

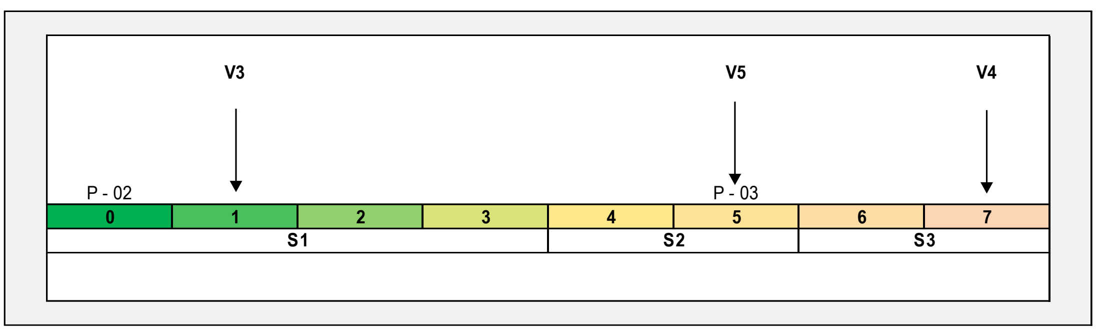


Illustration 5-58. Conceptual model of the segmentation scheme of simulation section No. 2.
Source: INGEX, 2016.

From Illustration 5-59 to Illustration 5-61, the results of the calibration of the cross sections associated with the segmentation scheme of simulation section No. 2. Illustration 5-59. Cross section S1 Illustration 5-60. Cross Section S2.

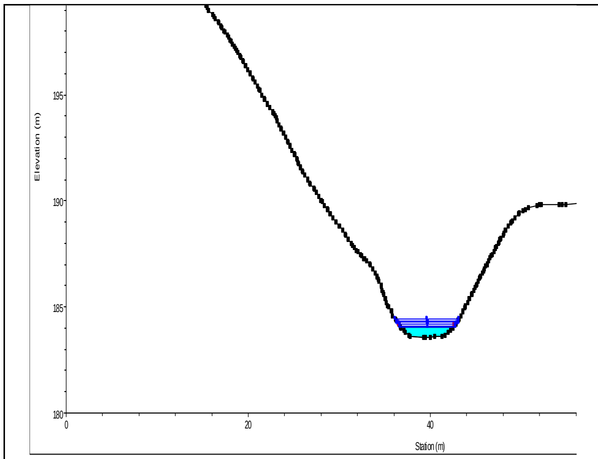


Illustration 5-1. Cross section S1

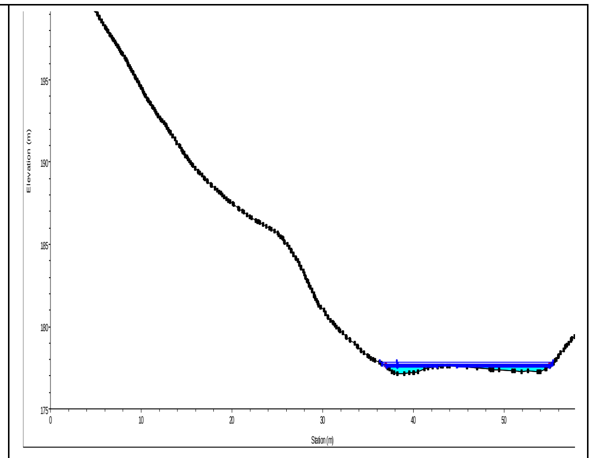


Illustration 5-2. Cross section S2

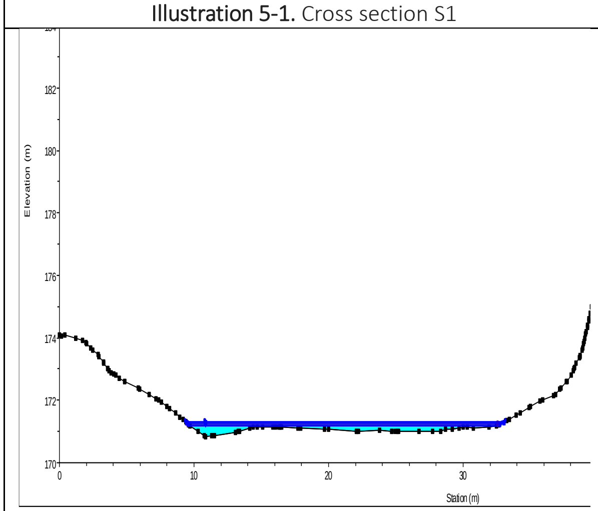


Illustration 5-3. Cross section S2

Source: INGEX, 2016.

The hydraulic calibration curves of each of the cross sections associated with the segments of the simulation section No. 2 are shown from Illustration 5-62 to Illustration 5-67, these were obtained considering the return periods of 2.33, 5, 10, 25 and 50 years.

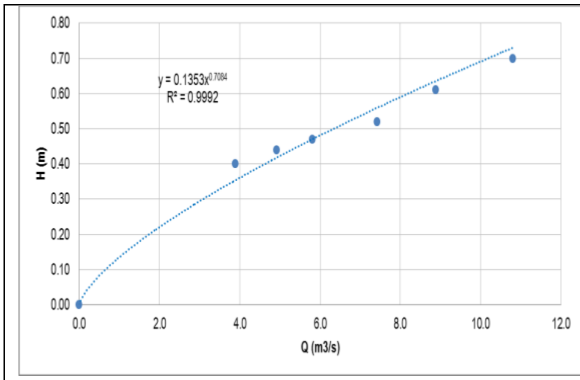


Illustration 5-4. H vs Q (S2)

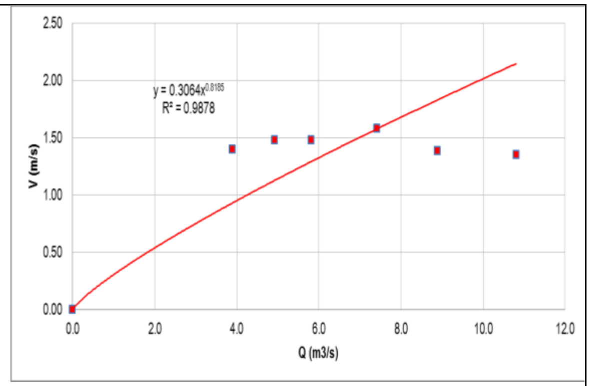


Illustration 5-5. V vs Q (S2)

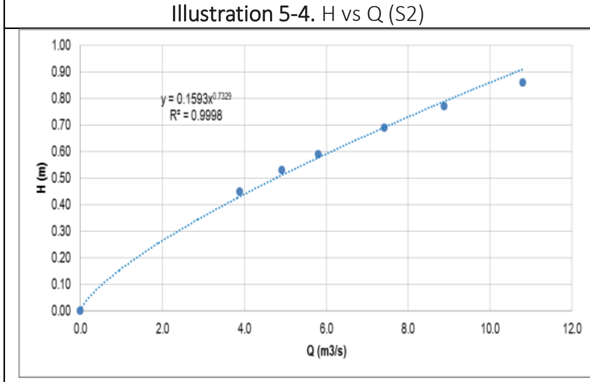


Illustration 5-6. H vs Q (S1)

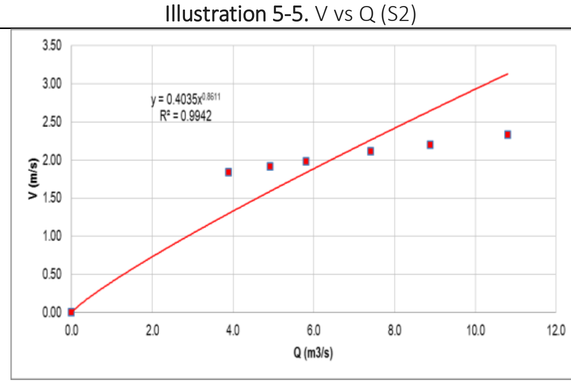


Illustration 5-7. V vs Q (S1)

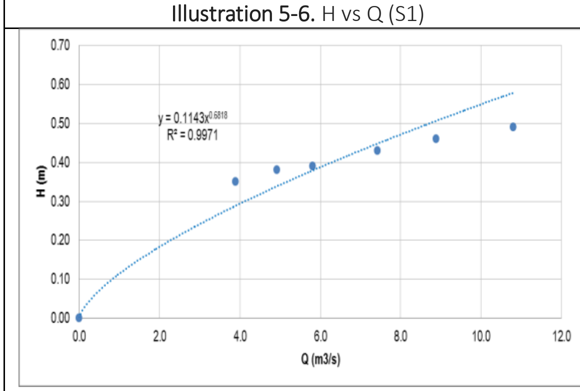


Illustration 5-8. H vs Q (S3)

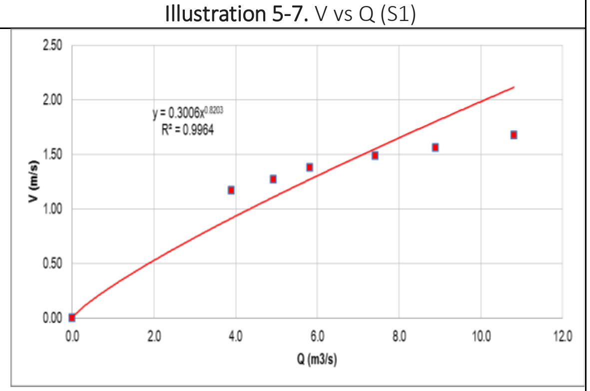


Illustration 5-9. V vs Q (S3)

Source: INGEX, 2016.

Finally, in Table 5-22 the hydraulic characteristics of the simulation section N ° 1 are presented.

To perform the calibration of the QUAL2Kw model in the current conditions scenario, without consider the influence of domestic and non-domestic wastewater discharges from the "El Pescado" mining project, the gauging flows of the monitoring points were used evaluated in the basins afferent to Concession 5969, see Table 5-23.

Table 5-22. Hydraulic characteristics of the simulation section Nº 2

Segment (N°)	Segment length (km)	Elevation N°1 (m)	Elevation N°2 (m)	Speed		Sheet		Slope (m/m)
				Coefficient	Exponent	Coefficient	Exponent	
0			198.0	0.4035	0.8611	0.1593	0.7329	0.0771
1	0.12	198.0	189.0	0.4035	0.8611	0.1593	0.7329	0.0771
2	0.09	189.0	184.0	0.4035	0.8611	0.1593	0.7329	0.0532
3	0.10	184.0	180.0	0.4035	0.8611	0.1593	0.7329	0.0413
4	0.04	180.0	178.0	0.3064	0.8185	0.1353	0.7084	0.0523
5	0.06	178.0	176.0	0.3064	0.8185	0.1353	0.7084	0.0358
6	0.09	176.0	175.0	0.3006	0.8203	0.1143	0.6818	0.0113
7	0.08	175.0	173.0	0.3006	0.8203	0.1143	0.6818	0.0242

Source: INGEX, 2016.

Table 5-23. Hydraulic characteristics determined in the field.

Monitoring point	Cross section (m^2)	Speed (m/s)	Q (m^3/s)	Q (L/s)
P-01	0.057	0.300	0.017	17.100
P-02	0.313	0.297	0.093	92.961
P-03	0.300	0.344	0.103	103.200
P-04	0.423	0.140	0.059	59.220
P-07	0.272	0.403	0.110	109.616
P-08	0.143	0.410	0.059	58.630
P-10	0.495	0.680	0.337	336.600
P-11	0.668	0.687	0.459	458.916

Source: INGEX, 2016.

5.3.1.6.4 Initial meteorological conditions

Within the variables defined in this group are related:

- Air Temperature (°C)
- Dew Temperature (°C)
- Wind Direction (rad)
- Shade percentage. (%)

The meteorological conditions of the area of direct influence of the "El Pescado" mining project are presented in Table 5-24, these values correspond to the averages established by the IDEAM in the study area.

Table 5-24. Weather conditions of the study area.

Air temperature (°C)	Dew Temperature (°C)	Wind speed (m/s)	Shade (%)
25	17.2	2.75	20

Source: INGEX, 2016.

5.3.1.6.5 Initial physical-chemical conditions

The initial physical, chemical and microbiological conditions of each segment of the sections of defined simulations were selected based on the results of the characterization of the monitoring points. The simulation of water quality included the following parameters:

- Water temperature (TA)
- Dissolved oxygen (OD)
- Biochemical oxygen demand (DBO_5)
- Total suspended solids (SST)
- Fecal coliforms (CF)
- Nitrates (NO_3)
- Nitrites (NO_2)
- Ammonia nitrogen (NH_3)
- Inorganic phosphorus (PO_4)
- Organic phosphorus (P)
- Electrical conductivity (CE)
- pH
- Total alkalinity (Alk)

Table 5-25 presents the initial physical, chemical and microbiological information used for the calibration and verification of QUAL2Kw quality model in the scenario of current conditions without Discharges associated to the mining project "El Pescado". QUAL2Kw simulates the biochemical demand of oxygen in terms of the latest BOD (DBOu), given the above, it was necessary to convert the BOD5 reported by the Laboratory (UPB - UDEA - SGS - CORANTIOQUIA). To perform the conversion of BOD5 to DBOu (both of carbonaceous type) the following expression was used.

$$\mathrm{DBO_u} = \frac{\mathrm{DBO_5}}{1-\mathrm{e}^{-5\mathrm{k}}}$$

Where k (1 / d) is the rate of degradation of organic matter, which ranges between 0.05 - 0.3 1 / d of compliance with the biodegradable characteristics of the wastewater discharged into the stream (Chapra, 1997).

For the simulation of water quality in the sections of interest, a degradation rate was assumed of 0.22 1 / d considering the simulation hypotheses proposed by Kannel et al (2007), which has account for the BOD / COD ratio of each segment. The selected degradation constant additionally, it is affected by the development of anthropic activities in the basins afferent to the 5969 concession such as agriculture and mining, among others. The DBOu is represented by a dissolved fraction called rapid BOD (Cf) and a fraction of slow degradation (Cs), was considered a DBOu distribution in 0% in Cf and 100% in the case of (Cs). Matter was not simulated particulate organic (Detritus) and the content of suspended inorganic solids, was replaced by total suspended solids.

Table 5-25. Initial physical, chemical and microbiological conditions of the monitoring points evaluated.

Parameters	Units	Monitoring point							
		P - 01	P - 02	P - 03	P - 04	P - 07	P - 08	P - 10	P - 11
Total suspended solids	mg/L	7.00	7.00	9.00	7.00	7.00	11.00	7.00	7.00
Electrical conductivity	µS/cm	117.00	115.00	114.00	102.00	118.00	127.00	120.00	122.00
pH	u.s	6.62	6.79	6.80	6.48	6.80	7.80	7.14	6.56
Dissolved oxygen	mgO_2/L	6.40	5.30	6.20	5.80	7.10	6.80	6.70	6.40
DBO5	mgO_2/L	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Nitrites	mg NO_2-N/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nitrates	mg NO_3-N/L	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Ammonia nitrogen	mg NH_3-N/L	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Organic phosphorus	mg P/L	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Inorganic Phosphorus	mg P/L	0.038	0.03	0.03	0.03	0.06	0.03	0.03	0.03
Total alkalinity	mg $CaCO_3$/L	59.60	59.00	58.40	51.80	56.80	64.00	58.90	59.80
Fecal coliforms	NMP/100mL	201.00	122.00	17329.00	110.00	108.00	5475.00	1354.00	4884.00
Water temperature	ºC	28.00	28.00	26.00	25.00	26.00	28.00	29.00	26.00

Source: INGEX, 2016.

The genetic algorithm PIKAIA (Pelletier et al, 2006) was used to calibrate the QUAL2Kw model whose objective function (f (x)) is defined by expression 14. The optimal adjustment of the variables evaluated, was determined from the reciprocal of the mean error root (RMSE).

$$f(x) = \left[\sum_{i=1}^{q} w_i\right]\left[\sum_{i=1}^{q}\frac{1}{w_i}\left[\frac{\frac{\sum_{j=1}^{m} O_{ij}}{m}}{\left[\frac{\sum_{j=1}^{m}\left(P_{ij}-O_{ij}\right)^2}{m}\right]^{\frac{1}{2}}}\right]\right] \qquad 1.$$

Where O_{ij} = observed value, P_{ij} = modeled value, m = number of modeled and observed pairs, w_i = weight factor and q = number of simulated state variables.

5.3.1.6.6 Calibration of the QUAL2KW model

Below are the results of the hydraulic, physical, chemical and microbiological of the defined simulation sections. The calibration was done through the implementation of the PIKAIA genetic algorithm (Pelletier et al, 2006) whose code is included in the QUAL2Kw; priority was given to biochemical oxygen demand, dissolved oxygen, species of nitrogen and phosphorus, in addition to total suspended solids, in addition to fecal coliforms.

5.3.1.6.7 Hydraulic calibration

The simulated (s) and field (c) flow curves are shown below. The abscissa 0 and 2.17 km represents the hydraulic characteristics of the simulation section N ° 1 from segment N ° 11 to No. 0 (Headwater in the QUAL2Kw model), respectively (see Illustration 5-68).

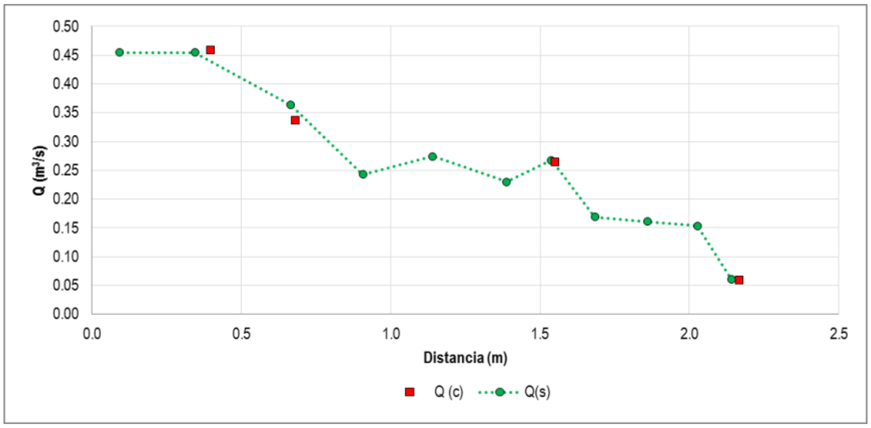


Illustration 5-68. Hydraulic calibration result of simulation section N ° 1
Source: INGEX, 2016.

The simulation section N ° 2, extends from the segment N ° 7 to the N ° 0 (Headwater) corresponding to abscissa 0 and 0.573 km, respectively (see Illustration 5-69).

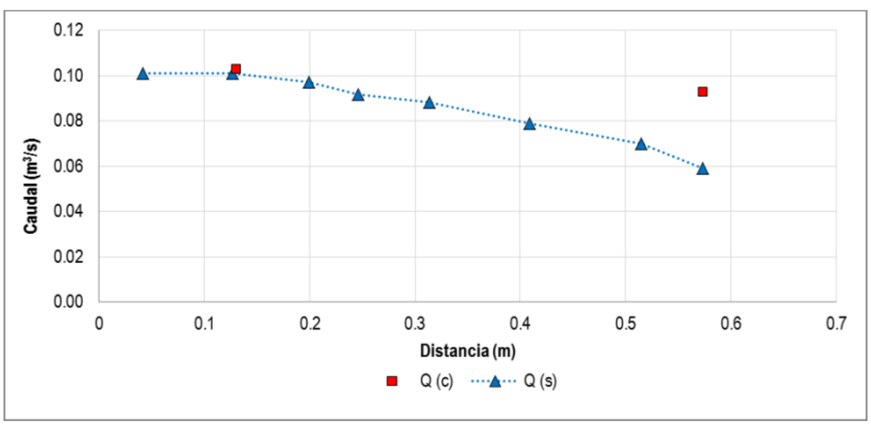


Illustration 5-69. Hydraulic calibration result of simulation section No. 2
Source: INGEX, 2016.

5.3.1.6.8 Calibration of physical, chemical and microbiological parameters

The kinetic constants of the physical, chemical and microbiological parameters considered in the calibration of the QUAL2Kw quality model in simulation sections N ° 1 and 2, are presented in the Table 5-26.

Table 5-26. Constants of physicochemical transformation

Inorganic suspended solids			
Settling velocity	0.1231	m/d	v_i
Oxygen			
Reaeration model	Thackston-Dawson		
Temp correction	1.024		q_a
Reaeration wind effect	None		
O2 for carbon oxidation	2.69	gO_2/gC	r_{oc}
O2 for NH4 nitrification	4.57	gO_2/gN	r_{on}
Oxygen inhib model CBOD oxidation	Exponential		
Oxygen inhib parameter CBOD oxidation	0.60	L/mgO2	K_{socf}
Oxygen inhib model nitrification	Exponential		
Oxygen inhib parameter nitrification	0.60	L/mgO2	K_{sona}
Oxygen enhance model denitrification	Exponential		
Oxygen enhance parameter denitrification	0.60	L/mgO2	K_{sodn}
Oxygen inhib model phyto resp	Exponential		
Oxygen inhib parameter phyto resp	0.60	L/mgO2	K_{sop}
Oxygen enhance model bot alg resp	Exponential		
Oxygen enhance parameter bot alg resp	0.60	L/mgO2	K_{sob}
Slow CBOD			
Hydrolysis rate	0.6161	/d	k_{hc}
Temp correction	1.047		q_{hc}
Oxidation rate	0.00125	/d	k_{dcs}
Temp correction	1.047		q_{dcs}
Ammonium			
Nitrification	0.5648	/d	k_{na}
Temp correction	1.07		q_{na}
Nitrate			
Denitrification	0	/d	k_{dn}
Temp correction	1.07		q_{dn}
Sed denitrification transfer coeff	0.38039	m/d	v_{di}
Temp correction	1.07		q_{di}
Organic P			
Hydrolysis	0.2334	/d	k_{hp}
Temp correction	1.07		q_{hp}
Settling velocity	0.02574	m/d	v_{op}
Inorganic P			
Settling velocity	0.81208	m/d	v_{ip}
Sed P oxygen attenuation half sat constant	1.05826	mgO_2/L	k_{spi}
Pathogens			
Decay rate	1.4	/d	k_{dx}
Temp correction	1.07		q_{dx}
Settling velocity	0.209473	m/d	v_x
alpha constant for light mortality	1	/d per ly/hr	apath
pH			
Partial pressure of carbon dioxide	347	ppm	p_{CO2}

Source: INGEX, 2016.

Below are the comparison curves of simulated data (s) and information from field (c) corresponding to the scenario of current conditions without the inclusion of shedding of domestic and non-domestic wastewater associated with the operation of the mining project "El Pescado".

5.3.1.6.8.1 Electrical conductivity

The behavior of the electrical conductivity in the simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-70. The Mean Square Error (RMSE) resulting from the calibration of the field values - CE (c), with respect to the simulated values or prediction of the model QUAL2Kw CE (s), was on average 2.02, with a coefficient of variation normalized (CV%) of the order of 1.8%, where an error of less than 10% is an indication of the adjustment optimal parameter. The data of electrical conductivity in the field along the stretch of Simulation No. 1 ranged from 102 to 119 µS/cm, from segment No. 0 (Headwater) and No. 11, respectively.

In the simulation section N ° 2, the variation of the electrical conductivity associated with the conditions current without the inclusion of domestic wastewater discharges and not from the Concession 5959, is presented in Illustration 5-71. The Mean Square Error (RMSE) resulting from the calibration of the field values - CE (c), with respect to the simulated or prediction values of the model QUAL2Kw CE (s), was on average 0.70, with a normalized coefficient of variation (CV%) of the order of 0.6%, where an error of less than 10% is an indication of the optimum adjustment of the parameter. The electrical conductivity data in the field along the simulation section No. 2 ranged between 115 and 114 µS / cm, from segment N ° 0 (Headwater) and N ° 7, respectively.

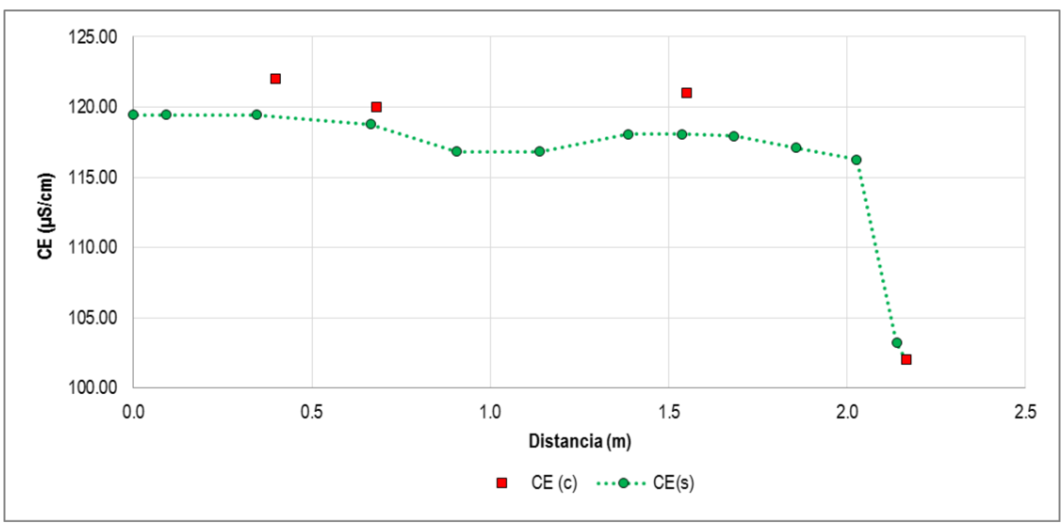


Illustration 5-70. Results calibration of the electrical conductivity in the simulation section N ° 1
Source: INGEX, 2016.

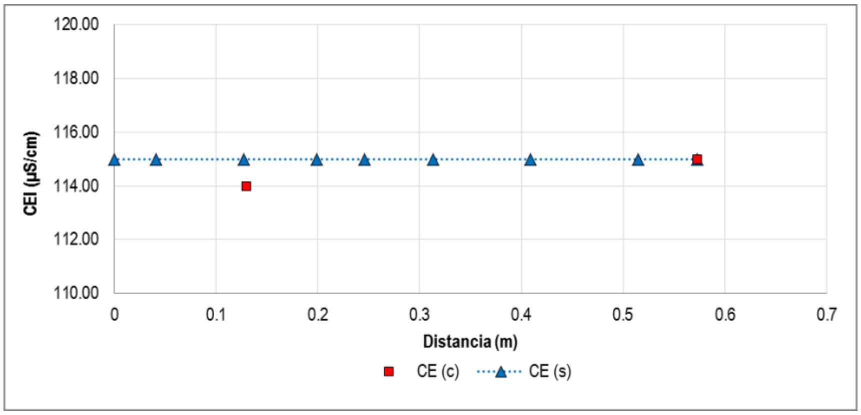


Illustration 5-71. Results calibration of electrical conductivity in simulation section No. 2
Source: INGEX, 2016.

5.3.1.6.8.2 Total suspended solids

The behavior of the total suspended solids in the simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-72. The Mean Square Error (RMSE) resulting from the calibration of the field values - SST (c), with respect to the simulated values or prediction of their QUAL2Kw SST (s) model, was on average 0.22, with a coefficient of Normalized variation (CV%) of the order of 3.0%, where an error of less than 10% is indicative of the optimal setting of the parameter. The data of total suspended solids in the field along the stretch of simulation No. 1 ranged between 7.0 and 9.0 mg / L, from segment No. 0 (Headwater) and No. 11.

In the simulation section N ° 2, the variation of the total suspended solids associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is presented in Illustration 5-73. The Mean Square Error (RMSE) resulting from the calibration of the field values - SST (c), with respect to the simulated values or prediction of the QUAL2Kw SST (s) model, was on average 0.08, with a coefficient of Normalized variation (CV%) of the order of 1.0%, where an error of less than 10% is indicative of the optimal setting of the parameter. The data of total suspended solids in the field along the stretch of simulation No. 2 ranged between 7.0 and 9.0 mg / L, from segment No. 0 (Headwater) and No. 7, respectively.

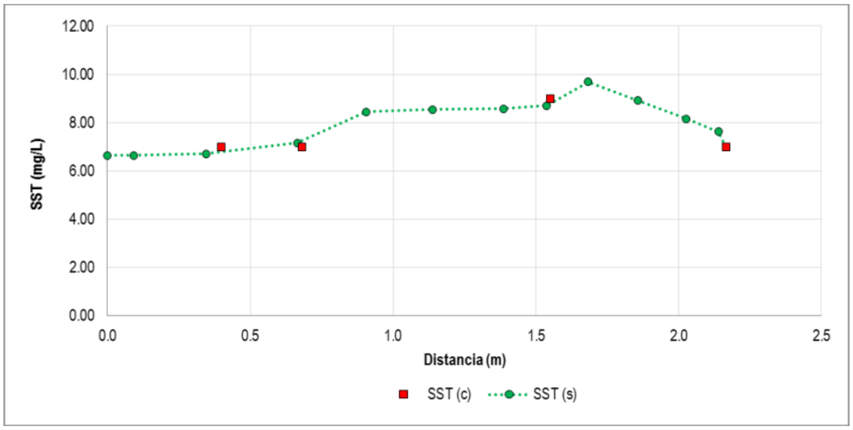


Illustration 5-72. Results calibration of the suspended solids in the simulation section N ° 1
Source: INGEX, 2016.

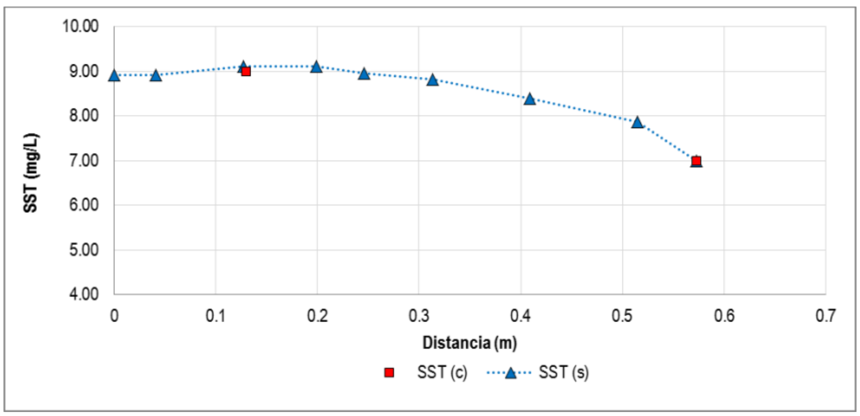


Illustration 5-73. Results calibration of the suspended solids in the simulation section N ° 2
Source: INGEX, 2016.

5.3.1.6.8.3 Dissolved oxygen

The behavior of the levels of dissolved oxygen in the simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-74. The Mean Square Error (RMSE) resulting from the calibration of the field values - OD (c), with respect to the simulated values or prediction of the QUAL2Kw OD (s) model, was on average 0.65, with a coefficient of Normalized variation (CV%) of the order of 9.8%, where an error of less than 10% is indicative of the optimal setting of the parameter. The dissolved oxygen data in the field along the stretch of Simulation No. 1 ranged between 5.8 and 6.7 mg / L, from segment No. 0 (Headwater) and No. 11. In the simulation section N ° 2, the variation of the total suspended solids associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is presented in Illustration 5-75.

The Mean Square Error (RMSE) resulting from the calibration of the field values - OD (c), Regarding the simulated or predicted values of the QUAL2Kw OD (s) model, it was on average 1.17, with a normalized coefficient of variation (CV%) of the order of 19.0%, where a lower error at 10% is an indication of the optimum adjustment of the parameter, in this case the threshold was not reached desired using the reassignment model proposed by Tsivoglou-Neal according to the morphometric characteristics of the basin, however these characteristics favor the constitution of predominantly aerobic environments (OD> 4 mg / L), guaranteeing the development of species sensitive to variations in dissolved oxygen levels (i.e. fish, macroinvertebrates, etc.). Dissolved oxygen data in the field along the simulation stretch No. 2 ranged between 5.3 and 6.2 mg / L, from segment No. 0 (Headwater) and No. 7, respectively.

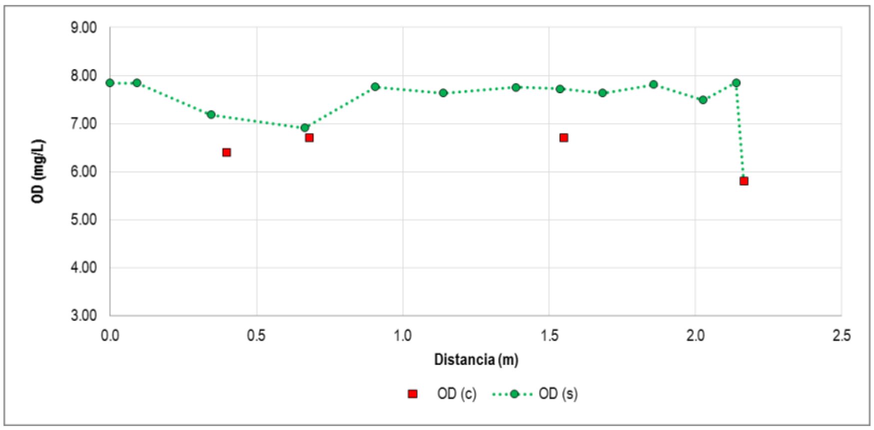


Illustration 5-74. Results calibration of the dissolved oxygen in the simulation section N ° 1
Source: INGEX, 2014.

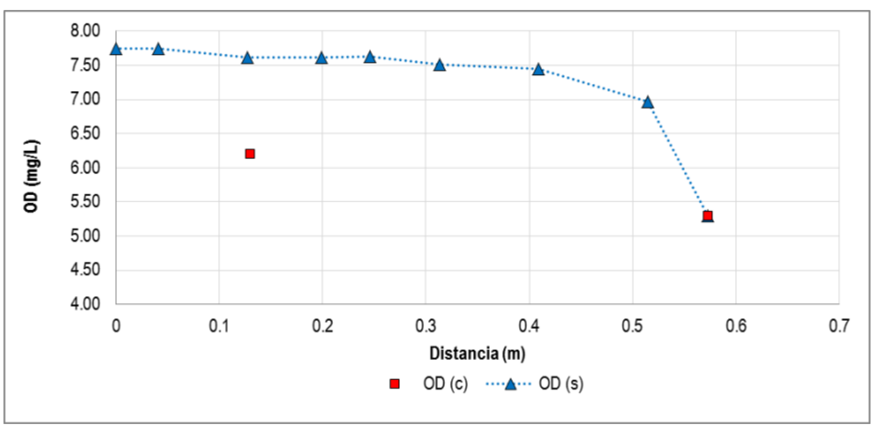


Illustration 5-75. Calibration results of dissolved oxygen in simulation section No. 2
Source: INGEX, 2016.

5.3.1.6.8.4 Biochemical oxygen demand

The behavior of the biochemical oxygen demand in the simulation section N ° 1, associated to current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-76. The Mean Square Error (RMSE) resulting from the calibration of the field values - BOD (c), with respect to the values simulated or predicted model QUAL2Kw BOD (s), was on average 0.01, with a coefficient of normalized variation (CV%) of the order of 0.3%, where an error of less than 10% is an indicative of the optimal parameter setting. The biochemical oxygen demand data in the field throughout of the simulation section No. 1 remained around 3.0 mg / L (below the limit of detection), from segment N ° 0 (Headwater) and N ° 11.

In the simulation section N ° 2, the variation of the biochemical oxygen demand associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is presented in Illustration 5-77. The Mean Square Error (RMSE) resulting from the calibration of the field values - BOD (c), with respect to the values simulation or prediction of the QUAL2Kw DBO (s) model, averaged 0.04, with a coefficient of normalized variation (CV%) of the order of 1.3%, where an error of less than 10% is an indicative of the optimal parameter setting. The biochemical oxygen demand data in the field throughout of the simulation stretch No. 2 remained around 3.0 mg / L (below the limit of detection), from segment N ° 0 (Headwater) and N ° 7, respectively.

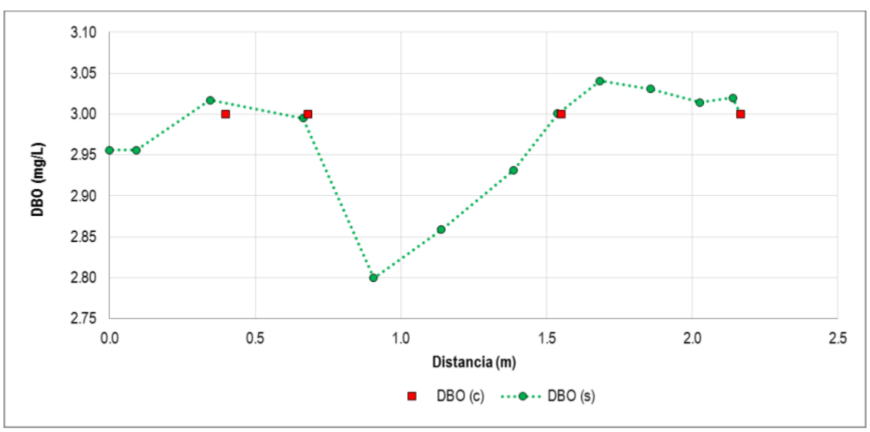


Illustration 5-76. Results calibration of the biochemical oxygen demand in the simulation section N ° 1
Source: INGEX, 2016

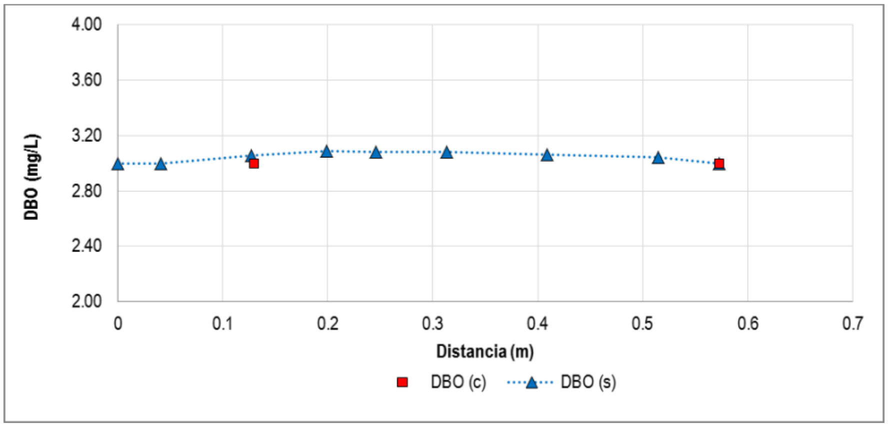


Illustration 5-77. Results calibration of the biochemical oxygen demand in the simulation section N ° 2
Source: INGEX, 2016.

5.3.1.6.8.5 Ammonium

The behavior of the ammonium levels in the simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-78. The Mean Square Error (RMSE) resulting from the calibration of the field values - NH4 (c), with respect to the values simulated or predicted model QUAL2Kw NH4 (s), was on average of 21.33, with a normalized coefficient of variation (CV%) of the order of 2.1%, where an error of less than 10% is an indicative of the optimal setting of the parameter. The ammonia data in the field along the stretch of Simulation No. 1 were maintained around 1.0 mg / L (below the detection limit), starting from of segment N ° 0 (Headwater) and N ° 11.

In simulation section N ° 2, the variation of ammonium associated with current conditions without the Inclusion of domestic wastewater discharges and not from Concession 5959, is presented in Illustration 5-79. The Mean Square Error (RMSE) resulting from the calibration of the field values - NH4 (c), with respect to the simulated or model prediction values QUAL2Kw NH4 (s), averaged 84.44, with a normalized coefficient of variation (CV%) of the order of 8.2%, where an error of less than 10% is an indication of the optimum adjustment of the parameter. The Ammonium data in the field along the simulation stretch No. 2 were kept around 1.0 mg / L (below the detection limit), from segment No. 0 (Headwater) and No. 7, respectively.

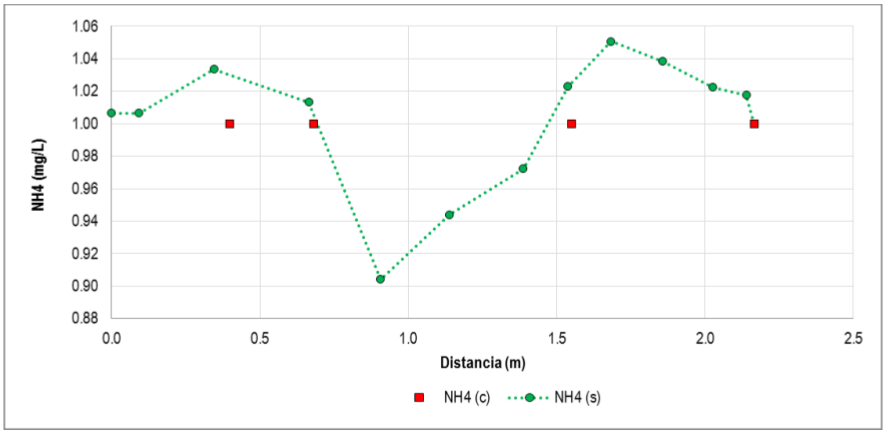


Illustration 5-78. Calibration results of ammonium in simulation section N ° 1
Source: INGEX, 2016

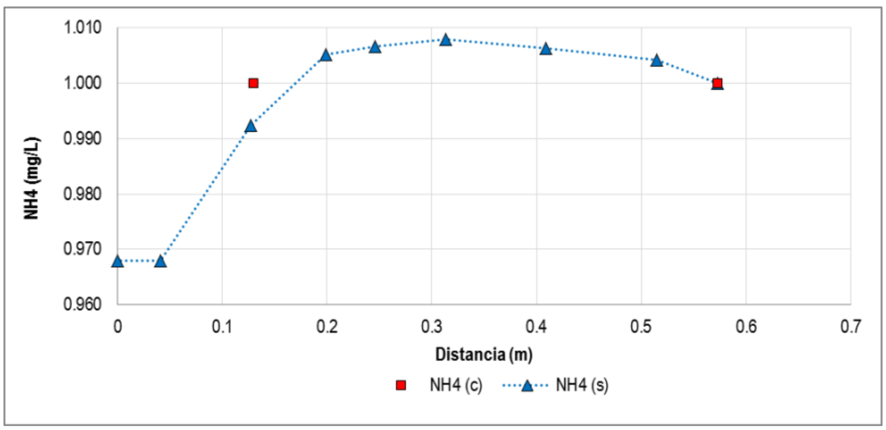


Illustration 5-79. Calibration results of ammonium in simulation section No. 2
Source: INGEX, 2016

5.3.1.6.8.6 Nitrates

The behavior of nitrate levels in simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-80. The Mean Square Error (RMSE) resulting from the calibration of the field values - NO3 (c), with respect to the values simulated or predicted model QUAL2Kw NO3 (s), was on average 41.56, with a normalized coefficient of variation (CV%) of the order of 2.8%, where an error of less than 10% is an indicative of the optimal setting of the parameter. The nitrate data in the field along the stretch of Simulation No. 1 were maintained around 1.5 mg / L (below the detection limit), starting of segment N ° 0 (Headwater) and N ° 11.

In the simulation section N ° 2, the variation of nitrate levels associated with the conditions current without the inclusion of domestic wastewater discharges and not from the Concession 5959, is presented in Illustration 5-81. The Mean Square Error (RMSE) resulting from the calibration of the field values - NO3 (c), with respect to the simulated or prediction values of the model QUAL2Kw NO3 (s), was on average of 16.11, with a normalized coefficient of variation (CV%) of the order of 1.1%, where an error of less than 10% is indicative of the optimal adjustment of the parameter. The nitrate data in the field along the simulation stretch No. 2 was maintained around 1.5 mg / L (below the detection limit), from segment No. 0 (Headwater) and No. 7, respectively.

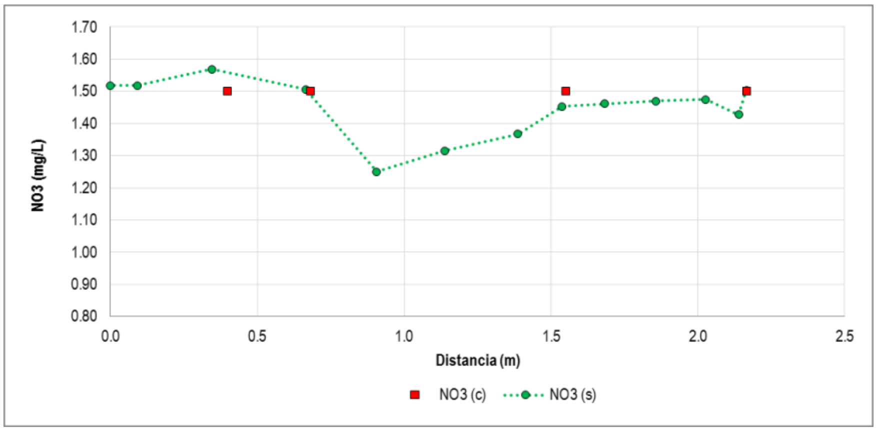


Illustration 5-80. Results calibration of the nitrates in the simulation section N ° 1
Source: INGEX, 2016

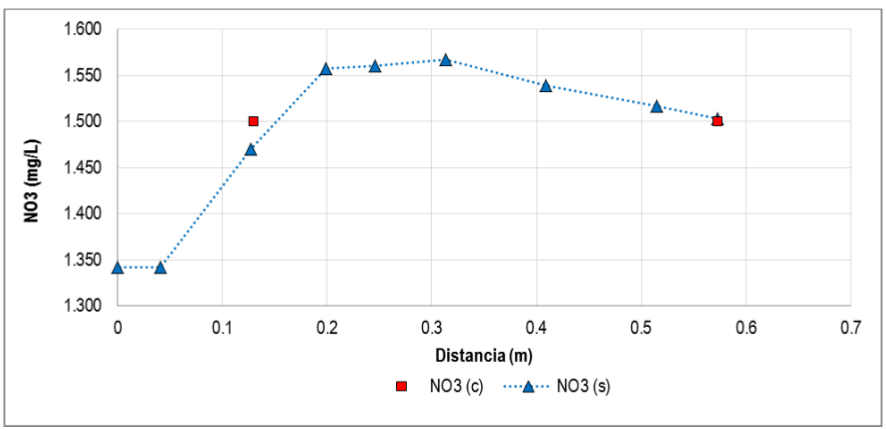


Illustration 5-81. Calibration results of nitrates in simulation section No. 2
Source: INGEX, 2016

5.3.1.6.8.7 Organic phosphorus

The behavior of the levels of organic phosphorus in the simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-82. The Mean Square Error (RMSE) resulting from the calibration of the field values - P (c), with respect to the simulated values or prediction of the model QUAL2Kw P (s), was on average 0.05, with a coefficient of variation normalized (CV%) of the order of

0.2%, where an error of less than 10% is an indication of the adjustment optimal parameter. The organic phosphorus data in the field along the simulation section No. 1 were maintained around 0.025 mg / L (below the limit of detection), from segment No. 0 (Headwater) and No. 11.

In the simulation section N ° 2, the variation of the levels of organic phosphorus associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is presented in Illustration 5-83. The Mean Square Error (RMSE) resulting from the calibration of the field values - P (c), with respect to the simulated values or prediction of the model QUAL2Kw P (s), was on average 0.03, with a coefficient of variation normalized (CV%) of the order of 0.1%, where an error of less than 10% is an indication of the adjustment optimal parameter. The organic phosphorus data in the field along the simulation section No. 2 were maintained around 0.025 mg / L (below the detection limit), from segment No. 0 (Headwater) and No. 7, respectively.

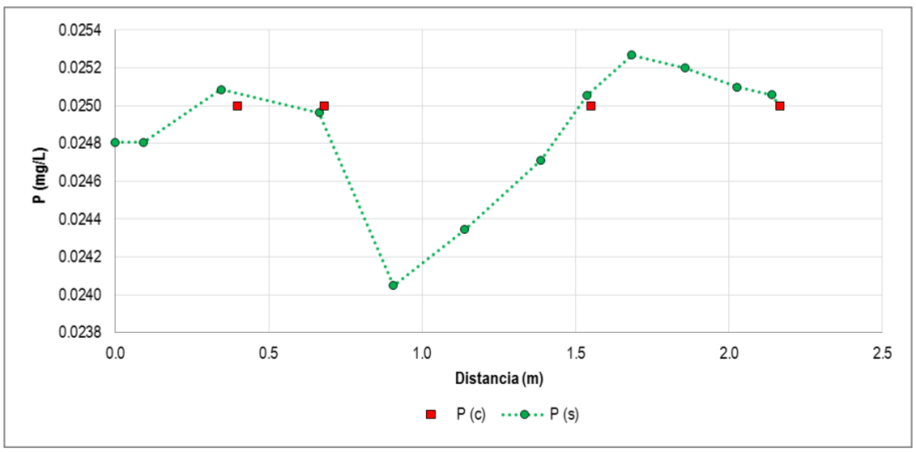


Illustration 5-82. Calibration results of organic phosphorus in the simulation section N ° 1.
Source: INGEX, 2016

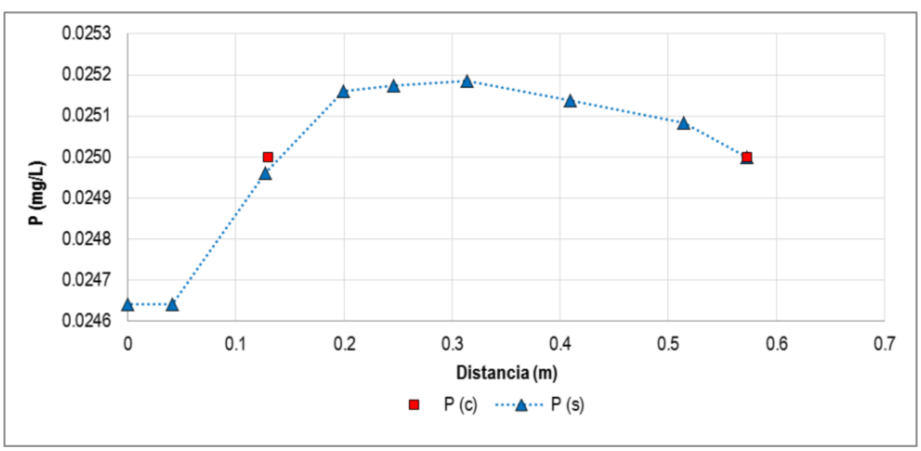


Illustration 5-83. Calibration results of organic phosphorus in simulation section No. 2
Source: INGEX, 2016

5.3.1.6.8.8 Inorganic phosphorus

The behavior of pathogens expressed in terms of fecal coliform content in the simulation section N ° 1, associated to the current conditions without the inclusion of the shedding of domestic wastewater and not from the 5959 Concession, is related to the illustration 5-86. The Mean Square Error (RMSE) resulting from the calibration of the field values - CF (c), Regarding the simulated or predicted values of the QUAL2Kw CF (s) model, it was on average 1421.84, with a normalized coefficient of variation (CV%) of the order of 77.2%, where an error less than 10% is indicative of the optimum setting of the parameter, in this case the threshold is not met minimum and, therefore, the model does not allow for an adequate prediction of the evolution of the variable of interest in the study area. Fecal coliform data in the field along the Simulation Section N ° 1 was maintained between 110 and 4884 NMP / 100ml, from segment N ° 0 (Headwater) and No. 11.

In the simulation section N ° 2, the variation of the inorganic phosphorus levels associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is presented in Illustration 5-87. The Mean Square Error (RMSE) resulting from the calibration of the field values - CF (c), with respect to the simulated values or prediction of the model QUAL2Kw CF (s), was on average 523.84 with a coefficient of normalized variation (CV%) of the order of 6.1%, where an error of less than 10% is indicative of the optimum adjustment of the parameter, therefore the model allows to predict in an appropriate way the evolution of the variable of interest in the study area. Fecal coliform data in the field along the simulation section N ° 1 they were maintained between 122 and 17329 NMP / 100ml, from segment No. 0 (Headwater) and No. 11.

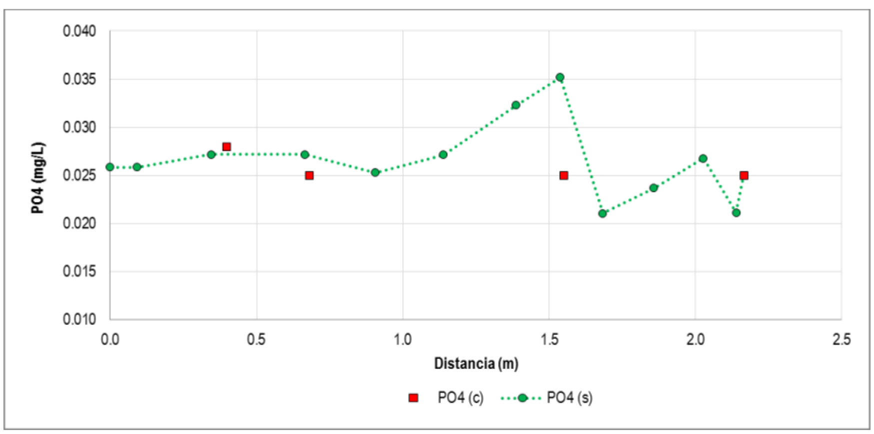


Illustration 5-84. Results calibration of inorganic phosphorus in the simulation section N ° 1
Source: INGEX, 2016

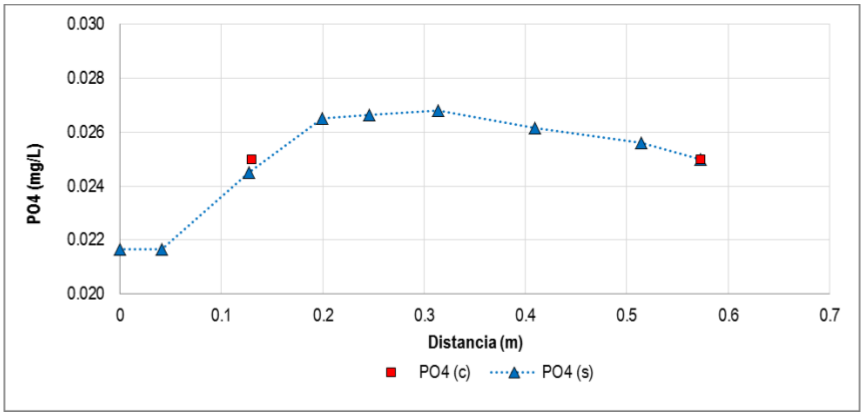


Illustration 5-85. Calibration results of inorganic phosphorus in simulation section No. 2
Source: INGEX, 2016

5.3.1.6.8.9 Fecal coliforms

The behavior of pathogens expressed in terms of fecal coliform content in the simulation section N ° 1, associated to the current conditions without the inclusion of the shedding of domestic wastewater and not from the 5959 Concession, is related to the illustration 5-86. The Mean Square Error (RMSE) resulting from the calibration of the field values - CF (c), Regarding the simulated or predicted values of the QUAL2Kw CF (s) model, it was on average 1421.84, with a normalized coefficient of variation (CV%) of the order of 77.2%, where an error less than 10% is indicative of the optimum setting of the parameter, in this case the threshold is not met minimum and, therefore, the model does not allow for an adequate prediction of the evolution of the variable of interest in the study area. Fecal coliform data in the field along the Simulation Section N° 1 was maintained between 110 and 4884 NMP / 100ml, from segment N ° 0 (Headwater) and No. 11.

In the simulation section N ° 2, the variation of the inorganic phosphorus levels associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is presented in Illustration 5-87. The Mean Square Error (RMSE) resulting from the calibration of the field values - CF (c), with respect to the simulated values or prediction of the model QUAL2Kw CF (s), was on average 523.84 with a coefficient of normalized variation (CV%) of the order of 6.1%, where an error of less than 10% is indicative of the optimum adjustment of the parameter, therefore the model allows to predict in an appropriate way the evolution of the variable of interest in the study area. Fecal coliform data in the field along the simulation section N ° 1 they were maintained between 122 and 17329 NMP / 100ml, from segment No. 0 (Headwater) and No. 11.

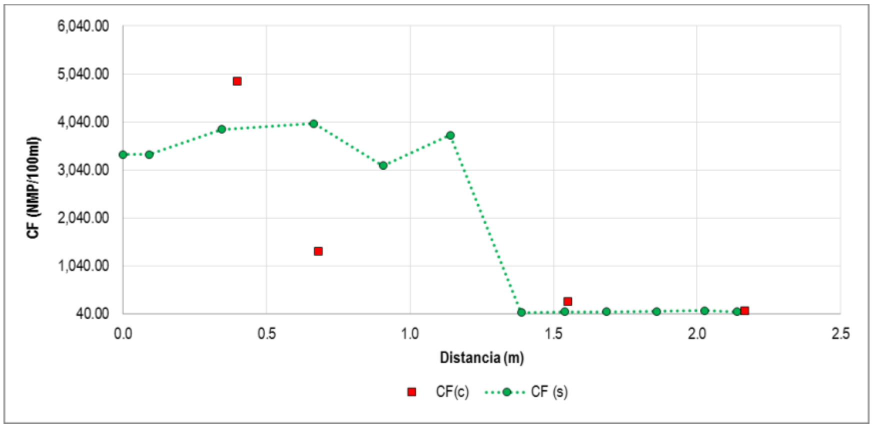


Illustration 5-86. Results calibration of fecal coliforms in the simulation section N ° 1
Source: INGEX, 2016

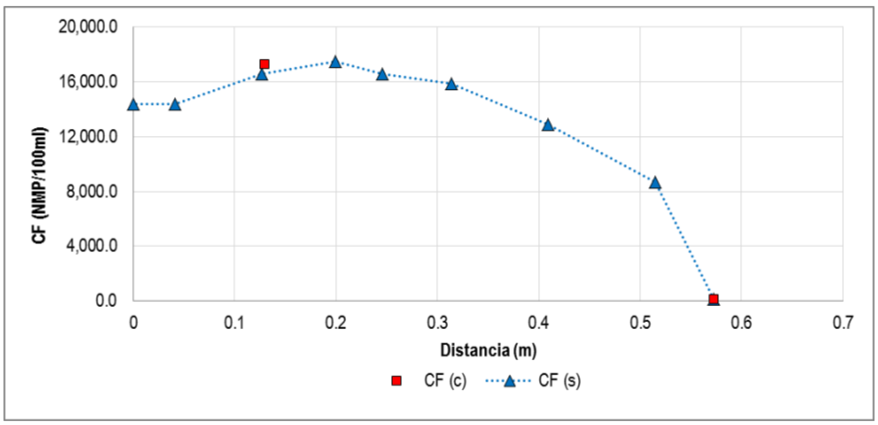


Illustration 5-87. Results calibration of fecal coliforms in the simulation section No. 2
Source: INGEX, 2016

5.3.1.6.8.10 Alkalinity

The behavior of the alkalinity levels in the simulation section N ° 1, associated with the current conditions without the inclusion of domestic wastewater discharges and not from the 5959 Concession, is related in Illustration 5-88. The Mean Square Error (RMSE) resulting from the calibration of the field values - Alk (c), with respect to the simulated values or prediction of the QUAL2Kw Alk (s) model, was on average 1.17, with a coefficient of Normalized variation (CV%) of the order of 2.07%, where an error of less than 10% is indicative of the optimal setting of the parameter. The alkalinity data in the field along the simulation section No. 1 were maintained between 51.8 and 59.8 mg / L, from segment No. 0 (Headwater) and No. 11.

In the simulation section N ° 2, the variation of alkalinity levels associated with the conditions current without the inclusion of domestic wastewater discharges and not from the Concession 5959, is presented in Illustration 5-89. The Mean Square Error (RMSE) resulting from the calibration of the field values - Alk (c), with respect to the simulated or prediction values of the model QUAL2Kw Alk (s), was on average 0.42 with a normalized coefficient of variation (CV%) of the order of 0.7%, where an error of less than 10% is indicative of the optimum adjustment of the parameter, therefore the model allows to predict in a suitable way the evolution of the variable of interest in the study area. The data of alkalinity in the field along the simulation section N ° 1 they maintained between 58.4 and 59.0 mg / L, from segment No. 0 (Headwater) and No. 11.

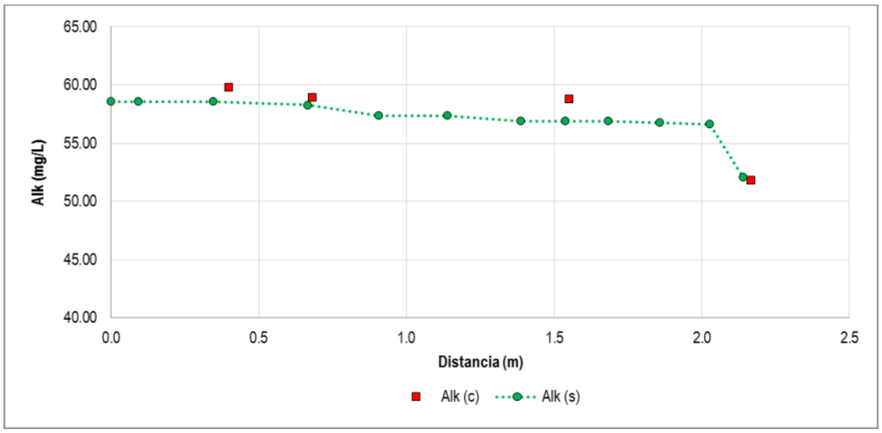


Illustration 5-88. Results calibration of the alkalinity in the simulation section N ° 1
Source: INGEX, 2016

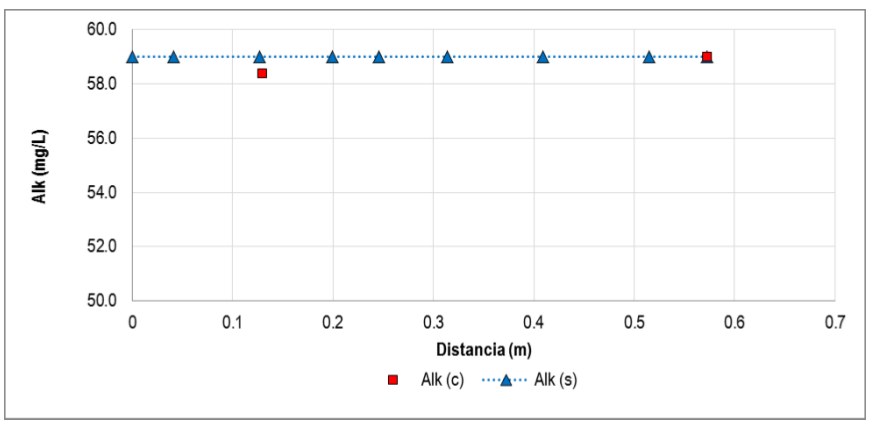


Illustration 5-89. Results calibration of the alkalinity in the simulation section N ° 2
Source: INGEX, 2016

5.3.1.6.8.11 Temperature

In Illustration 5-90 and Illustration 5-91 respectively, the results of the adjustment of the water temperature values in field - T (c) corresponding to simulation section N° 1 and 2. In all cases, a normalized coefficient of variation (CV%) of less than 10% was obtained, to the simulated data - T (s), therefore the model allows to predict in an appropriate way the evolution of the variable of interest in the study area. The temperature data in the field at the length of the section of the simulation sections was maintained between 25 and 29 ° C.

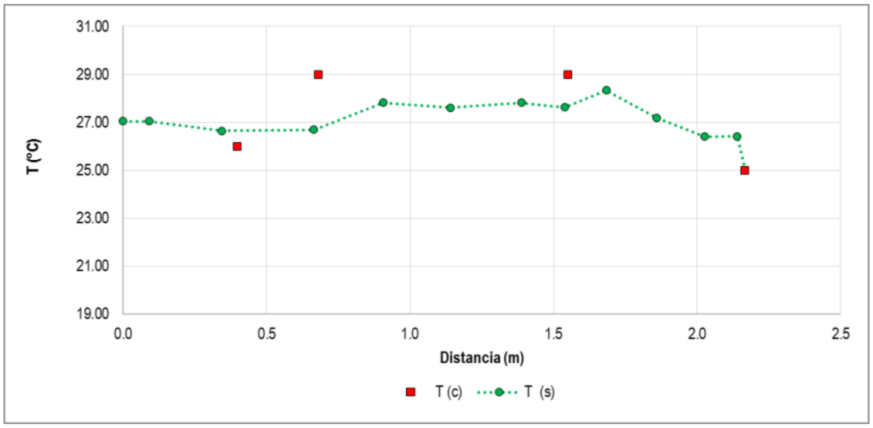


Illustration 5-90. Results calibration of the temperature in the simulation section N ° 1
Source: INGEX, 2016

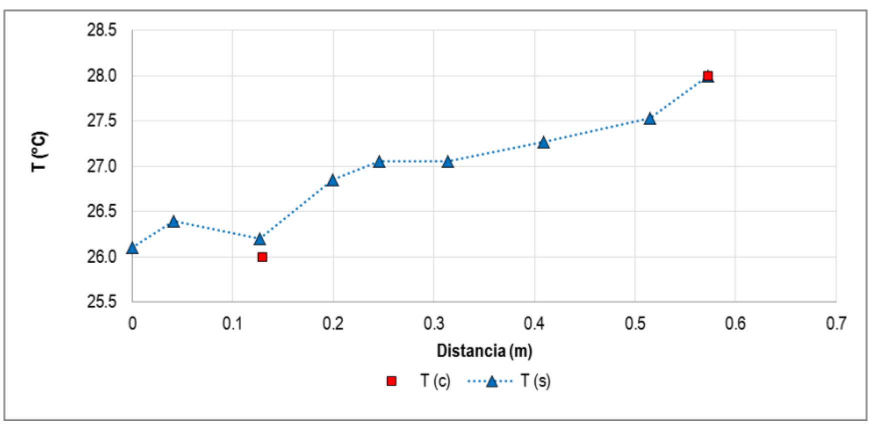


Illustration 5-91. Results calibration of the temperature in the simulation section N ° 2
Source: INGEX, 2016

5.3.1.6.8.12 pH

In Illustration 5-92 and illustration 5-93 respectively, the results of the adjustment of the pH values of the water in the field - pH (c) corresponding to simulation section No. 1 and 2. In all the cases a normalized coefficient of variation (CV%) of less than 10% was obtained with respect to the data simulated - pH (s), therefore the model allows to predict in a suitable way the evolution of the variable of interest in the study area. The pH data in the field along the stretch of the Simulation tranches were maintained between 6.48 and 7.14 u.s.

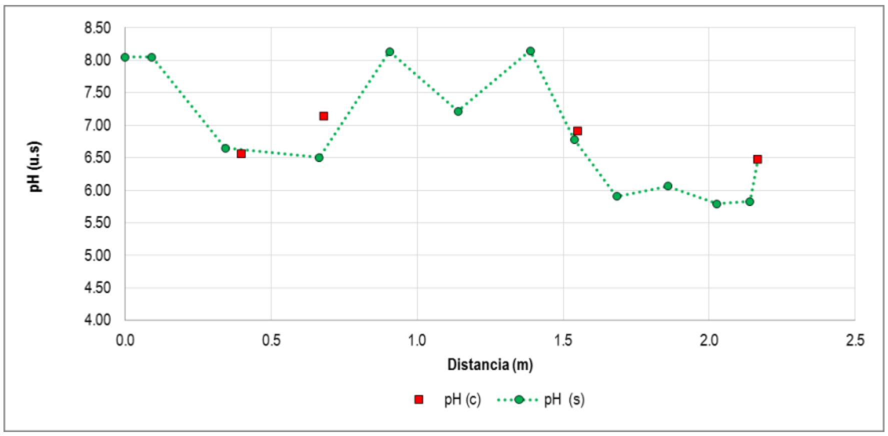


Illustration 5-92. Results calibration of the pH in the simulation section N ° 1
Source: INGEX, 2016

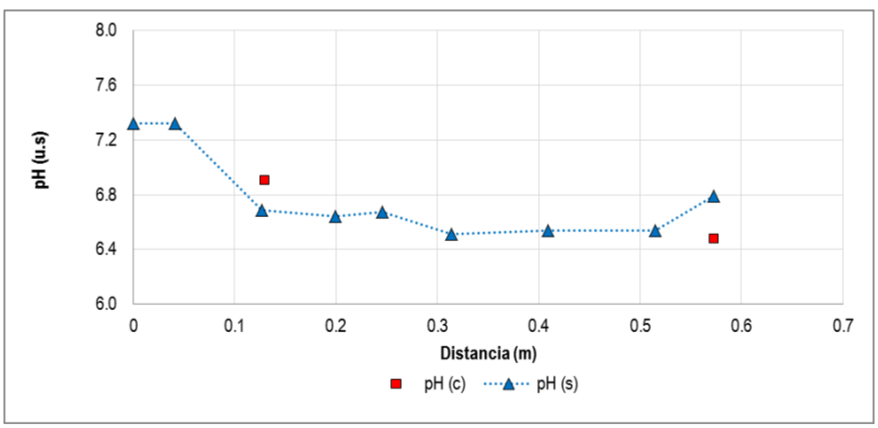


Illustration 5-93. Results calibration of the pH in the simulation section N ° 2
Source: INGEX, 2016

The calibration of the parameters of interest in each one of the defined simulation sections was carried out based on the adjustment of the flow rates and physical, chemical and microbiological characteristics of the diffuse sources, which was carried out by means of a Monte Carlo simulation coded in the YASAIw ® add-in from Visual Basic *for Applications*. This algorithm allows us to carry out a sensitivity analysis with respect to the variation of the parameters considered in diffuse sources. Internally, the YASAIw® complement generates random numbers in a deviation range defined by the user based on the desired value of the parameter in the simulation section; the values generated are evaluated in the functions ofQUAL2Kw in approximately 1000 simulations determining in percentage form, what value of each parameter generates a coefficient of variation (CV%) or minor relative error.

In Table 5-27. Physical, chemical, microbiological and hydraulic calibration of the diffuse sources associated with the simulation section N ° 1 and Table 5-28.Physical, chemical, microbiological and hydraulic calibration of the diffuse sources associated with the simulation section N ° 2, the results of the calibration of the diffuse sources located in the basins afferent to the simulation sections N ° 1 and 2, respectively. In this way in the simulation section N ° 1, a significant flow inflow is evidenced along the 2.17 and 1.55 km abscissa, in addition to the 0.68 and 0.40 km, with an abstraction of flow (*abstraction*) between the abscissas 1.55 and 0.68 km.

Table 5-27. Physical, chemical, microbiological and hydraulic calibration of the diffuse sources associated with the simulation section No. 1

Name	Up	Down	Abstraction	Inflow	T	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
	km	km	m^3/s	m^3/s	°C	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100 ml	mg/L	u.s
D1	2.17	1.55	---	0.03	38.40	135.20	29.80	0.72	5.31	2089.00	4260.00	37.12	23.12	400.00	59.80	4.00
D2	0.68	0.40	---	0.24	23.20	122.00	5.34	0.58	3.55	1276.00	2122.00	27.53	36.20	9000.00	59.80	5.67
D3	1.55	0.68	0.169	---	---	---	---	---	---	---	---	---	---	---	---	---

Source: INGEX, 2016

Table 5-28. Physical, chemical, microbiological and hydraulic calibration of the diffuse sources associated with the simulation section N ° 2

Name	Up	Down	Abstraction	Inflow	T	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
	km	km	m^3/s	m^3/s	°C	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100 ml	mg/L	u.s
D	0.57	0.13	---	0.04	17.90	115.00	14.30	3.20	3.82	1590.00	3197.00	28.80	65.00	78976.00	59.00	5.30

Source: INGEX, 2016

Additionally, in the simulation section N ° 2, a significant flow inflow is evidenced along the abscissa 0.57 and 0.13 km.

After the calibration of the QUAL2Kw model in the section the defined simulation sections, the performs environmental assessment of domestic and industrial wastewater discharges produced during the operation of the project.

5.3.1.6.9 Evaluation of scenarios

5.3.1.6.9.1 Hydraulic characteristics of surface water sources

The analysis of scenarios was made considering the reduction of the flows of the sources of surface water afferent to Concession 5969 as a consequence of the occurrence of droughts, besides an increase of the same ones in humid times represented by the flows maximum associated with the return period of 2.33 years. Taking into account that the campaigns of water quality monitoring and survey of cross sections and sources gauging of interest, were made during the expression of a dry period considered the condition hydrological of the ENSO (El Niño - Southern Oscillations), the current calibration condition was assumed as the critical scenario whose hydraulic characteristics are listed in Table 5-29. Characteristics hydraulic extreme condition.

Table 5-29. Hydraulic characteristics extreme condition.

Monitoring point	Cross section (m^2)	Speed (m/s)	Q (m^3/s)	Q (L/s)
P-01	0.057	0.300	0.017	17.100
P-02	0.313	0.297	0.093	92.961
P-03	0.300	0.344	0.103	103.200
P-04	0.423	0.140	0.059	59.220
P-07	0.272	0.403	0.110	109.616
P-08	0.143	0.410	0.059	58.630
P-10	0.495	0.680	0.337	336.600
P-11	0.668	0.687	0.459	458.916

Source: INGEX, 2016

The hydraulic characteristics established for the environmental evaluation of the shedding, are relate in Table 5-30 and Table 5-31 for the simulation section No. 1 and 2, respectively.

Table 5-30. Hydraulic characteristics wet condition simulation section No. 1.

Section (N°)	Flows	Speed	Sheet
	m^3/s	m/s	m
S1	3.92	0.73	0.87
S2	3.92	0.52	0.7
S3	14.18	2.58	1.06
S4	14.18	2.4	0.83
S5	19.19	2.64	1.07
S6	23.08	2.73	1.24
S7	23.08	1.84	1.14

Source: INGEX, 2016.

Table 5-31. Hydraulic characteristics wet condition simulation section No. 2

Section (N°)	Flow	Speed	Sheet
	m^3/s	m/s	m
S1	3.89	0.45	184.03
S2	3.89	0.4	177.53
S3	3.89	0.35	171.19

Source: INGEX, 2016.

5.3.1.6.9.2 Physical, chemical and microbiological characteristics of surface water.

For the analysis of dumping scenarios, the physical characteristics will be kept constant, chemical and microbiological tests in the simulation sections and diffused sources previously calibrated.

5.3.1.6.9.3 Physical, chemical and microbiological characteristics of surface water.

Given the form of operation of the associated non-domestic wastewater treatment system to Tails N ° 3, which is a sedimentation pool that will be enabled that additionally works as a water storage system for its later use, however, without these discharges it will be considered in the evaluation of scenarios. Finally, the projected flows for domestic and industrial wastewater discharges from the mining project, are listed in Table 5-32.

Table 5-32. Flows projected for the discharges of the Mining Project - Concession 5969.

ID	Description	Type	Flow (m^3/day)	Flow (L/s)
V1	Shedding tails N° 1 of flotation	ARnD	200.0	2.315
V2	Shedding tails N° 2 of cyanide	ARnD	150.0	1.736
V3	Shedding tails N° 3 of flotation	ARnD	200.0	2.315
V4	Shedding of camp	ARD	12.0	0.139
V5	Shedding of other sanitary units	ARD	8.0	0.093

Source: INGEX, 2016.

Based on Decree 1076 of 2015, Section N ° 5 "Obtaining discharge permits and compliance plans", when considering Articles N ° 2.2.3.3.5.1, 2.2.3.3.5.2 and which retake the requirements of the environmental assessment listed in Articles No. 41, 42 and 43 of the Decree 3930 of 2010, which by Resolution 0631 of 2015 define the maximum permissible limits in the discharges of domestic and industrial wastewater over bodies of surface water and sewer network, it is possible to establish the maximum concentrations expected in the Discharges associated with the 5969 Concession.

Table 5-33 and Table 5-34 show the maximum permissible limits defined for the discharges of domestic wastewater (ARD) and non-domestic wastewater (ARnD) of the mining project "El Pescado".

Table 5-33. Maximum allowable limit (LMP) for ARD discharges (Article No. 8 Resolution 0631 of 20115).

Parameter	Units	LMP
pH	u.s	6.0 – 9.0
Chemical Oxygen Demand (DQO)	mg/L	200
Biochemical Oxygen Demand (DBO_5)	mg/L	90
Solids Suspended Totals (SST)	mg/L	100
Settleable solids (SSED)	ml/L	5
Greases and Oils (G&A)	mg/L	20

Source: INGEX, 2016.

Table 5-34. Maximum allowable limit (LMP) in discharges of ARnD (Article No. 10 Resolution 0631 of 2015).

Parameter	Units	Reference
pH	Units de pH	6.0 - 9.0
Chemical Oxygen Demand (DQO)	mg/L O2	150
Biochemical Oxygen Demand (DBO_5)	mg/L O2	50
Solids Suspended Totals (SST)	mg/L	50
Settleable solids (SSED)	mL/L	2
Greases and Oils	mg/L	10
Phenols	mg/L	0.2
Active Substances to Methylene Blue (SAAM)	mg/L	Analysis and Report
Hydrocarbons		
Total Hydrocarbons (HTP)	mg/L	10
Phosphorus compounds		
Orthophosphates ($P\text{-}PO_4^{3-}$)	mg/L	Analysis and Report
Total Phosphorus (P)	mg/L	Analysis and Report
Nitrogen compounds		
Nitrates ($N\text{-}NO_3^-$)	mg/L	Analysis and Report
Nitrites ($N\text{-}NO_2^-$)	mg/L	Analysis and Report
Ammonia Nitrogen ($N\text{-}NH_3$)	mg/L	Analysis and Report
Total Nitrogen (N)	mg/L	Analysis and Report
Ions		
Total Cyanide (CN-)	mg/L	1
Chlorides (Cl-)	mg/L	250
Sulfates (SO_4^{2-})	mg/L	1.200
Sulfides (S^{2-})	mg/L	1
Metals and Metalloids		

Parameter	Units	Reference
Arsenic (As)	mg/L	0.1
Cadmium (Cd)	mg/L	0.05
Zinc (Zn)	mg/L	3
Copper (Cu)	mg/L	1
Chromium (Cr)	mg/L	0.5
Iron (Fe)	mg/L	2
Mercury (Hg)	mg/L	0.002
Nickel (Ni)	mg/L	0.5
Lead (Pb)	mg/L	0.2
Other Parameters for Analysis and Reporting		
Acidity Total	mg/L $CaCO_3$	Analysis and Report
Total Alkalinity	mg/L $CaCO_3$	Analysis and Report
Calcium Hardness	mg/L $CaCO_3$	Analysis and Report
Hardness Total	mg/L $CaCO_3$	Analysis and Report
Real Color	m^{-1}	Analysis and Report

Source: INGEX, 2016.

In general terms, within the parameters related in the simulation of shedding that present numerical values defined as maximum permissible limits, different from the reference "Analysis and Reporting", establishes the hydrogen potential (pH), the temperature of the water (T), the biochemical oxygen demand (BOD) and total suspended solids (TSS); therefore not the concentrations of nitrogen and phosphorus species in the effluent of the systems are defined of treatment.

In Table 5-35, the physical and chemical characteristics projected for the dumping are related Wastewater from Concession 5969. In accordance with Article N ° 5 and 6 of the Resolution 0631 assumed an average temperature of the effluents of each treatment system of the order of 30 ° C, with a pH of approximately 7.5 u.s.

Table 5-35. Quality of the projected dumping (evaluation of simulation scenarios).

ID	Description	Type	T (°C)	pH (u.s)	DBO (mg/L)	SST (mg/L)
V1	Shedding relay N° 1 of flotation	ARnD	30	7.5	50	50
V2	Shedding relay N° 2 of cyanide	ARnD	30	7.5	50	50
V3	Shedding relay N° 3 of flotation	ARnD	30	7.5	50	50
V4	Shedding of camp	ARD	30	7.5	90	100
V5	Shedding of other sanitary units	ARD	30	7.5	90	100

Source: INGEX, 2016.

Regarding the content of nitrogen and phosphorus species, in addition to fecal coliforms in the discharge, it was considered a low value of typical characteristics of wastewater municipalities without treatment (see Table 5-36), established in the management guide for management, treatment and final disposal of municipal wastewater (SINA, 2002). It was assumed a 50:50 total nitrogen distribution based on nitrate and ammonium content, as well as in organic and inorganic phosphorus species.

Table 5-36. Typical characteristics of wastewater (SINA, 2002).

Parameter	u.s	Reference		
		High	Low	Average
Total nitrogen (N)	mg/L	80	50	25
Total phosphorus (P)	mg/L	20	15	5
Fecal Coliforms (CF)	NMP/100ml	1.0×10^9	1.0×10^7	1.0×10^5

Source: INGEX, 2016.

In the case of dissolved oxygen levels, a totally anoxic discharge (0 mg / L) was considered as a more critical condition, additionally the average values of conductivity were used electrical and alkalinity reported in the field for the simulation sections analyzed, 120 µS / cm and 58 mg / L, respectively.

5.3.1.6.10 Results

5.3.1.6.10.1 Simulation section No. 1

From Table 5-37 to Table 5-39, the results of the scenario simulation of the discharges associated with the operation of the project, where scenario E1 corresponds to the condition of dry season (dry season) without shedding; E2 the condition of low water with the inclusion of the shedding of Concession 5969 and, E3, the wet condition referred to the maximum flows of the period of return of 2.33 years in the affluent basins including the discharges of the 5969 Concession. The behavior of each of the parameters is related to Illustration 5-94. Simulation of scenarios (Flow). To Illustration 5-106.

For the purposes of determining the length of influences of shedding, the results were considered of the scenarios associated with the flows of low water periods, in this case E1 and E2, given that the scenario of wet conditions - E3, favors dilution processes due to the increase in flow rates.

Table 5-37. Results simulation of Scenario N ° 1

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
Km	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100ml	mg/L	u.s
2.166	102.00	7.00	5.80	3.00	1.00	1.50	0.03	0.03	110.00	51.80	6.48
2.140	103.23	7.62	7.86	3.02	1.02	1.43	0.03	0.02	88.55	52.10	5.83
2.027	116.26	8.15	7.49	3.01	1.02	1.47	0.03	0.03	113.34	56.62	5.79
1.859	117.09	8.92	7.81	3.03	1.04	1.47	0.03	0.02	99.29	56.76	6.06
1.684	117.94	9.69	7.63	3.04	1.05	1.46	0.03	0.02	90.44	56.90	5.91
1.538	118.07	8.70	7.72	3.00	1.02	1.45	0.03	0.04	86.88	56.88	6.78
1.388	118.07	8.57	7.75	2.93	0.97	1.37	0.02	0.03	72.60	56.88	8.15
1.140	116.81	8.55	7.63	2.86	0.94	1.32	0.02	0.03	3764.26	57.35	7.22
0.907	116.81	8.44	7.76	2.80	0.90	1.25	0.02	0.03	3125.25	57.35	8.14
0.665	118.78	7.16	6.91	2.99	1.01	1.51	0.02	0.03	4007.63	58.28	6.51
0.344	119.43	6.71	7.19	3.02	1.03	1.57	0.03	0.03	3885.41	58.59	6.65
0.091	119.43	6.65	7.84	2.96	1.01	1.52	0.02	0.03	3361.11	58.59	8.05
0.000	119.43	6.65	7.84	2.96	1.01	1.52	0.02	0.03	3361.11	58.59	8.05

Source: INGEX, 2016

Table 5-38. Simulation results of Scenario No. 2

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
km	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100ml	mg/L	u.s
2.166	102.00	7.00	5.80	3.00	1.00	1.50	0.03	0.03	110.00	51.80	6.48
2.140	103.23	7.62	7.86	3.02	1.02	1.43	0.03	0.02	88.55	51.80	7.39
2.027	116.26	8.15	7.49	3.01	1.02	1.47	0.03	0.03	113.34	51.98	6.97
1.859	117.09	8.92	7.81	3.03	1.04	1.47	0.03	0.02	99.29	52.00	7.16
1.684	117.96	10.09	7.61	3.50	1.16	1.57	0.05	0.04	804.59	52.02	7.01
1.538	118.08	8.95	7.72	3.28	1.09	1.52	0.04	0.05	465.38	52.15	7.60
1.388	118.10	9.16	7.72	3.59	1.13	1.52	0.06	0.06	1022.86	52.15	8.13
1.140	116.85	8.95	7.63	3.30	1.05	1.42	0.05	0.05	4245.13	52.30	7.92
0.907	116.85	8.84	7.75	3.24	1.01	1.35	0.05	0.04	3551.00	52.30	8.16
0.665	118.79	7.42	6.92	3.26	1.07	1.56	0.04	0.04	4224.19	52.56	7.31
0.344	119.43	6.92	7.19	3.22	1.08	1.61	0.04	0.04	4034.27	52.72	7.50
0.091	119.43	6.86	7.84	3.16	1.05	1.56	0.04	0.03	3497.87	52.72	8.08
0.000	119.43	6.86	7.84	3.16	1.05	1.56	0.04	0.03	3497.87	52.72	8.08

Source: INGEX, 2016

Table 5-39. Simulation results of Scenario No. 3

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
km	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100ml	mg/L	u.s
2.166	102.00	7.00	5.80	3.00	1.00	1.50	0.03	0.03	110.00	51.80	6.48
2.140	102.02	7.01	8.09	3.00	1.00	1.51	0.02	0.02	108.40	51.80	7.39
2.027	102.55	7.05	8.12	3.00	1.00	1.51	0.02	0.03	105.66	51.98	6.97
1.859	102.60	7.09	8.15	2.99	1.00	1.52	0.02	0.03	102.58	52.00	7.16
1.684	102.67	7.15	8.14	3.01	1.00	1.53	0.03	0.03	140.75	52.02	7.01
1.538	103.10	7.16	8.14	3.01	1.00	1.53	0.03	0.03	136.63	52.15	7.60
1.388	103.10	7.18	8.14	3.03	1.01	1.54	0.03	0.03	184.51	52.15	8.13
1.140	103.37	7.22	8.12	3.01	1.00	1.54	0.03	0.03	561.66	52.30	7.92
0.907	103.37	7.22	8.14	3.01	1.00	1.54	0.03	0.03	540.22	52.30	8.16
0.665	104.02	7.15	8.01	3.01	1.00	1.56	0.03	0.03	777.97	52.56	7.31
0.344	104.40	7.11	8.07	3.01	1.01	1.57	0.03	0.03	883.62	52.72	7.50
0.091	104.40	7.11	8.14	3.00	1.00	1.57	0.03	0.03	840.04	52.72	8.08
0.000	104.40	7.11	8.14	3.00	1.00	1.57	0.03	0.03	840.04	52.72	8.08

Source: INGEX, 2016.

The influence analysis of the discharges of domestic and non-domestic wastewater from the mining project "El Pescado" associated with the occurrence of dry season or dry periods, was performed considering the Mean Quadratic Error (RMSE) and the coefficient of variation (CV%) between the prediction data of scenario E1 and E2 in simulation section N ° 2. The results of Analysis of influence are presented in Table 5-40.

Table 5-40. Analysis of the influence of the shedding (simulation section N ° 2)

Parameter	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
RMSE	0.02	0.29	0.01	0.32	0.08	0.07	0.02	0.01	399.54	4.80	0.82
CV%	0%	4%	0%	10%	7%	5%	55%	45%	22%	9%	11%

Source: INGEX, 2016.

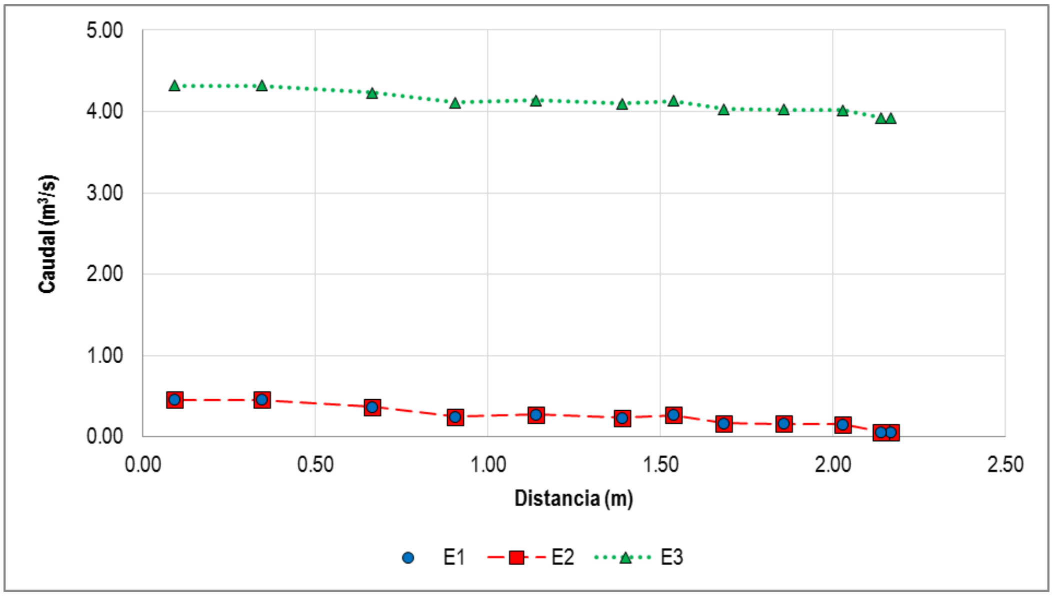


Illustration 5-94. Simulation of scenarios (Flow).
Source: INGEX, 2016.

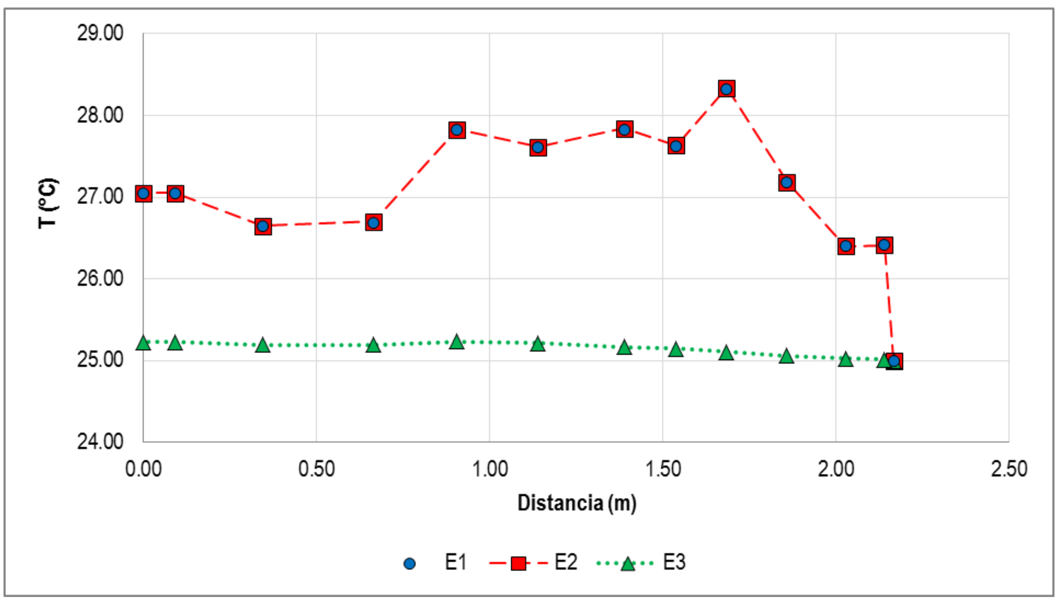


Illustration 5-95. Simulation of scenarios (Temperature)
Source: INGEX, 2016.

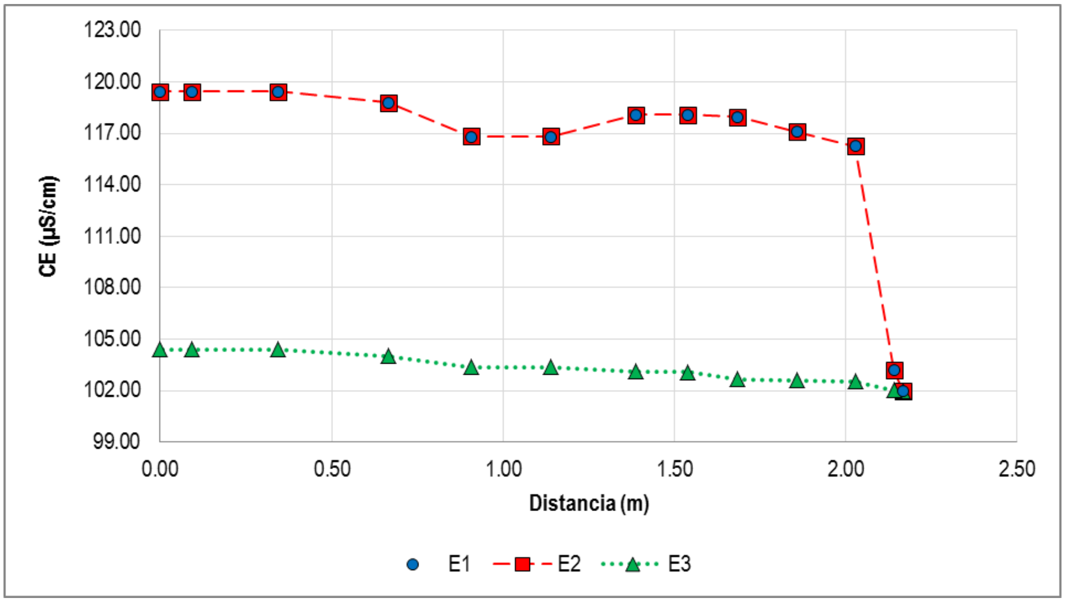


Illustration 5-96. Simulation of scenarios (Electrical conductivity)
Source: INGEX, 2016.

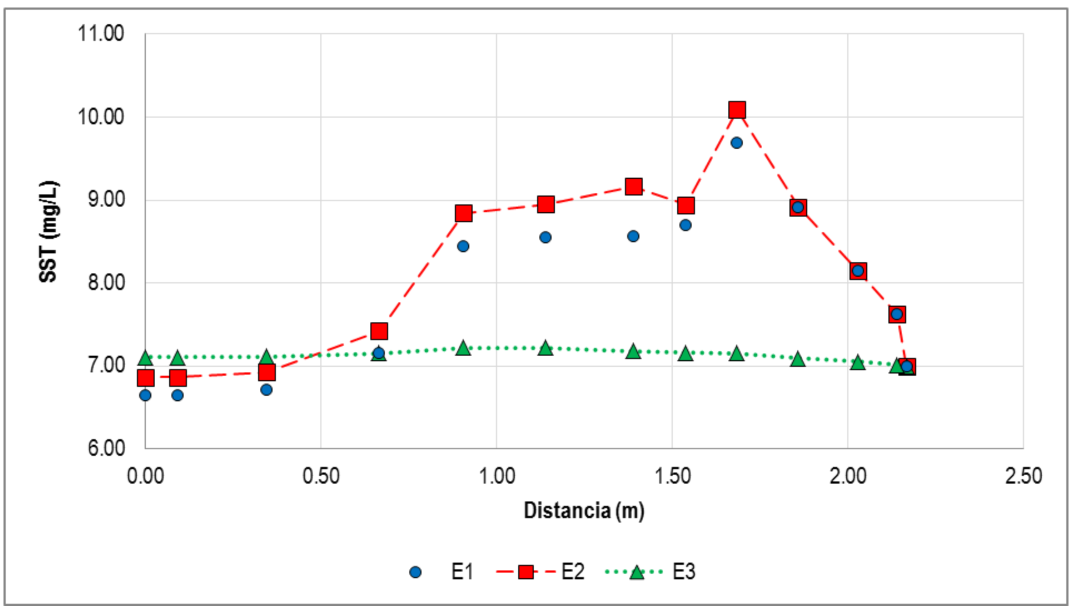


Illustration 5-97. Simulation of scenarios (Total suspended solids)
Source: INGEX, 2016.

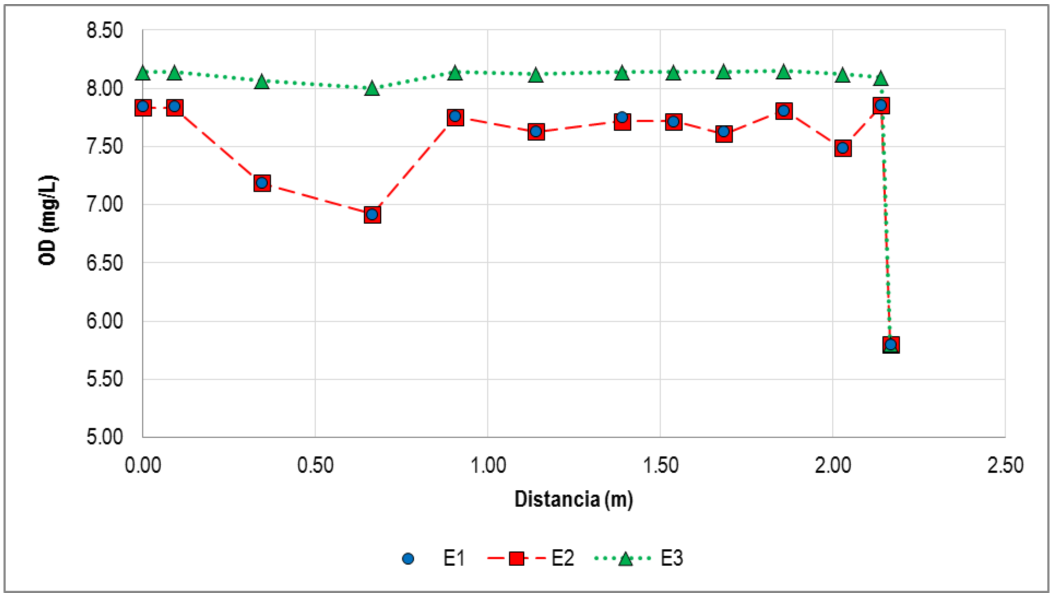


Illustration 5-98. Scenario simulation (dissolved oxygen)
Source: INGEX, 2016.

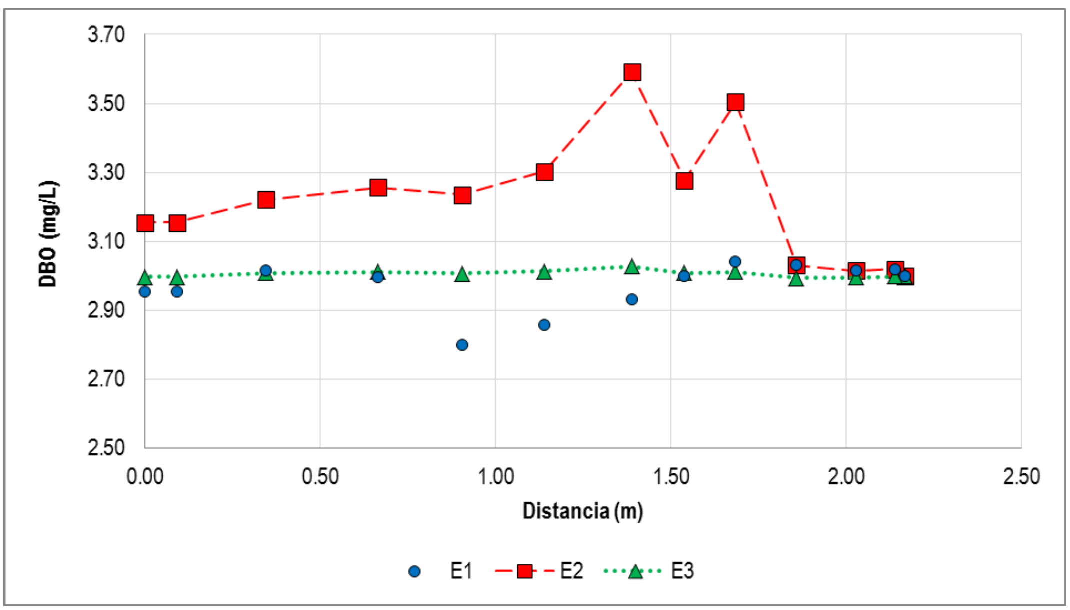


Illustration 5-99. Scenario simulation (biochemical oxygen demand)
Source: INGEX, 2016.

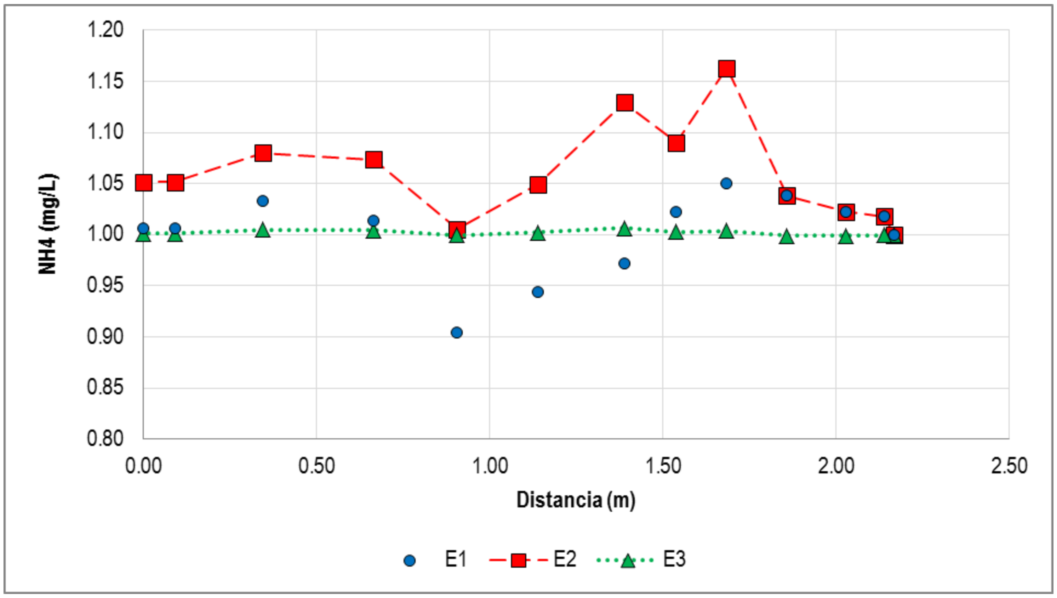


Illustration 5-100. Simulation of scenarios (Ammonium)
Source: INGEX, 2016.

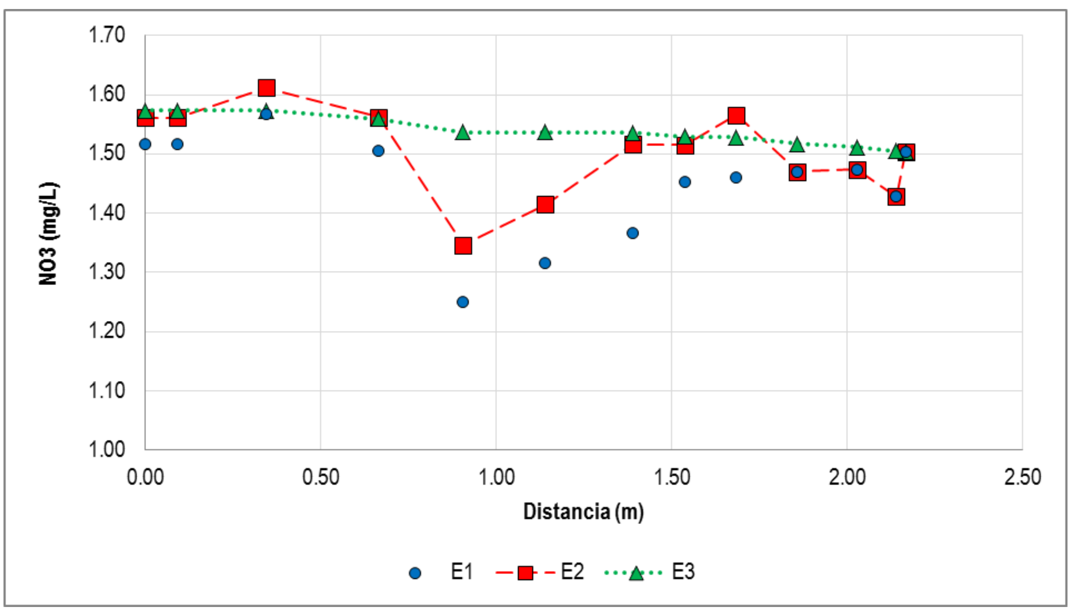


Illustration 5-101. Simulation of scenarios (Nitrates)
Source: INGEX, 2016.

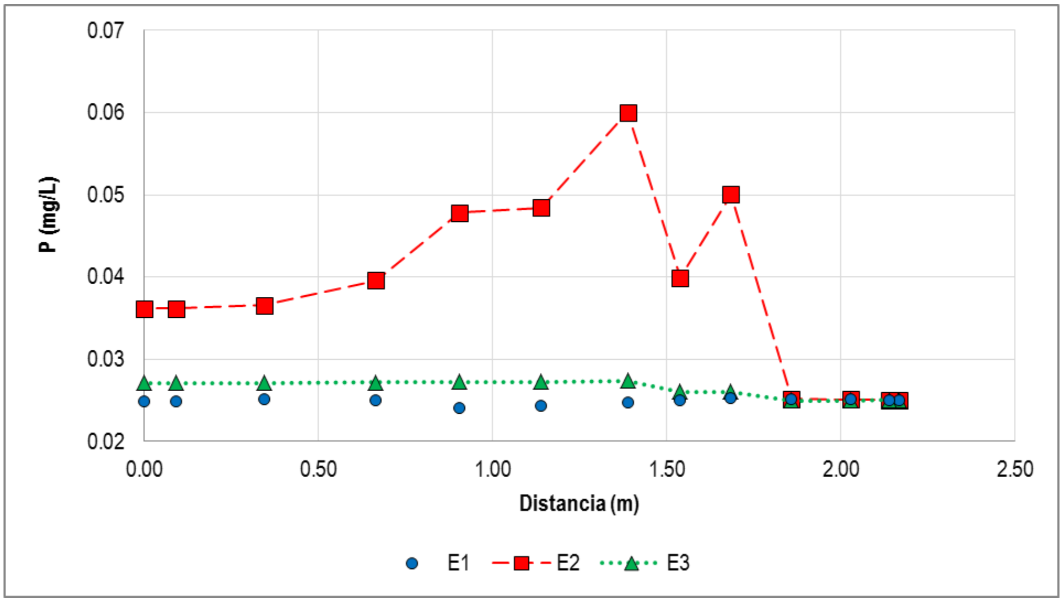


Illustration 5-102. Scenario simulation (Organic phosphorus)
Source: INGEX, 2016.

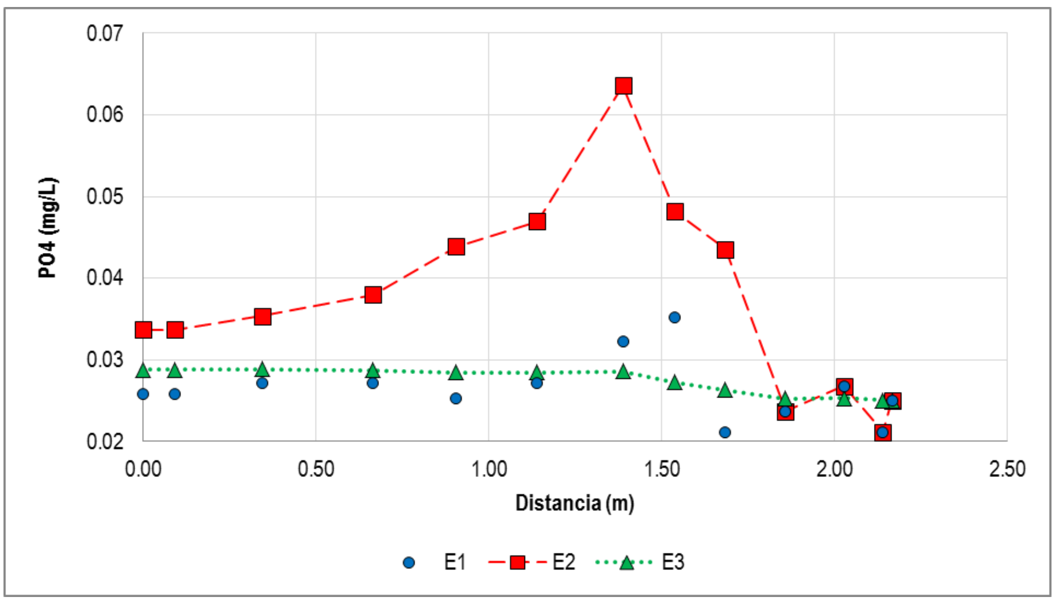


Illustration 5-103. Scenario simulation (inorganic phosphorus)
Source: INGEX, 2016.

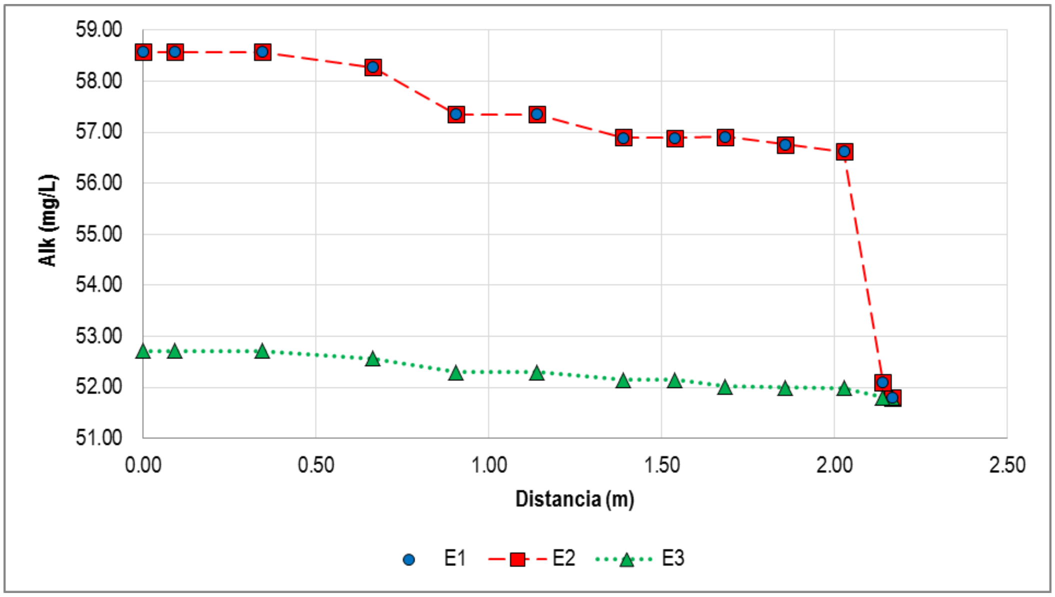


Illustration 5-104. Scenario simulation (Alkalinity)
Source: INGEX, 2016.

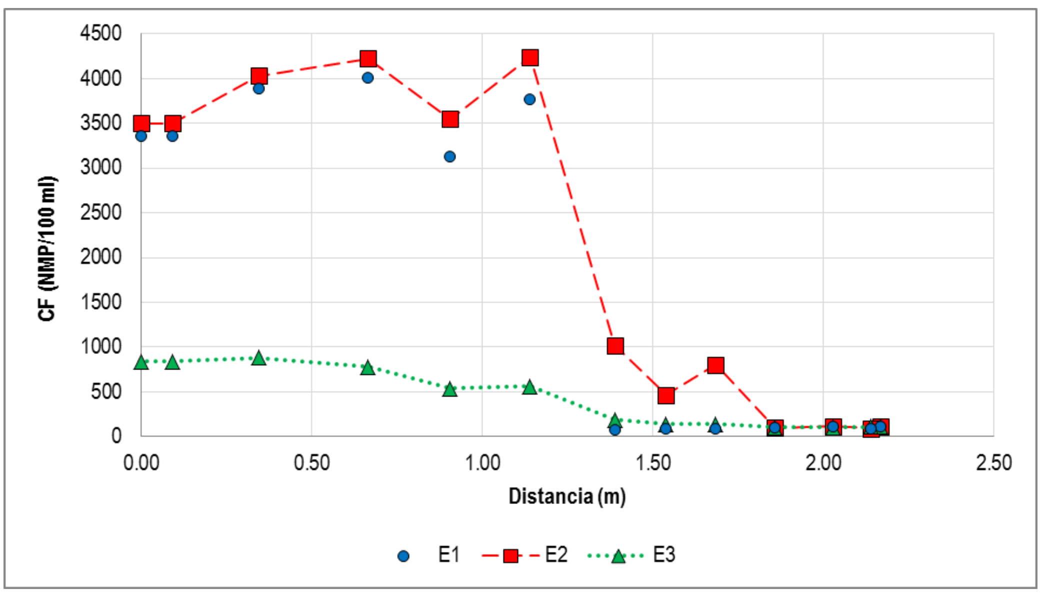


Illustration 5-105. Simulation of scenarios (fecal coliforms)
Source: INGEX, 2016.

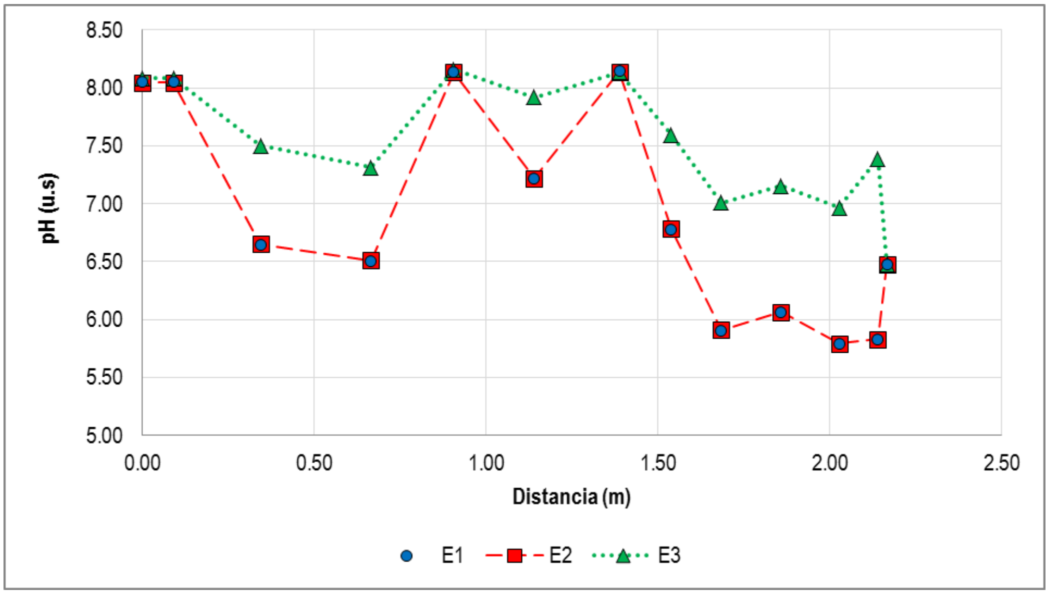


Illustration 5-106. Simulation of scenarios (pH)
Source: INGEX, 2016.

In accordance with the results obtained, there are important variations in the demand oxygen biochemistry, organic and inorganic phosphorus, fecal coliforms and pH, if taken into account coefficients of variation greater than 10%, which is defined by the magnitude of the data used in your determination. Taking as reference the concentrations mentioned above in the last segment (No. 11) for the scenarios of interest, we have:

- **Biochemical oxygen demand:** The dumping of wastewater produced in the mining project "El Pescado" generates an increase in biochemical oxygen demand, from 2.96 to 3.16 mg / L, compared to the scenario of current conditions without dumping.
- **Organic phosphorus:** The dumping of wastewater produced in the mining project "El Fish" generates an increase in nitrate levels, from 0.02 to 0.04 mg / L, regarding the scenario of current conditions without dumping.
- **Inorganic phosphorus:** The dumping of wastewater produced in the mining project "El Fish" generates an increase in nitrate levels, from 0.025 to 0.033 mg / L, regarding the scenario of current conditions without dumping.
- **Fecal coliforms:** The dumping of wastewater produced in the mining project "El Fish" generates an increase in fecal coliform content, passing 3361.11 to 3497.87 mg / L, with respect to the scenario of current conditions without dumping.
- **pH:** The dumping of wastewater produced in the "El Pescado" mining project generates an increase in pH levels, from 8.05 to 8.08 mg / L, compared to the scenario of current conditions without shedding.

In order to reduce the uncertainty associated with the magnitude or scale of the parameters analyzed, an analysis of variance of the simulation scenarios was performed, these results are presented in the Table 5-41.

Table 5-41. Results analysis of variance (ANOVA)

Source	Sum of squares	Degrees of freedom	Average of squares	F	Probability	Critical values for F
DBO - μ (E1) = μ (E2)	0.381	1	0.381	19.60	0.000178	4.26
P - μ (E1) = μ (E2)	0.001	1	0.001	17.92	0.000292	4.26
PO4 - μ (E1) = μ (E2)	0.001	1	0.001	9.48	0.005150	4.26
CF - μ (E1) = μ (E2)	495278	1	495278	0.15	0.703479	4.26
pH - μ (E1) = μ (E2)	2.581	1	2.58	4.52	0.044084	4.26

Source: INGEX, 2016

According to the results obtained, given that the values of F for all the sources are higher than the critical value of F, the null hypothesis with a statistical significance of 95% is accepted, In this way, it is concluded that there are no significant differences between the results of the simulations of the E1 and E2 scenarios, consequently the influence length of the shedding prevail within the simulation section N ° 1, that is, it does not exceed segment N ° 11. The pouring point of the flotation tailings treatment system No. 1 the maximum length of the discharge of wastewater from the 5969 Concession amounts to 2.09 km.

5.3.1.6.10.2 Simulation section No. 2

From Table 5-42 to Table 5-44, the results of the scenario simulation of the discharges associated with the operation of the project, where scenario E1 corresponds to the condition of dry season (dry season) without shedding; E2 the condition of low water with the inclusion of the shedding of Concession 5969 and, E3, the wet condition referred to the maximum flows of the period of return of 2.33 years in the affluent basins including the discharges of the 5969 Concession. Behavior of each of the parameters is related from Illustration 5-108 to the Illustration 5-119.

For the purposes of determining the length of influences of shedding, the results were considered of the scenarios associated with the flows of low water periods, in this case E1 and E2, given that the scenario of wet conditions - E3, favors dilution processes due to the increase in flow rates.

Table 5-42. Results simulation of Scenario N ° 1

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
km	**µS/cm**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**NMP/100ml**	**mg/L**	**u.s**
0.573	115.00	7.00	5.30	3.00	1.00	1.50	0.03	0.03	122.00	59.00	6.79
0.515	115.00	7.87	7.72	3.04	1.06	1.52	0.03	0.03	8719.04	59.00	7.00
0.409	115.00	8.40	7.77	3.06	1.09	1.54	0.03	0.03	12932.64	59.00	6.94
0.314	115.00	8.83	7.79	3.08	1.11	1.57	0.03	0.03	15899.27	59.00	6.90
0.246	115.00	8.96	7.85	3.08	1.12	1.57	0.03	0.03	16597.37	59.00	7.10
0.199	115.00	9.12	7.85	3.09	1.13	1.56	0.03	0.03	17502.14	59.00	7.01
0.127	115.00	9.11	7.86	3.06	1.12	1.48	0.02	0.02	16588.16	59.00	7.13

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
km	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100ml	mg/L	u.s
0.041	115.00	8.92	7.90	3.00	1.05	1.35	0.02	0.02	14383.96	59.00	8.20
0.000	115.00	8.92	7.90	3.00	1.05	1.35	0.02	0.02	14383.96	59.00	8.20

Source: INGEX, 2016.

Table 5-43. Simulation results of Scenario No. 2

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
km	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100ml	mg/L	u.s
0.573	115.00	7.00	5.30	3.00	1.00	1.50	0.03	0.03	122.00	59.00	6.79
0.515	115.16	9.18	7.69	4.50	1.29	1.82	0.10	0.09	10738.34	58.97	6.79
0.409	115.14	9.52	7.77	4.34	1.16	1.78	0.09	0.08	14287.32	58.97	6.79
0.314	115.13	9.81	7.79	4.20	1.18	1.77	0.09	0.07	16871.54	58.97	7.04
0.246	115.12	9.89	7.84	4.15	1.18	1.75	0.08	0.06	17451.52	58.98	7.11
0.199	115.12	10.08	7.84	4.16	1.19	1.74	0.08	0.06	18284.03	58.98	5.85
0.127	115.12	10.02	7.86	4.07	1.10	1.63	0.08	0.05	17261.03	58.98	5.85
0.041	115.12	9.93	7.90	4.12	1.02	1.50	0.08	0.05	15108.05	58.98	7.70
0.000	115.12	9.93	7.90	4.12	1.02	1.50	0.08	0.05	15108.05	58.98	7.70

Source: INGEX, 2016.

Table 5-44. Simulation results of Scenario No. 3

Abscissa	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
km	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	NMP/100ml	mg/L	u.s
0.573	115.00	7.00	5.30	3.00	1.00	1.50	0.03	0.03	122.00	59.00	6.79
0.515	115.16	9.18	7.69	4.50	1.29	1.82	0.10	0.09	10738.34	58.97	6.79
0.409	115.14	9.52	7.77	4.34	1.16	1.78	0.09	0.08	14287.32	58.97	6.79
0.314	115.13	9.81	7.79	4.20	1.18	1.77	0.09	0.07	16871.54	58.97	7.04
0.246	115.12	9.89	7.84	4.15	1.18	1.75	0.08	0.06	17451.52	58.98	7.11
0.199	115.12	10.08	7.84	4.16	1.19	1.74	0.08	0.06	18284.03	58.98	5.85
0.127	115.12	10.02	7.86	4.07	1.10	1.63	0.08	0.05	17261.03	58.98	5.85
0.041	115.12	9.93	7.90	4.12	1.02	1.50	0.08	0.05	15108.05	58.98	7.70
0.000	115.12	9.93	7.90	4.12	1.02	1.50	0.08	0.05	15108.05	58.98	7.70

Source: INGEX, 2016.

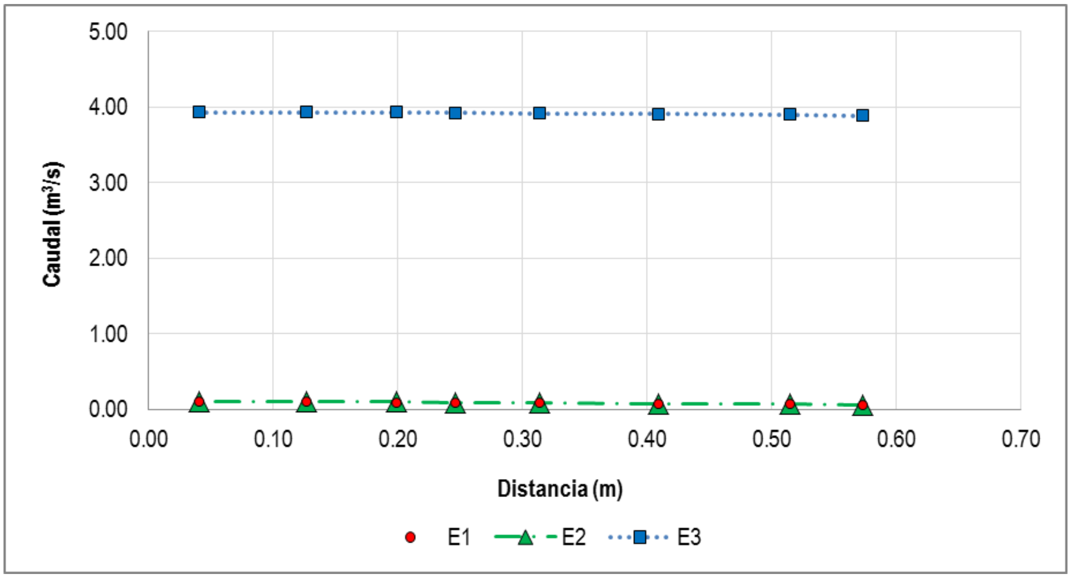


Illustration 5-107. Scenario simulation (Flow)
Source: INGEX, 2016.

The influence analysis of the discharges of domestic and non-domestic wastewater from the mining project "El Pescado" associated with the occurrence of dry season or dry periods, was performed considering the Mean Quadratic Error (RMSE) and the coefficient of variation (CV%) between the prediction data of scenario E1 and E2 in simulation section N ° 2. The results of Analysis of influence are presented in Table 5-45.

Table 5-45. Analysis of the influence of the shedding (simulation section N ° 1)

Parameter	CE	SST	OD	DBO	NH4	NO3	P	PO4	CF	Alk	pH
RMSE	0.12	0.98	0.01	1.10	0.09	0.19	0.06	0.04	1038.18	0.02	0.63
CV%	0%	11%	0%	31%	8%	12%	111%	92%	8%	0%	9%

Source: INGEX, 2016.

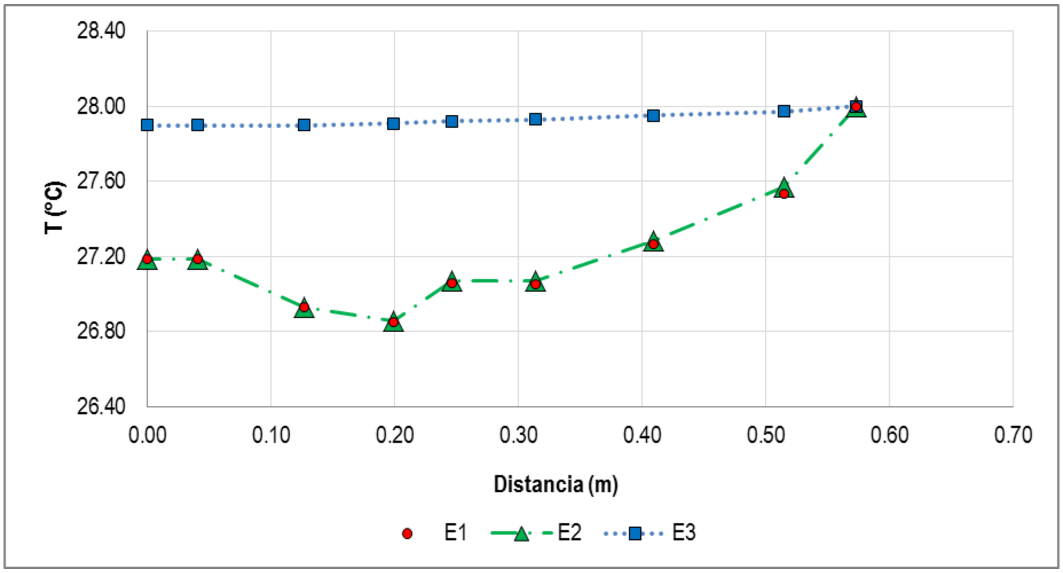


Illustration 5-108. Simulation of scenarios (Temperature)
Source: INGEX, 2016.

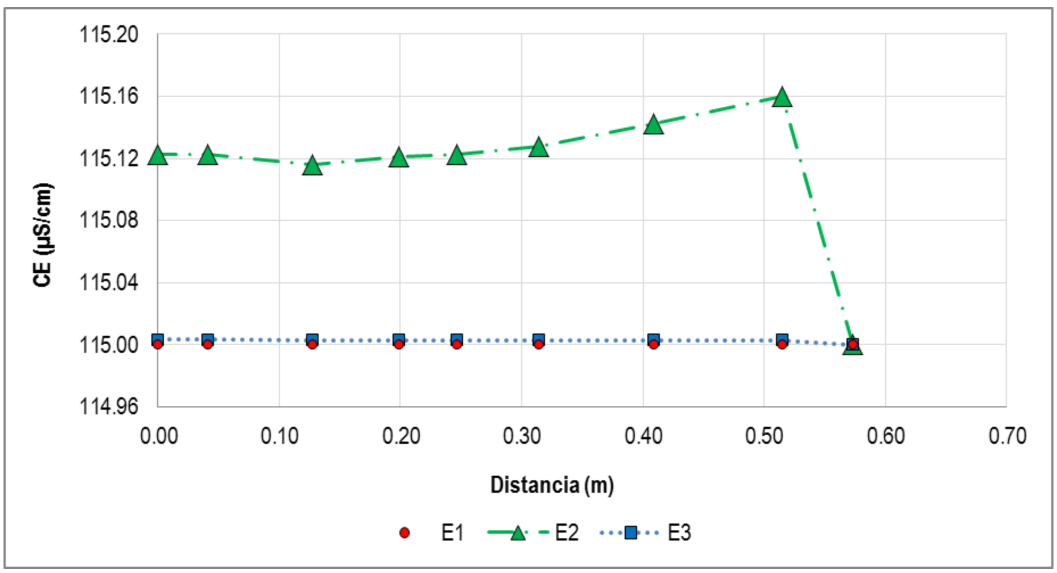


Illustration 5-109. Simulation of scenarios (Electrical conductivity)
source: INGEX, 2016.

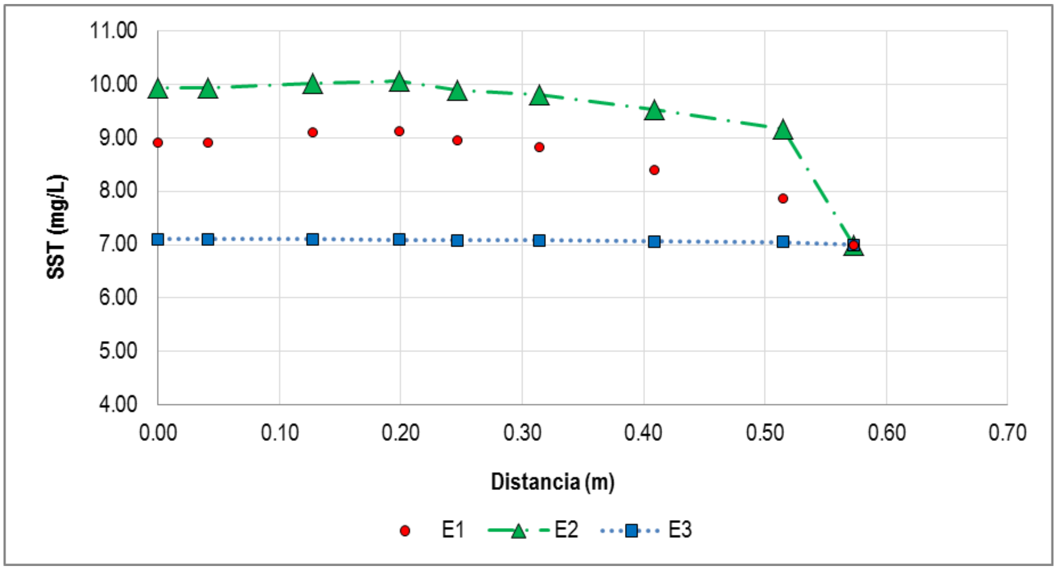


Illustration 5-110. Simulation of scenarios (Total suspended solids)
Source: INGEX, 2016.

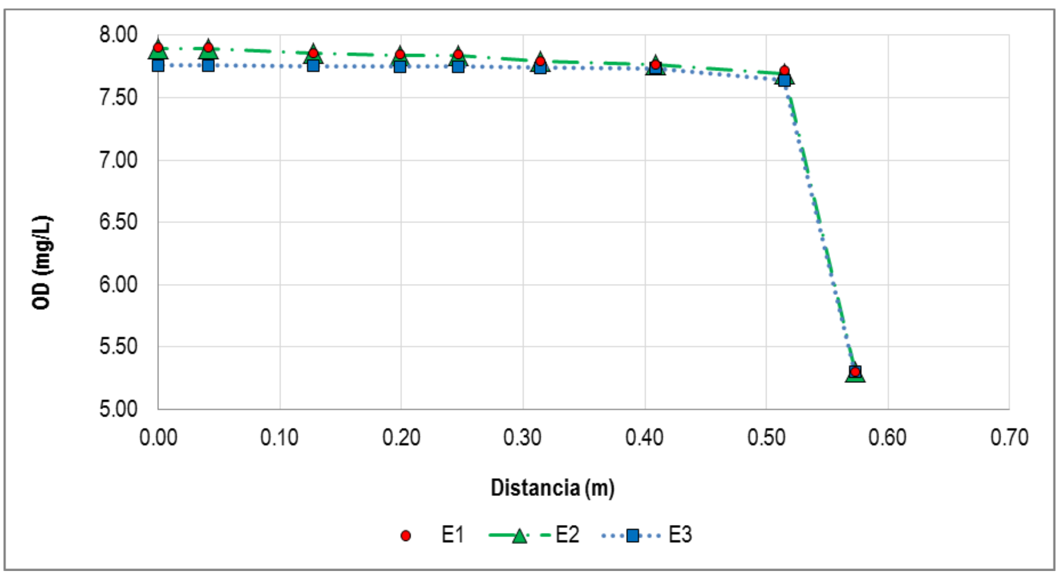


Illustration 5-111. Scenario simulation (dissolved oxygen)
Source: INGEX, 2016.

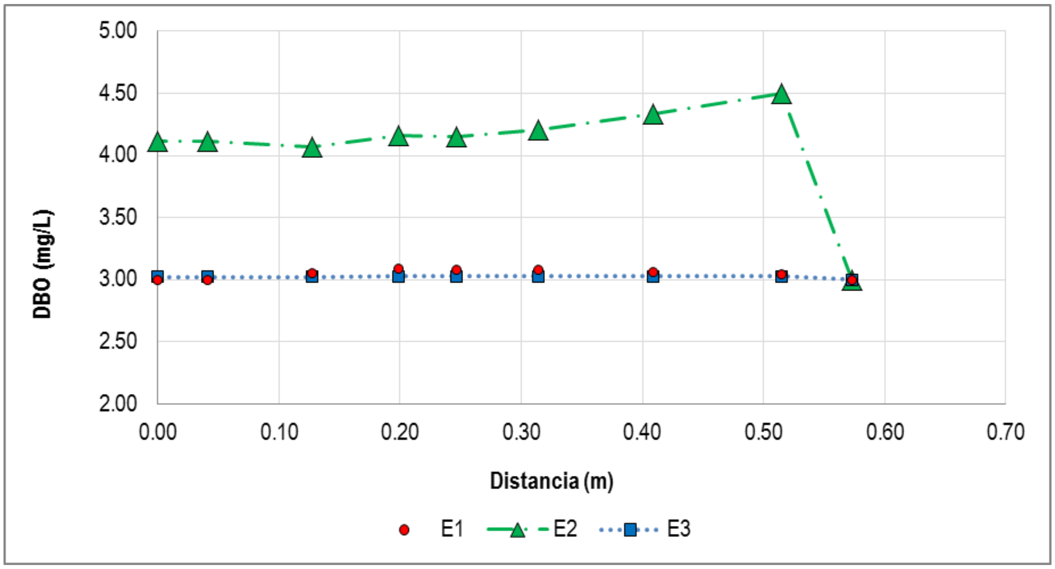


Illustration 5-112. Scenario simulation (biochemical oxygen demand)
Source: INGEX, 2016.

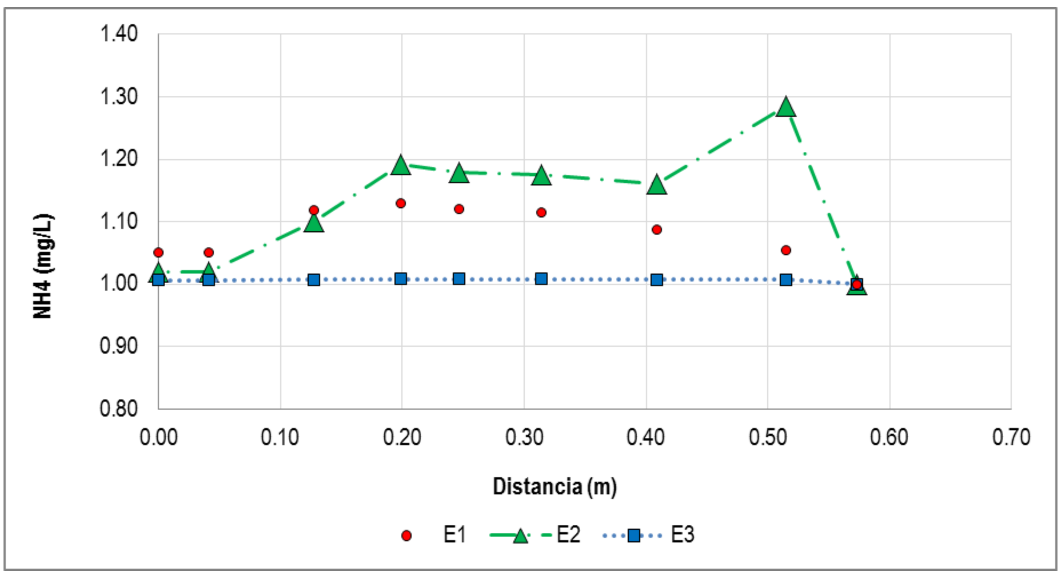


Illustration 5-113. Simulation of scenarios (Ammonium)
Source: INGEX, 2016.

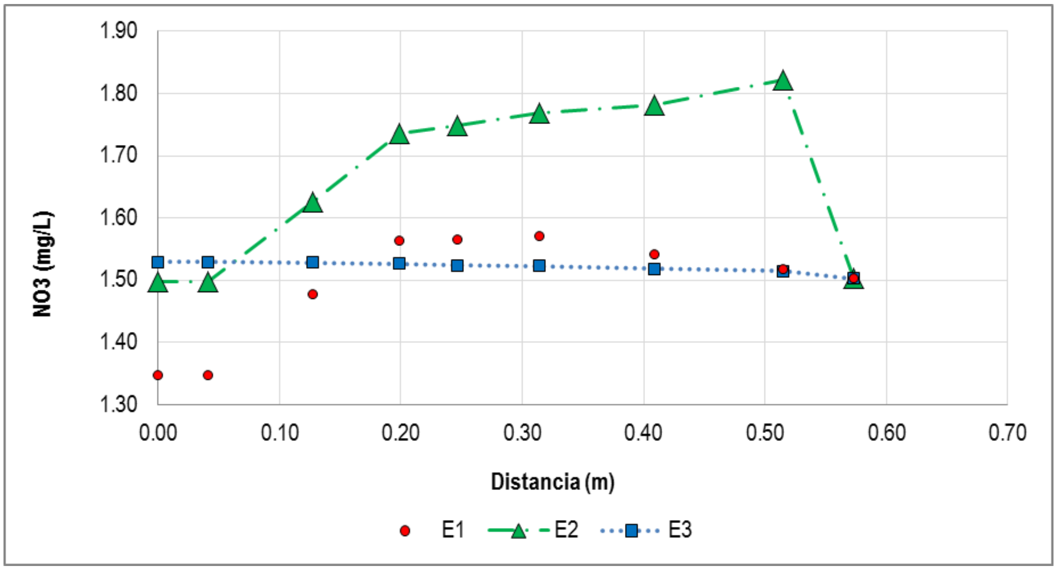


Illustration 5-114. Simulation of scenarios (Nitrates)
Source: INGEX, 2016.

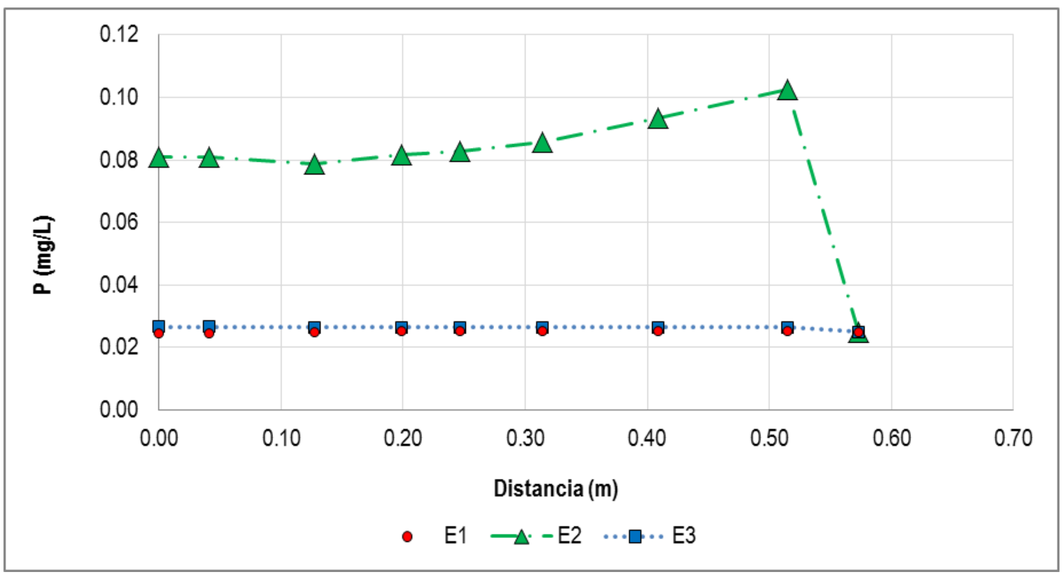


Illustration 5-115. Scenario simulation (Organic phosphorus)
Source: INGEX, 2016.

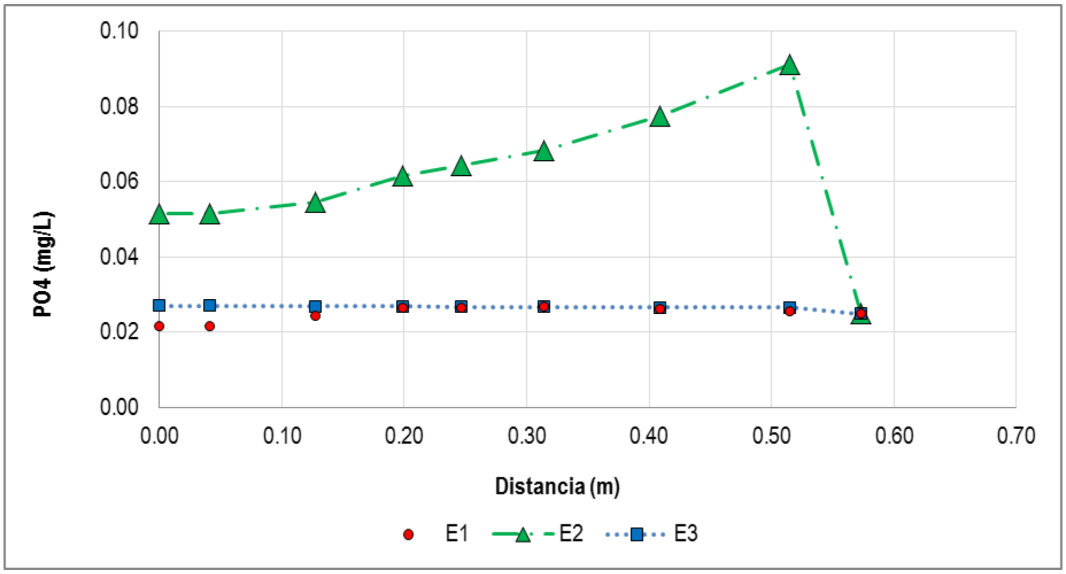


Illustration 5-116. Scenario simulation (inorganic phosphorus)
Source: INGEX, 2016.

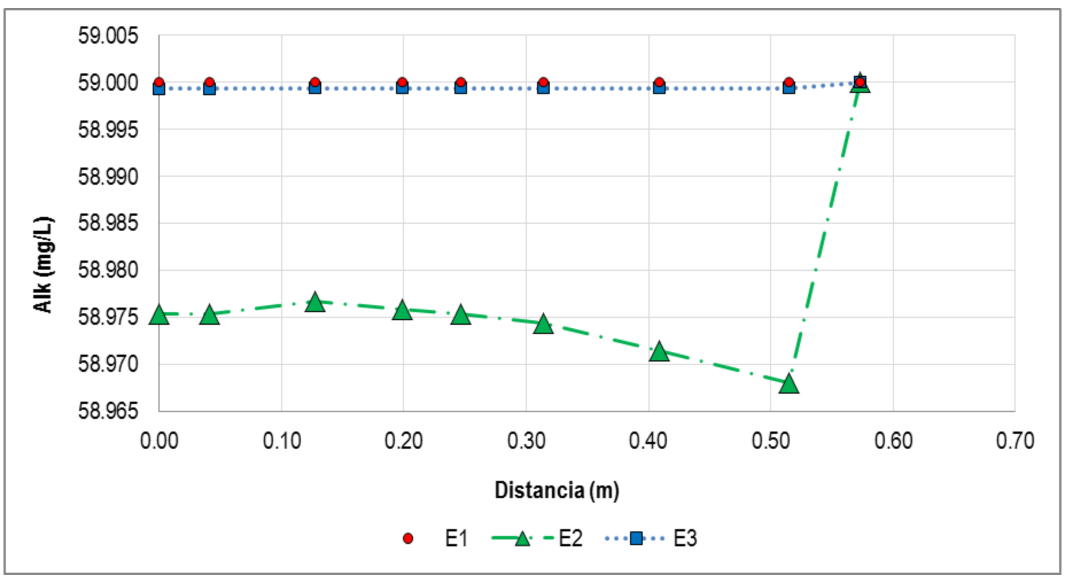


Illustration 5-117. Scenario simulation (Alkalinity)
Source: INGEX, 2016.

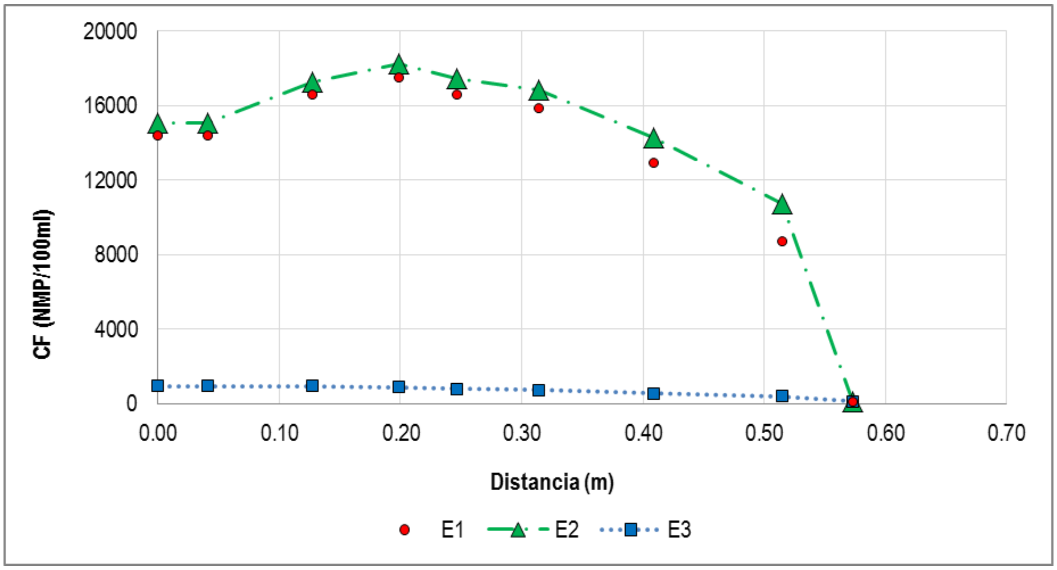


Illustration 5-118. Simulation of scenarios (fecal coliforms)
Source: INGEX, 2016.

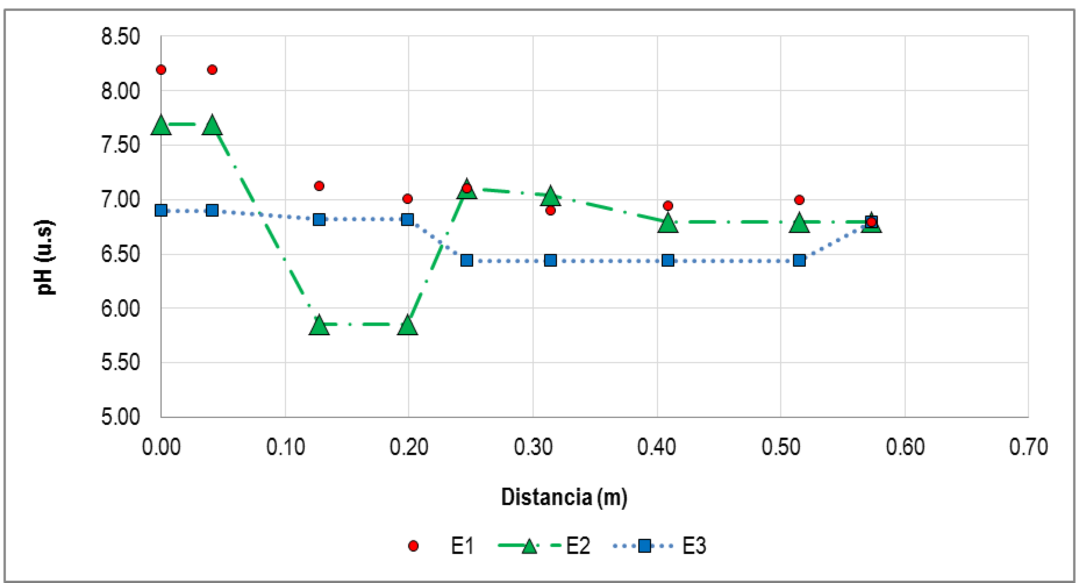


Illustration 5-119. Simulation of scenarios (pH)
Source: INGEX, 2016.

In accordance with the results obtained, important variations in the levels of suspended solids, biochemical oxygen demand, nitrates, organic and inorganic phosphorus, if taken into account coefficients of variation greater than 10%, which is defined by the magnitude of the data used in its determination. Taking the concentrations as reference mentioned previously in the last segment (N ° 7) for the scenarios of interest, we have:

- **Total suspended solids:** The discharge of wastewater produced in the project mining generates an increase in the content of total suspended solids, going from 8.92 to 9.93 mg / L, with respect to the scenario of current conditions without shedding.
- **Biochemical oxygen demand:** The dumping of wastewater produced in the mining project "El Pescado" generates an increase in biochemical oxygen demand, from 3.00 to 4.12 mg / L, compared to the scenario of current conditions without shedding.
- **Nitrates:** The dumping of wastewater produced in the "El Pescado" mining project generates an increase in nitrate levels, going from 1.35 to 1.50 mg / L, compared to Current conditions scenario without shedding.
- **Organic phosphorus:** The dumping of wastewater produced in the mining project "El Pescado" generates an increase in nitrate levels, from 0.02 to 0.08 mg / L, regarding the scenario of current conditions without shedding.
- **Inorganic phosphorus:** The dumping of wastewater produced in the mining project "El Pescado" generates an increase in nitrate levels, from 0.02 to 0.05 mg / L, regarding the scenario of current conditions without shedding.

In order to reduce the uncertainty associated with the magnitude or scale of the parameters analyzed, an analysis of variance of the simulation scenarios was performed, these results are presented in the Table 5-46.

Table 5-46. Results analysis of variance (ANOVA)

Source	Sum of squares	Degrees of freedom	Average of the squares	F	Probability	Critical value for F
SST - μ (E1) = μ (E2)	3.763	1	3.76	5.18	0.037003	4.49
DBO - μ (E1) = μ (E2)	4.753	1	4.75	52.42	0.000002	4.49
NO3 - μ (E1) = μ (E2)	0.133	1	0.13	10.30	0.005462	4.49
P - μ (E1) = μ (E2)	0.013	1	0.01	56.02	0.000001	4.49
PO4 - μ (E1) = μ (E2)	0.006	1	0.01	32.78	0.000031	4.49

Source: INGEX, 2016.

According to the results obtained, given that the values of F for all the sources are higher than the critical value of F, the null hypothesis with a statistical significance of 95% is accepted, in this way, it is concluded that there are no significant differences between the results of the simulations of the E1 and E2 scenarios, consequently the influence length of the shedding prevail within the simulation segment N ° 2, that is, it does not exceed segment N ° 7. The dumping point of the treatment system of the camps the maximum length of the Discharges of wastewater from Concession 5969 amounts to 0.044 km (44 m).

5.3.2 HYDRAULIC

In annexes 5.5 and 5.6 the hydraulic modeling of the area is related to the development of the mining project "El Pescado", as described below:

The development of hydraulic modeling aims to determine the maximum levels reached by the rising, of the currents that are within the area of direct influence of the mining concessions 6055 and 5969, in the municipality of Segovia in the department of Antioquia.

Therefore, the levels reached are determined in accordance with the information obtained from the cross sections of the river, geomorphology, hydrology and an analysis of the conditions current hydraulics of the channel to determine the water levels for each return period (2.33, 5, 10, 25, 50 and 100 years) in the sections of the river.

5.3.2.1 Hydraulic modeling

5.3.2.1.1 Hec-ras model

The software with which the modeling was carried out is the HEC-RAS 4.1 program, which has been developed by the Hydrologic Engineering Center - River Analysis System (Hydrological Center of Engineering - Analysis of the Rio System), which is an organization within the Institute for Water Resources (Institute for Water Resources), which belongs to the Center of Expertise for the US Army Corps of Engineers (Master's Center of the US Army Corps of Engineers). The products that were developed by this center are available to the public and can be freely download from your website (HEC-RAS, 2003).

The HEC RAS program is an easy tool to use and has a widespread use in the medium, although it is necessary to question its applicability to mountain channels, which are predominant in the topography of Antioquia, and that are very different from the currents of latitudes where this program has been developed, so you have to be very careful and have criteria to the modeling in our environment.

It is very important to mention that the expressions used by the model were developed to clean water flow, that is, without considering the variations due to high concentrations of sediments such as the case of lahar, mudflow and debris flow that present strong variations in the basic properties of fluids such as viscosity, density, among others, causing the behavior of the flow to be that of a non-Newtonian fluid. It is it is expected that when there are high flows, sediment concentrations increase; choosing the clean water flow application threshold is not easy, but it is accepted that despite that there are moderately high concentrations is not the case of mud or debris flow.

The HEC-RAS currently has, among its capabilities, the calculation of flow profiles in a single dimension for gradually varying flow in artificial or natural channels, and can calculate flow profiles in subcritical, supercritical regime and mixed flow regime.

5.3.2.1.1.1 Information required

The input information for the modeling is that corresponding to the cross sections of the topography of the stream (distance, abscised and elevation of each point), flow, the coefficient of Manning roughness (allows to work with three Manning roughness per section, benches and bed) and the slope of the study section.

5.3.2.1.1.2 Topographic information (cross sections)

Hydraulic modeling was carried out using the LIDAR image made for the study sector. This The cross sections were obtained with a separation of 10 m between them, covering approximately 1200 m from the river between the start of the open pit mines and the confluence of the unnamed stream # 9 and unnamed stream # 5 with a cross section greater than 50 meters long.

Similarly covers approximately 550 m of the stream without name # 2, in the vicinity from the mining project, to the confluence with the unnamed stream # 9, with a cross section greater than 50 meters in length.

For the analysis of the sections, the software "HEC RAS 4.1" was used, which allows to analyze the Flow profiles of the river for different flows. The HEC-RAS program requires data from input to perform the modeling defining each of the cross sections in the stretch for this purpose, a series of characteristics of the topography of the section, the distances between sections and roughness coefficients. Edge conditions set the initial value for the evaluation of the free surface, the available options are the following: known level, critical depth, normal depth and area-slope method, considering for the section initial calculation the slope of the energy line equal to the slope of the water surface. In Illustration 5-120 shows the topography and the location of the cross sections.

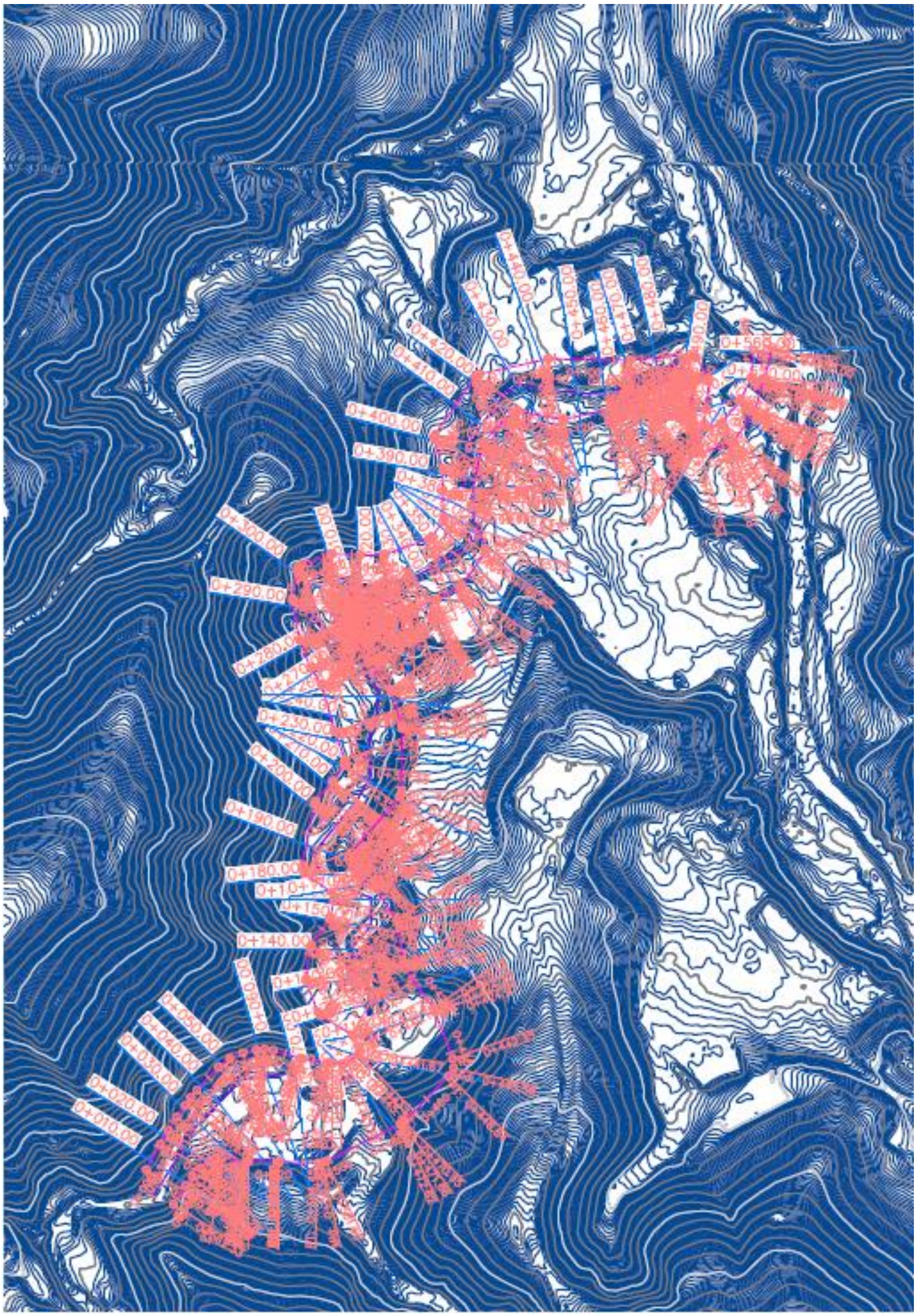


Illustration 5-120. Level curves extracted from the LIDAR image and location of the cross sections.
Source: INGEX, 2016.

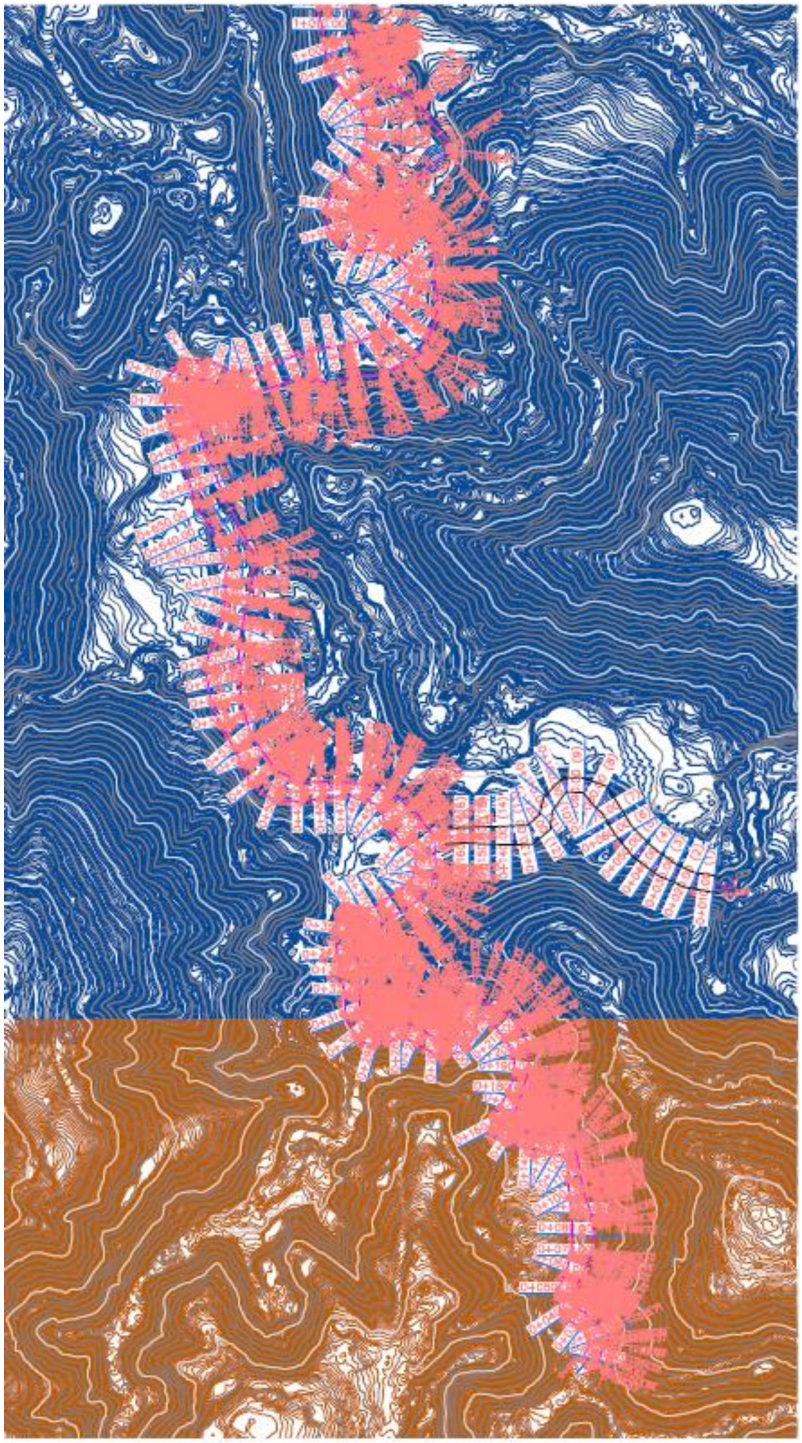


Illustration 5-121. Level curves extracted from the LIDAR image and location of the cross sections
Source: INGEX, 2015

5.3.2.1.1.3 Manning's stringency coefficient

Manning's roughness coefficient is a fundamental variable, which intrinsically picks up all the geomorphological and dynamic characteristics of the section studied, and therefore it is one of the most important variables that the program requires. For this reason, it is necessary to find a coefficient Manning, which is the most appropriate and that really represents the conditions that are presenting in the section of analysis of the bankrupt. Table 5-47 shows the different options for the values of this coefficient.

Table 5-47. Manning roughness coefficients taking into account the characteristics of the channel

	Coefficient of Manning
Ditches and uncoated canals	
In ordinary earth, uniform and smooth surface	0,020-0,025
In ordinary earth, irregular surface	0,025-0,035
On land with light vegetation	0,035-0,045
On land with thick vegetation	0,040-0,050
In earth mechanically excavated	0,028-0,033
In rock, uniform and smooth surface	0,030-0,035
In rock, surface with edges and irregularities	0,035-0,045
Ditches and uncoated canals	
Concrete	0,013-0,017
Concrete coated with gunite	0,016-0,022
Tunnel Lining	0,020-0,030
Concrete walls, gravel bottom	0,017-0,020
Walls covered, gravel bottom	0,023-0,033
Bituminous coating	0,013-0,016
Natural Currents	
Clean, straight edges, uniform bottom, height of sheet of water enough	0,027-0,033
Clean, straight edges, uniform bottom, height of sheet of water enough, some vegetation	0,033-0,040
Clean, meanders, reservoirs and minor eddies	0,035-0,050
Slow, with deep reservoirs and branched channels	0,060-0,080
Slow, with deep reservoirs and branched channels, dense vegetation	0,100-0,200
Rugged, currents on rocky mountain terrain	0,050-0,080
Flooding areas adjacent to the ordinary channel	0,030-0,200

Source: Table taken from S.M. Woodward and C. J Posey

For the manning roughness coefficient, a value of 0.040 was chosen for the benches and 0.035 for the channel, because the current is a clean stream with straight edges, uniform bottom and height of enough water sheet.

5.3.2.1.1.4 Type of flow and initial conditions

Each of the sections to be evaluated has an average longitudinal slope of 2.3% and 4% respectively. Due to this type of slopes and the characteristics of the channel, the modeling performed for the subcritical flow option. For the edge conditions for the study section, supposes critical depth for upstream and downstream.

5.3.2.1.1.5 Maximum flows

The objective of the study is to define the floodplains, for different periods of return, of the study section. The flows that were extracted from the hydrological study are:

Table 5-48. Maximum flows for different return periods used for modeling

Period of return (years)	Maximum Flows (m3/s)
	Current SN #2
2.33	3.48
5	4.4
10	5.19
25	6.64
50	7.94
100	9.66

Source: INGEX, 2016.

Table 5-49. Maximum flows for different return periods used for modeling.

Period of return (Years)	Maximum Flow (m3/s)		
	current SN7	current SN8	Confluence
2.33	3.92	10.26	14.18
5	4.97	12.99	17.96
10	5.86	15.33	21.19
25	7.49	19.6	27.09
50	8.97	23.47	32.44
100	10.91	28.53	39.44

Source: INGEX, 2016.

With this information the first stage of the modeling is carried out, which constitutes the location of the cross sections along the bed of the study section, in the HEC-RAS.

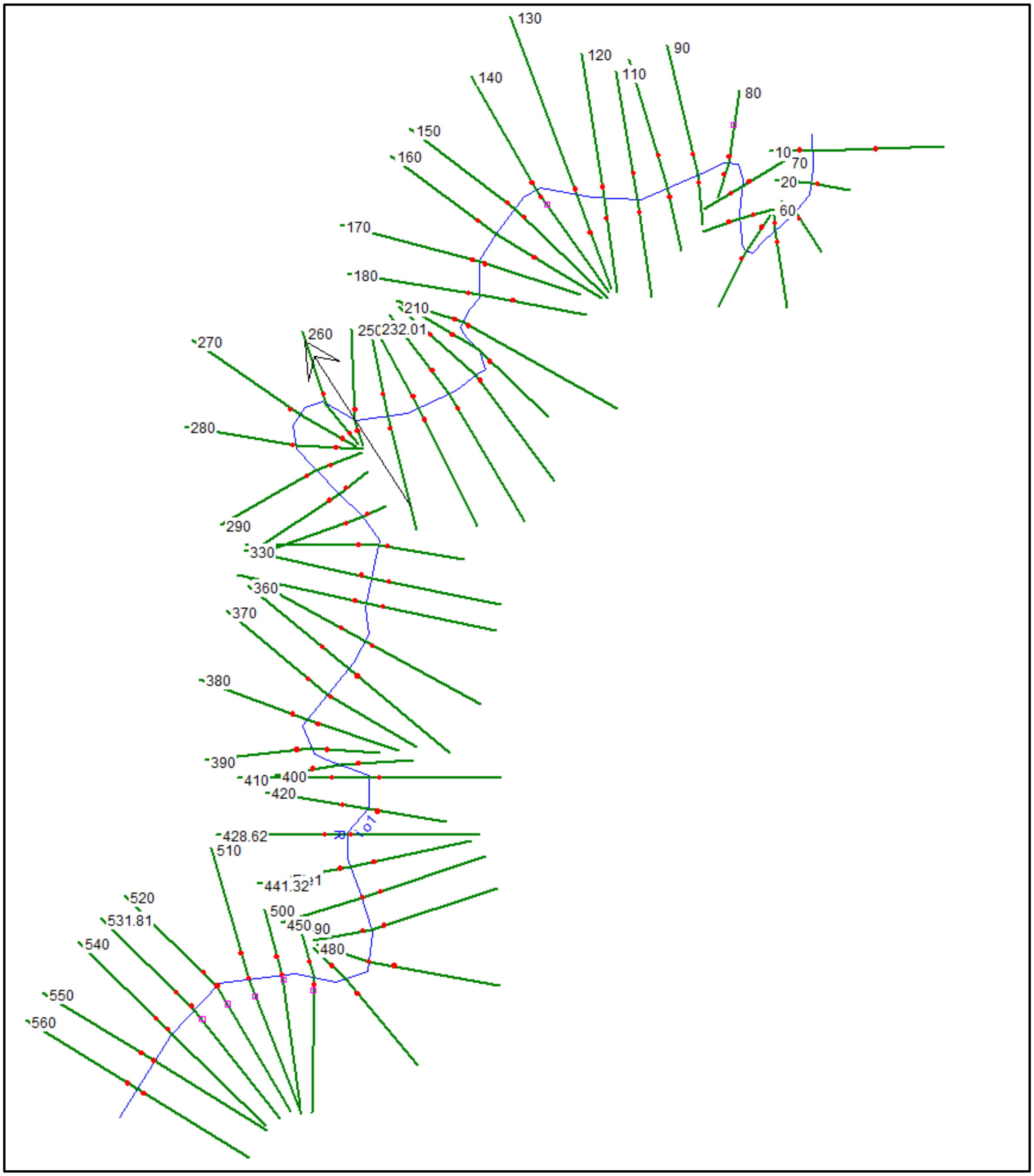


Illustration 5-122. Model in HEC-RAS
Source: INGEX, 2016.

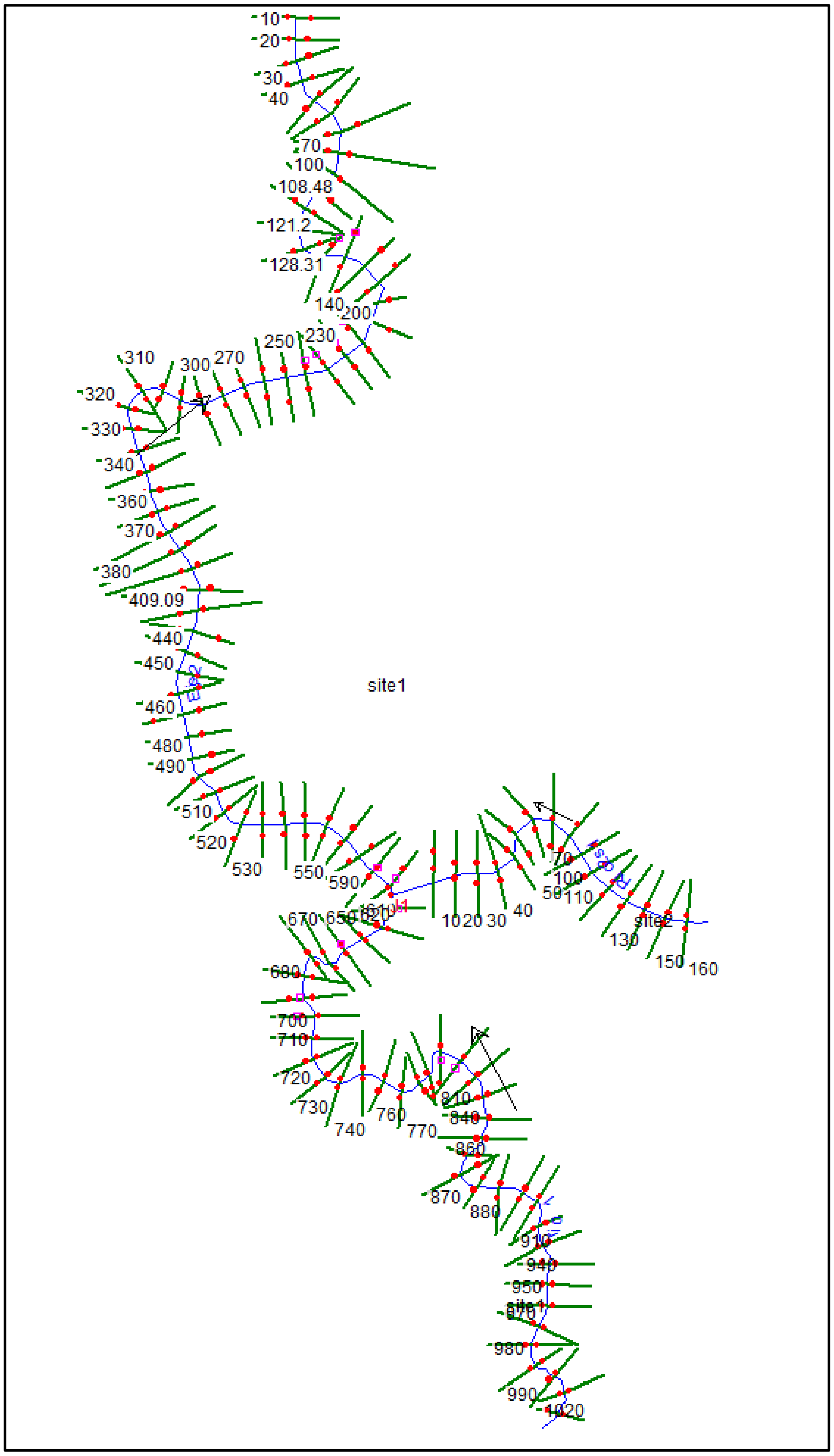


Illustration 5-123. Model in HEC-RAS
Source: INGEX, 2015

5.3.2.1.1.6 Summary table of the modeling

Transverse sections obtained from the LIDAR image
Flows for return periods of 2.33, 5, 10, 25, 50 and 100 years
Slope of the section 2%
n of manning 0.040 for the pews and 0.035 for the channel
Modeling in subcritical flow

Transverse sections obtained from the LIDAR image
Flows for return periods of 2.33, 5, 10, 25, 50 and 100 years
Slope of the section 4%
n of manning 0.040 for the pews and 0.035 for the channel
Modeling in subcritical flow

5.3.2.1.1.7 Results of the modeling

The Illustration 5-125. Flow profile in the study section. - Illustration 5-125, shows the levels at along the channel reached by the flow for the flow of return periods of 2.33, 5, 10, 25, 50 and 100 years in the river section studied. The levels of the free surface in the river, in general, are in the order of 2 m for the flows with a return period of 100 years. In the modeling of the stretch of study we can see how the flow throughout the study sector behaves critically. For all flow rates and return periods, the flow profile behaves in a stable manner.

In Illustration 5-126 and Illustration 5-127, water levels are presented for the different return periods for each of the sections analyzed. From this Illustration it can be seen that the levels of the increases for the return period of 2.33, 5, 10, 25, 50 and 100 years, always They keep within a channel, showing the capacity of the river section.

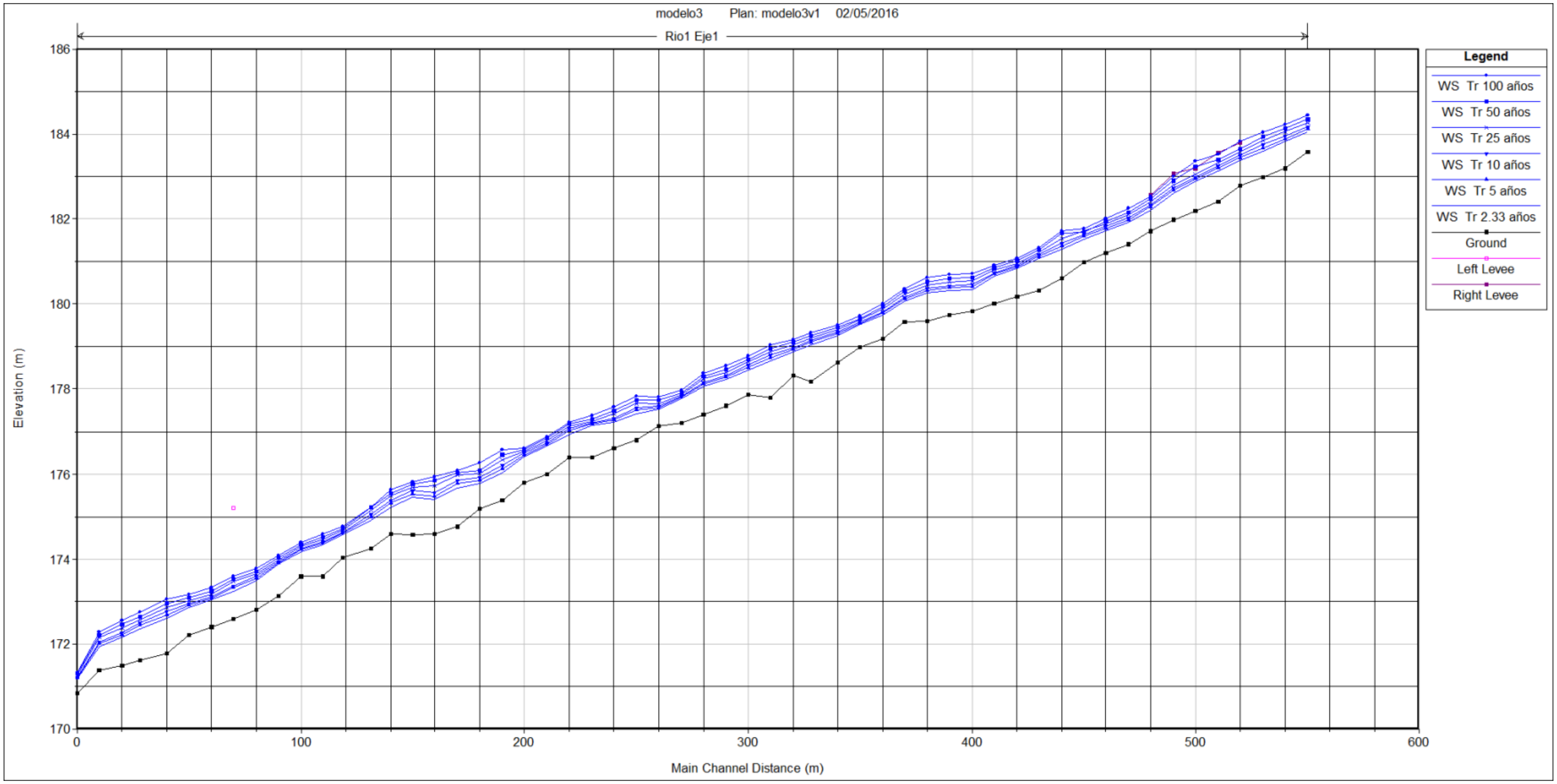


Illustration 5-124. Flow profile in the study section.
Source: INGEX, 2016.

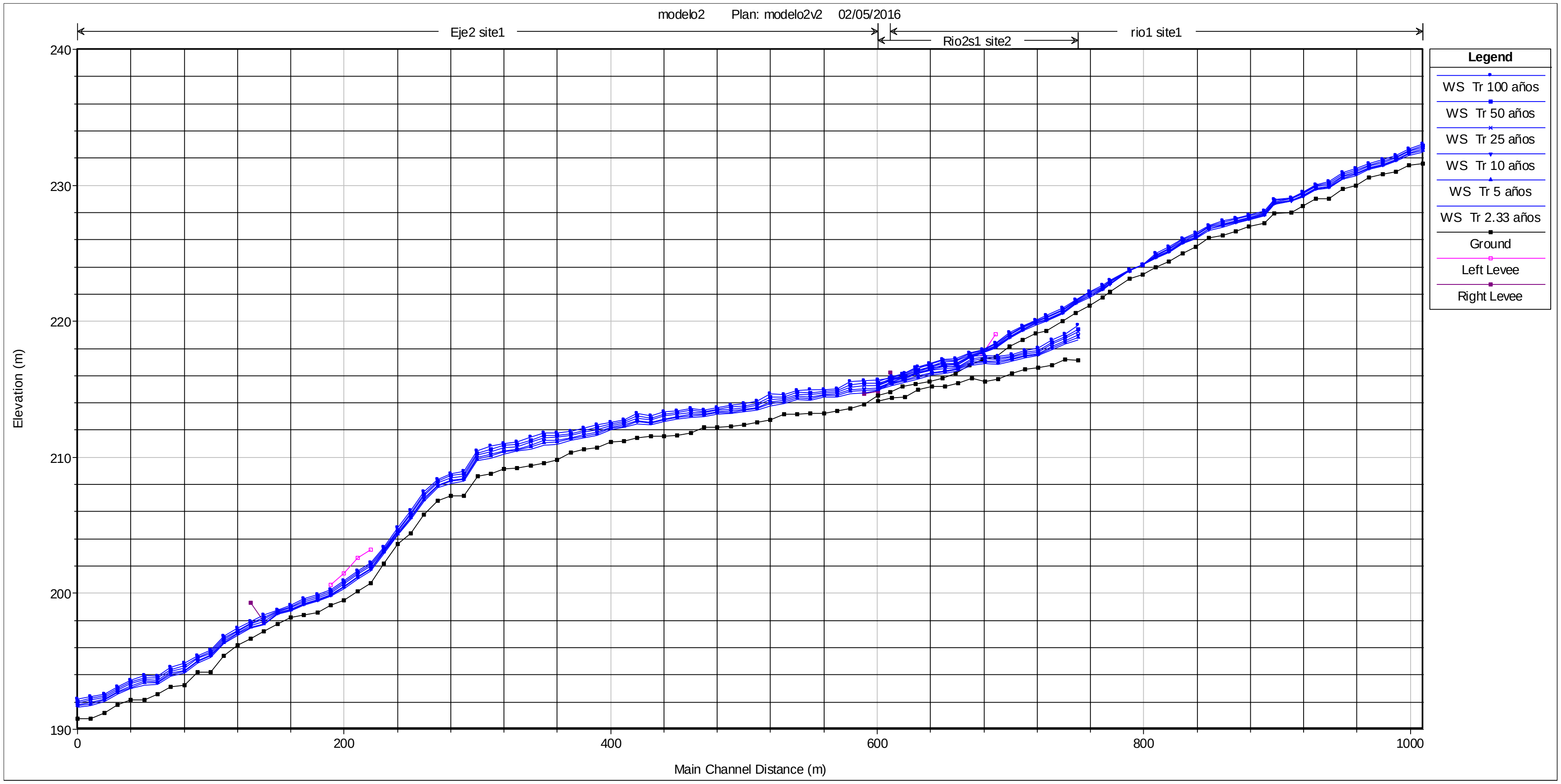
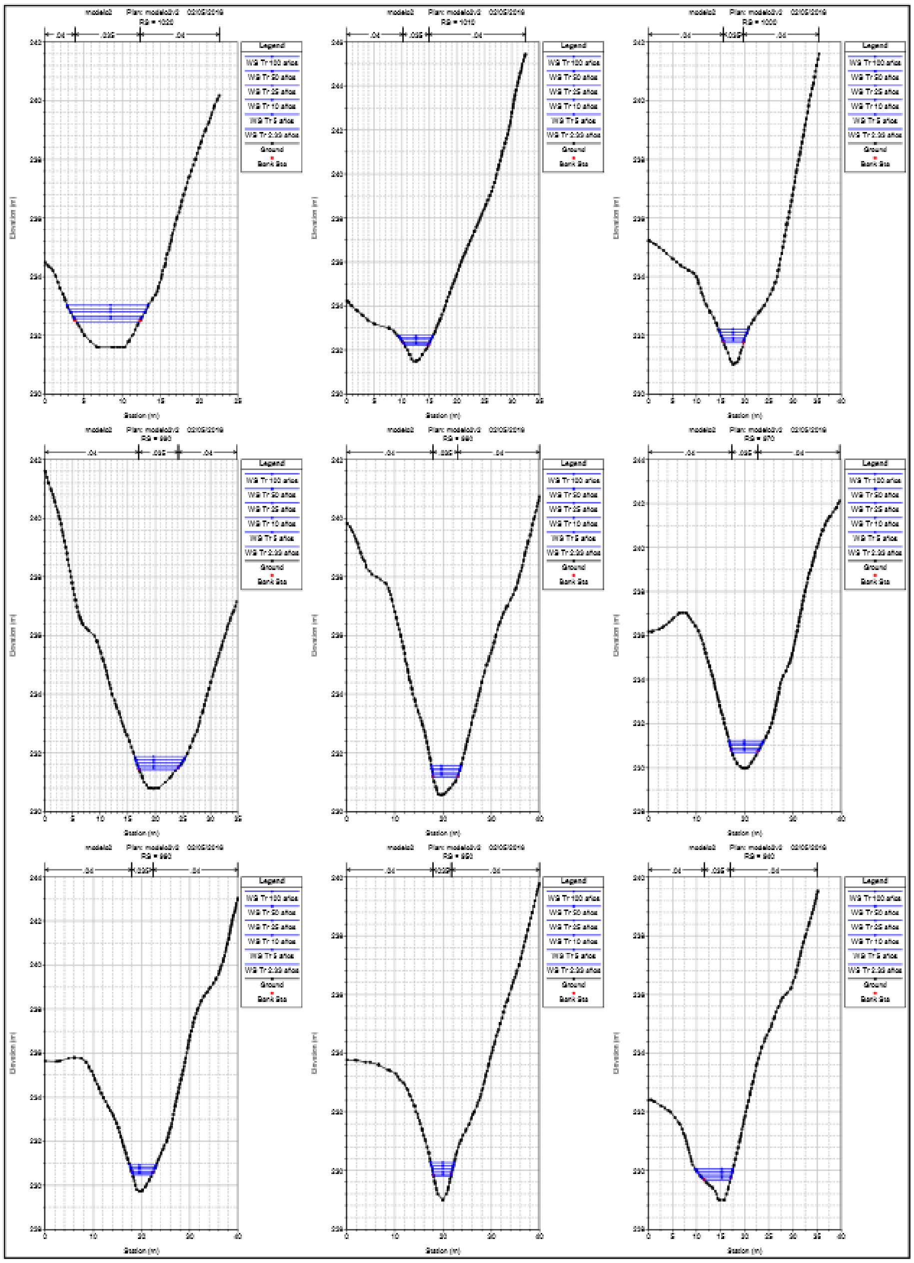
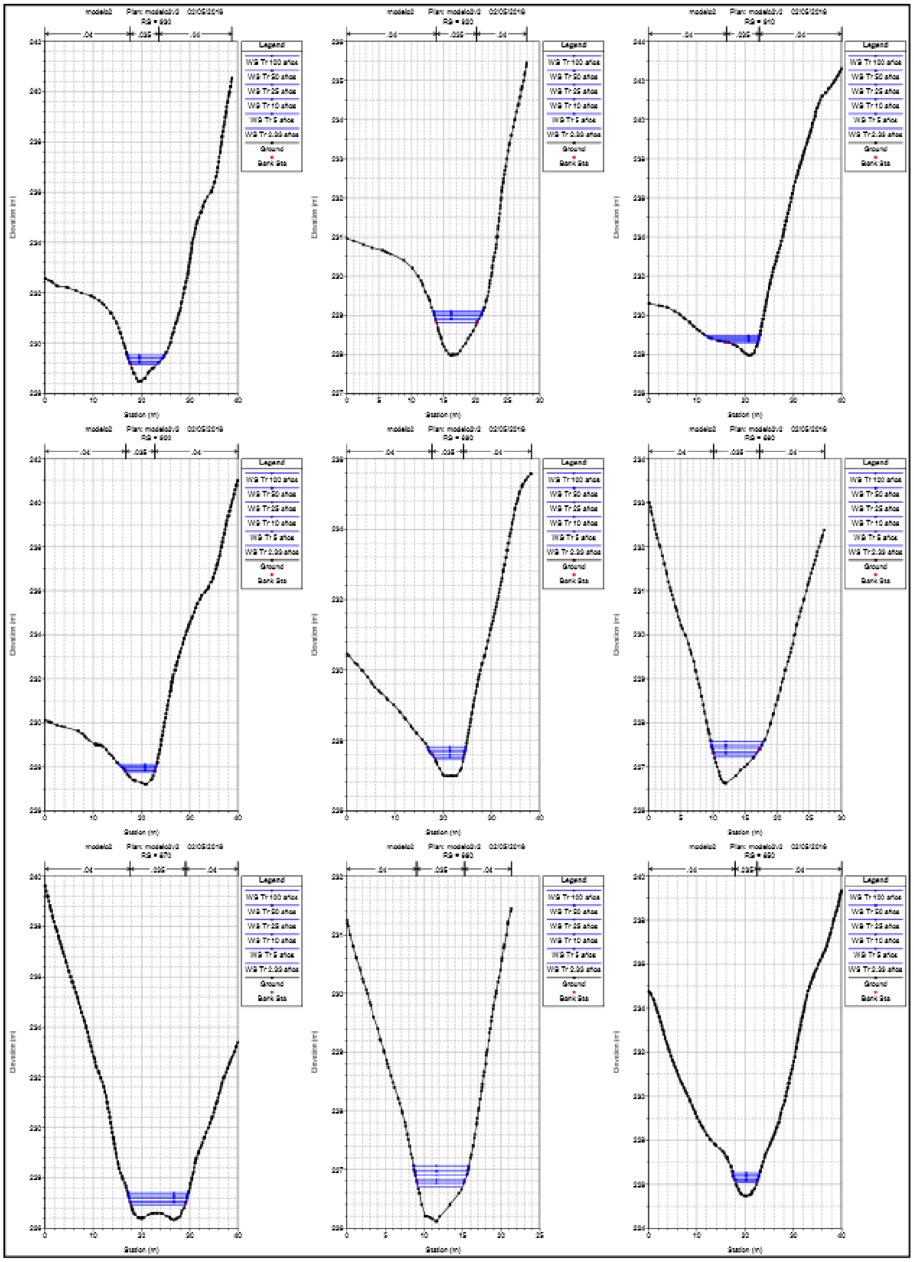
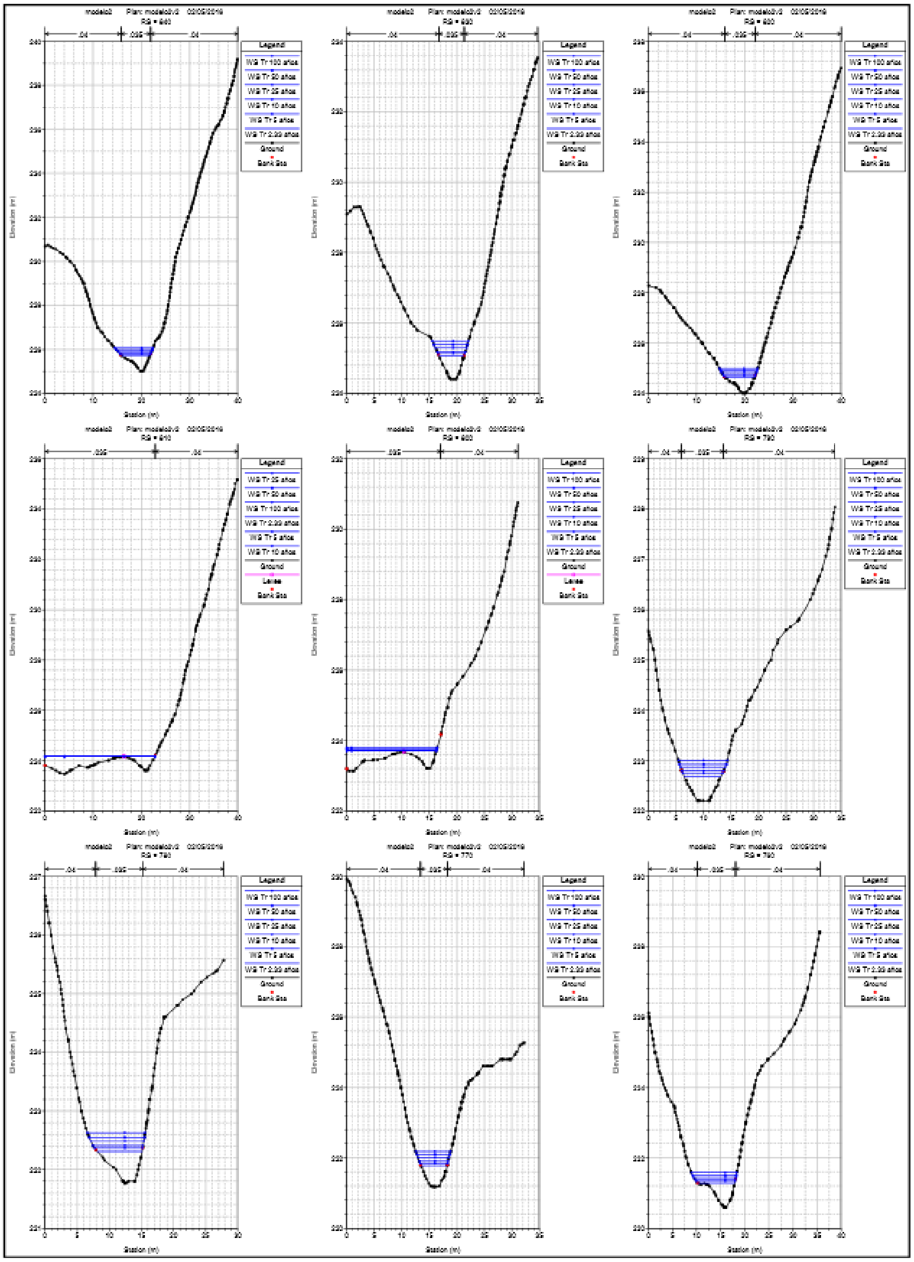
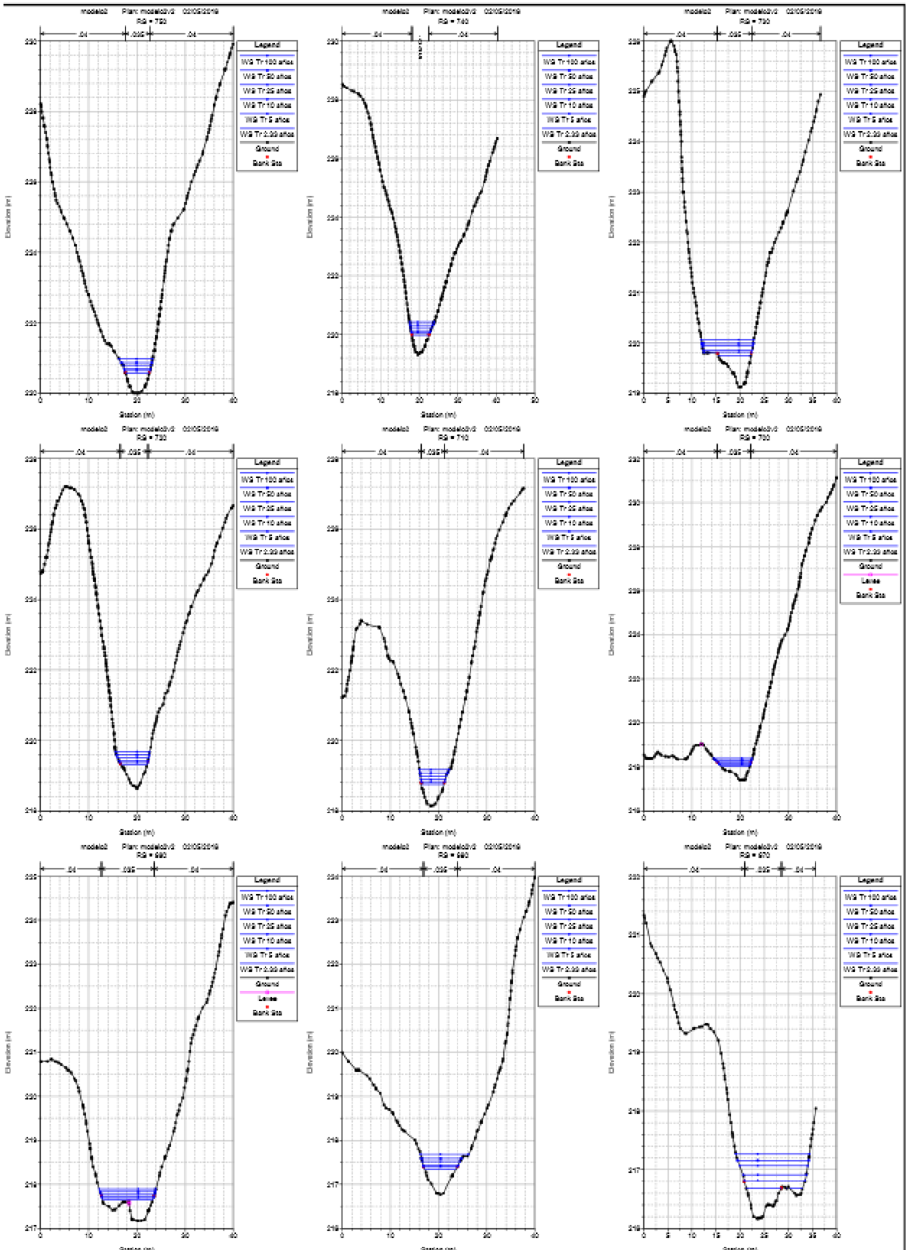


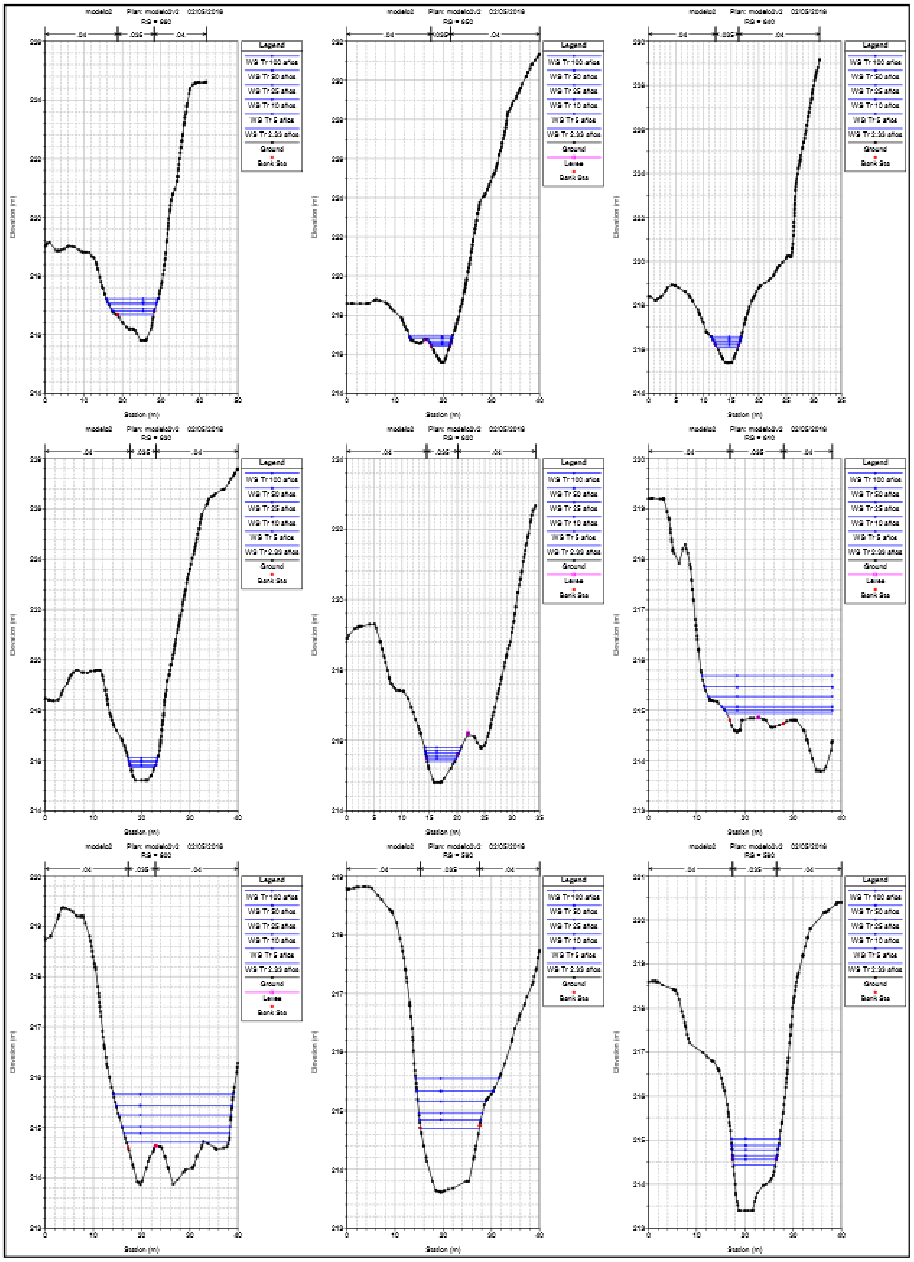
Illustration 5-125. Flow profile in the study section.
Source. INGEX, 2016.

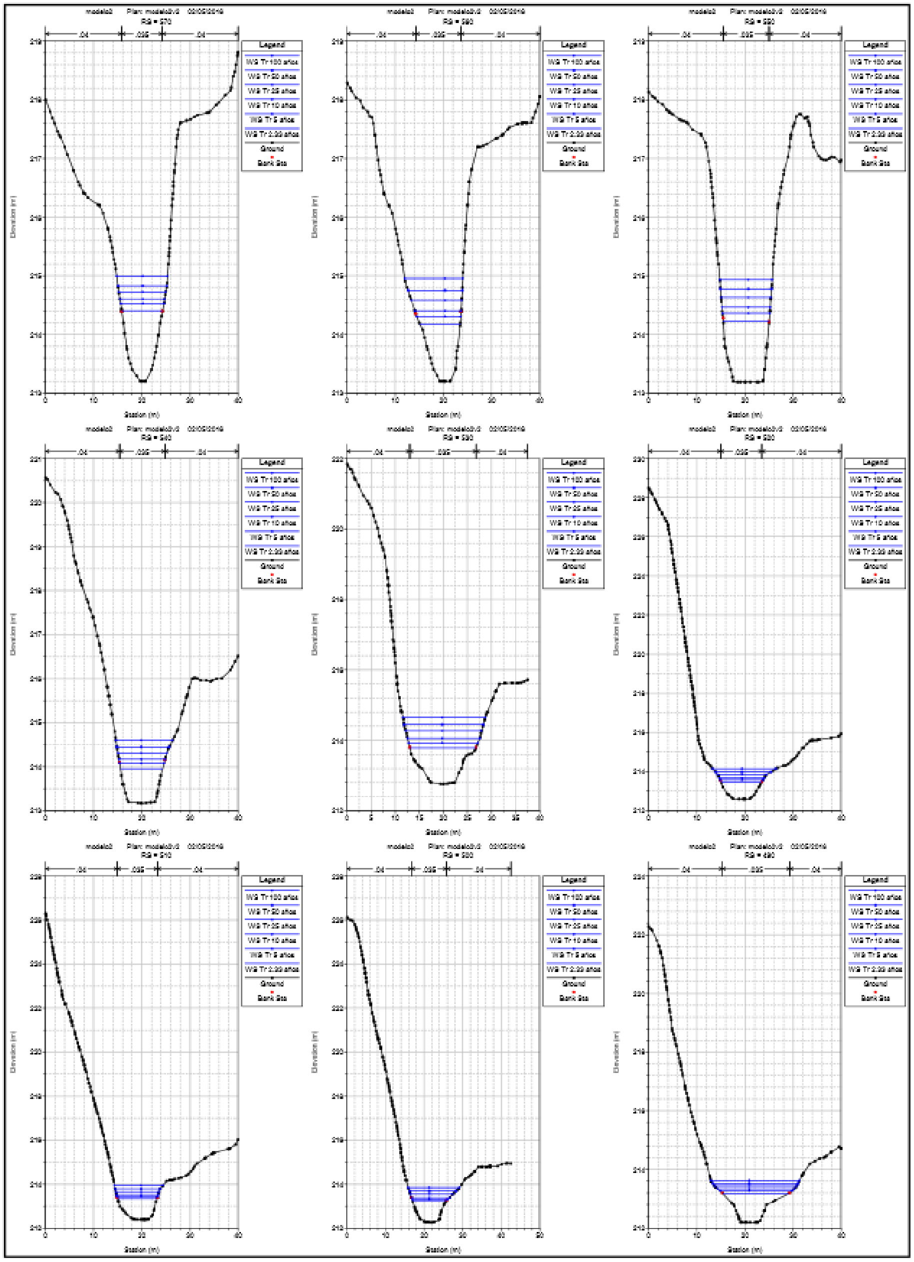

Legend
WS Tr 100 años
WS Tr 50 años
WS Tr 25 años
WS Tr 10 años
WS Tr 5 años
WS Tr 2.33 años
Ground
Bank Sta
Elevation (m)
Station (m)

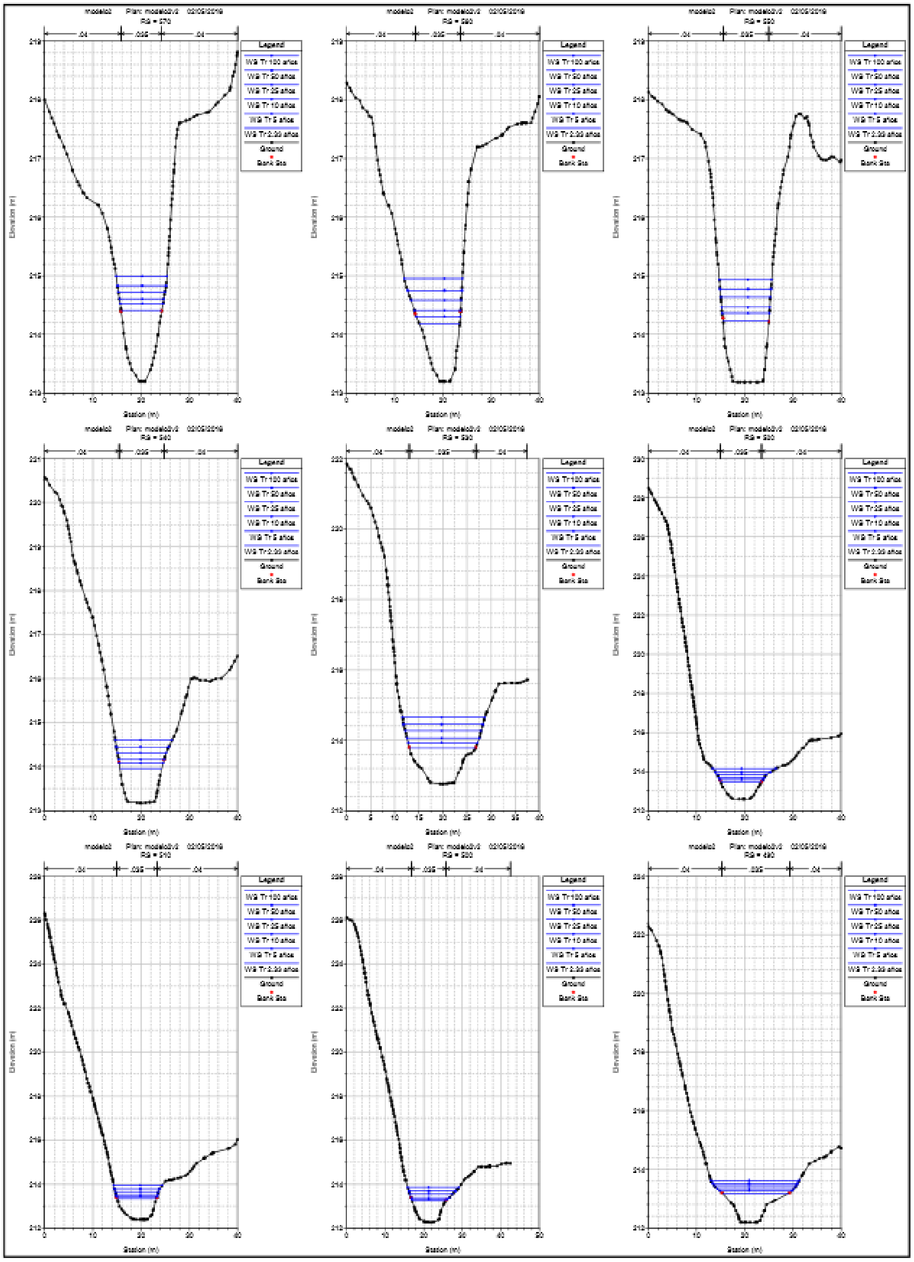


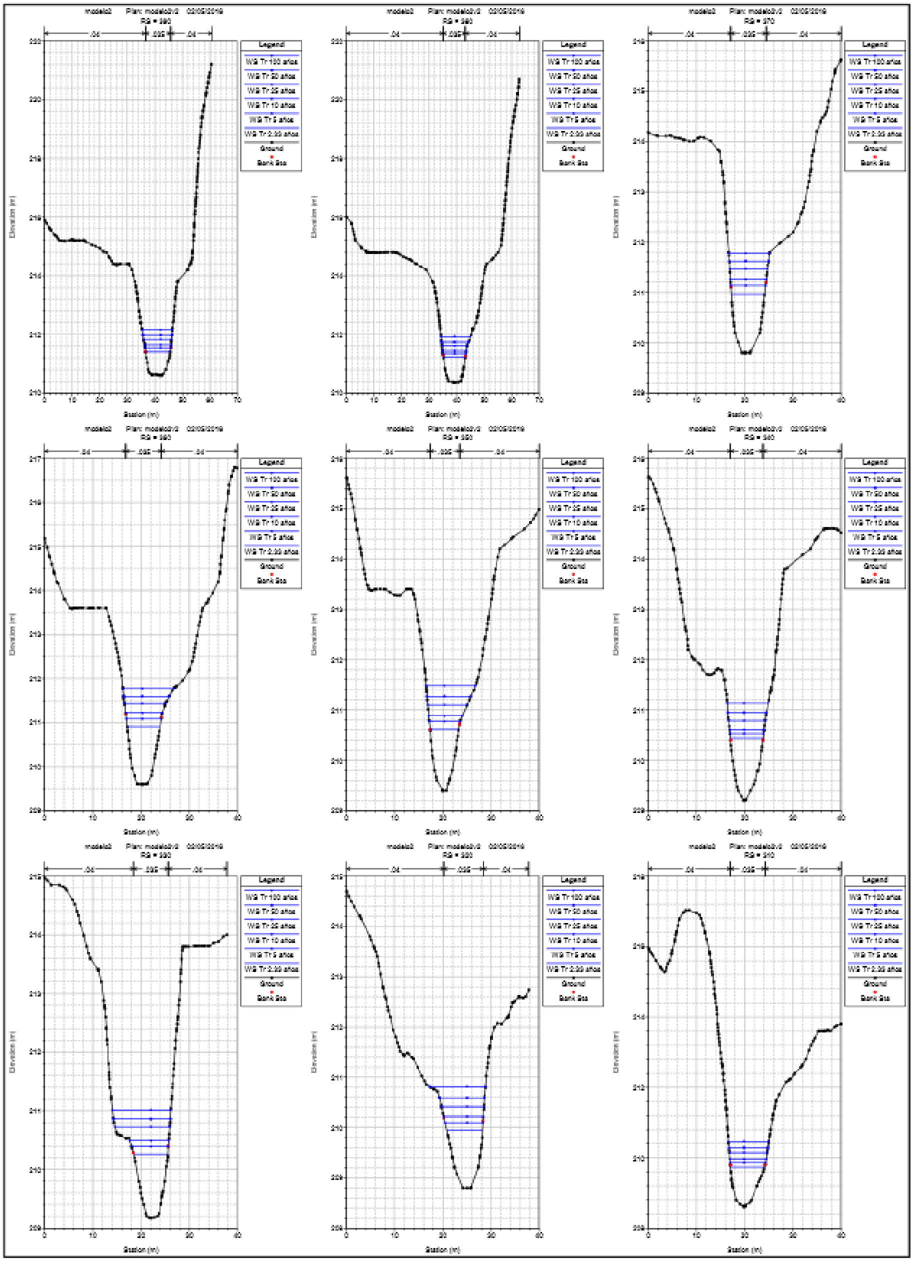


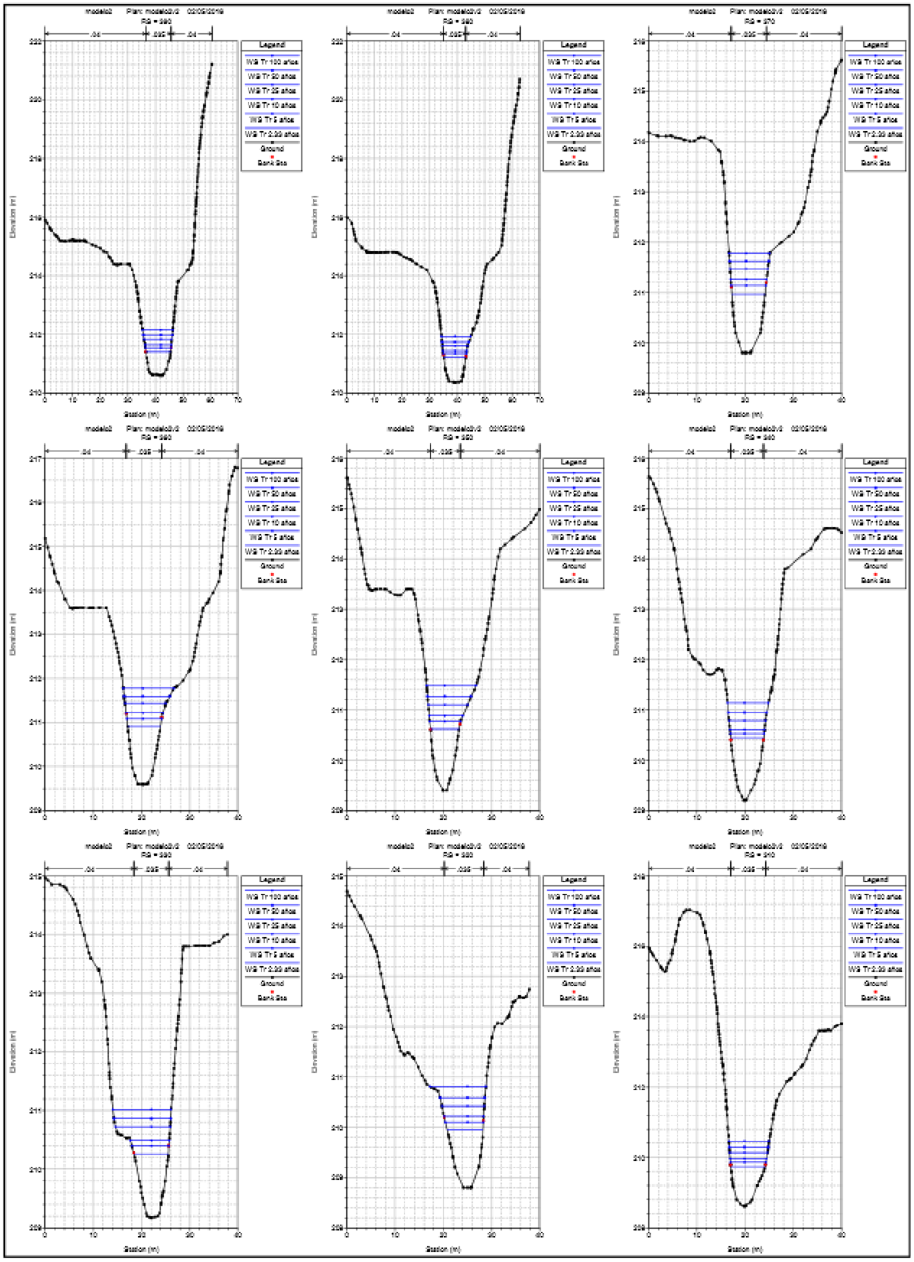


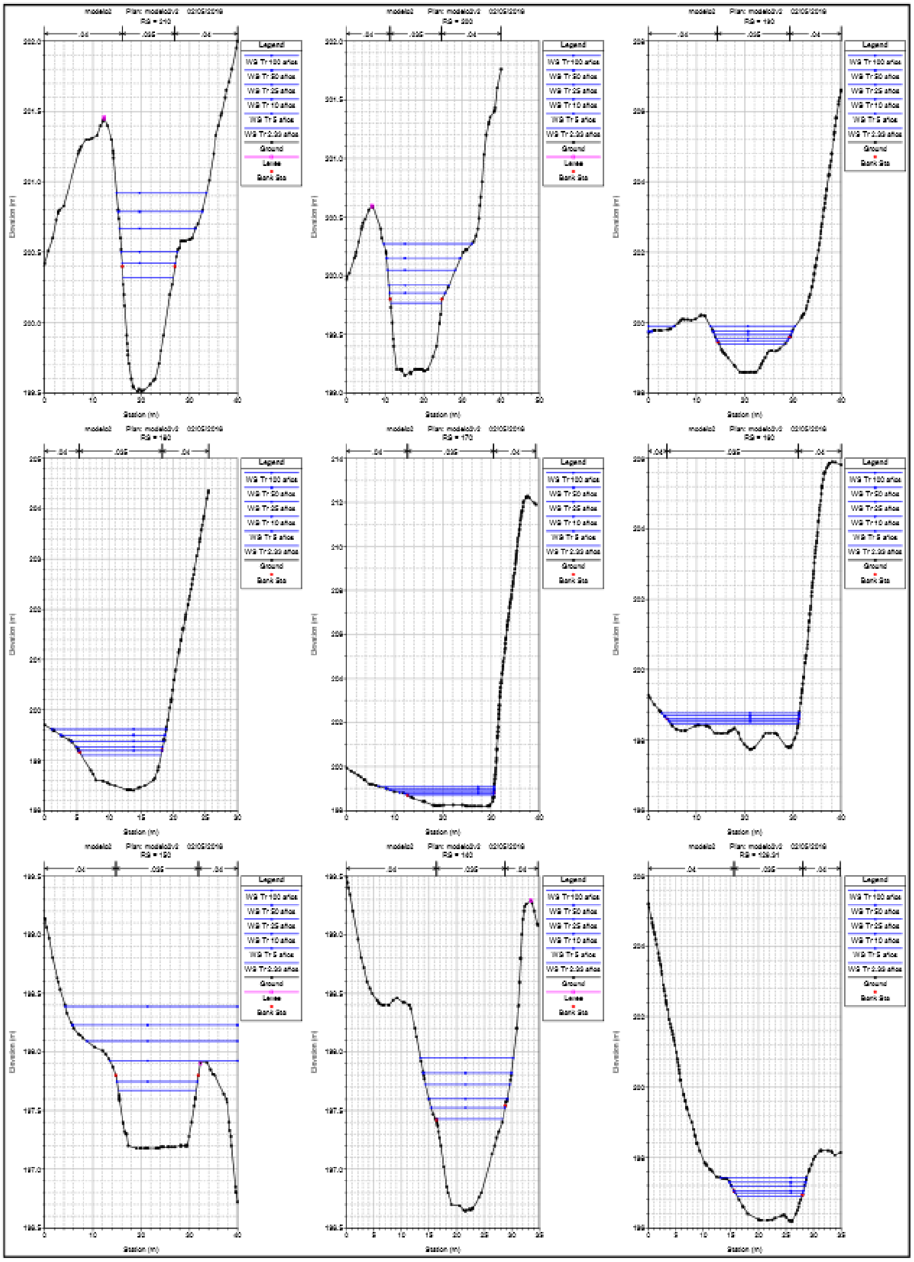


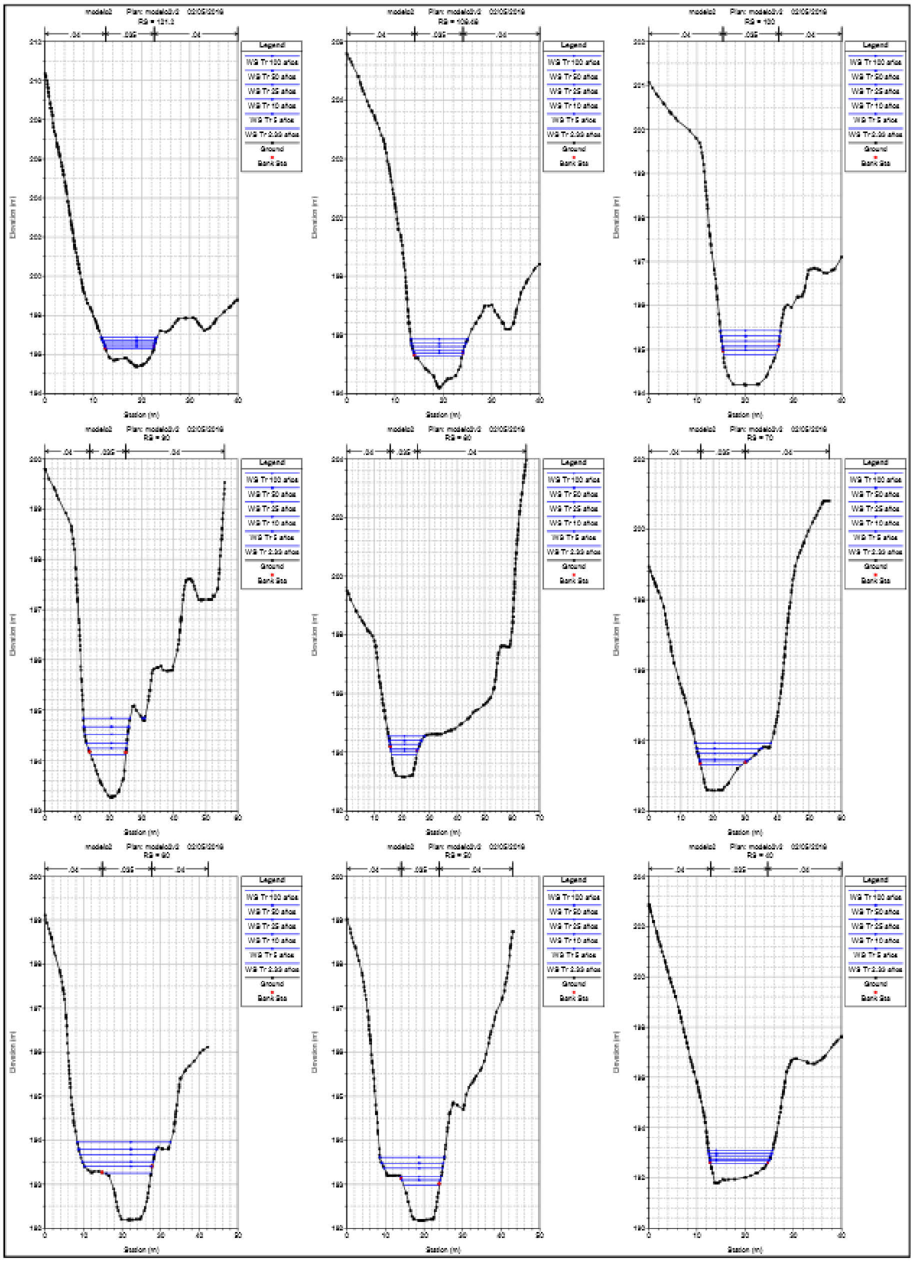











Legend
WS Tr 100 años
WS Tr 50 años
WS Tr 25 años
WS Tr 10 años
WS Tr 5 años
WS Tr 2.33 años
Ground
Bank Sta
Elevation (m)
Station (m)

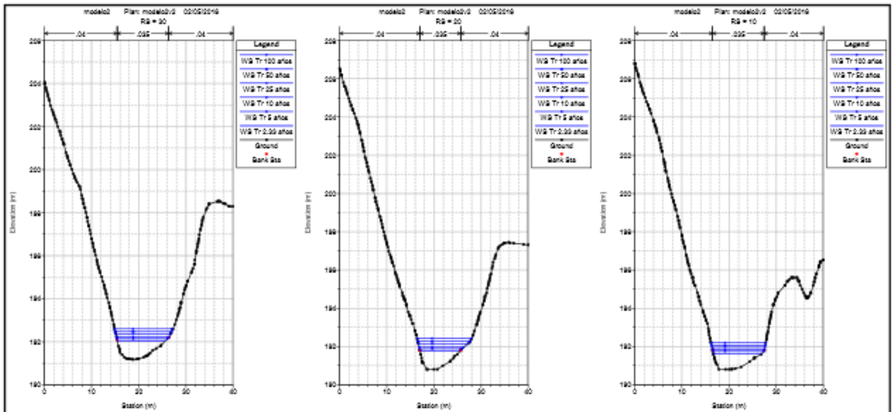
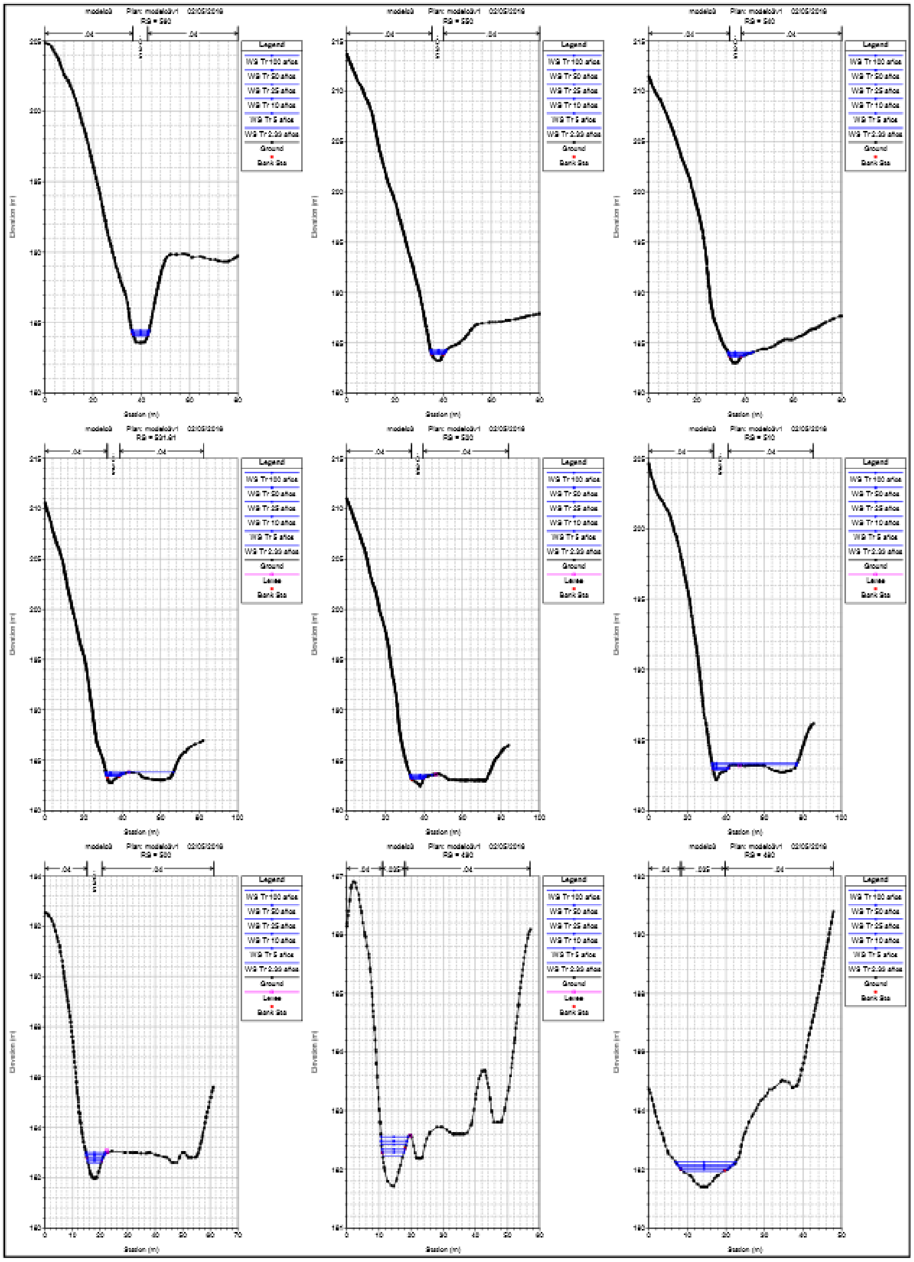
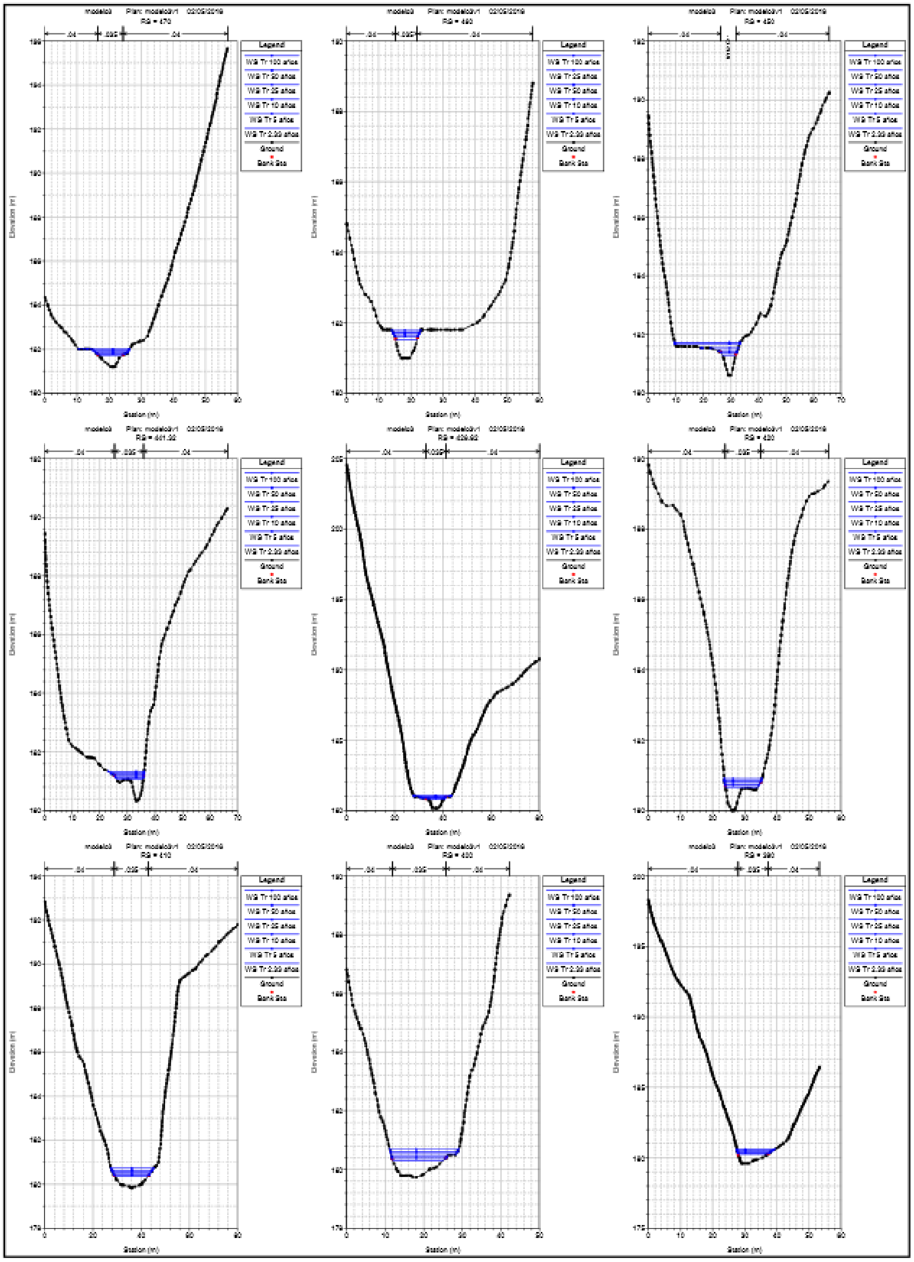
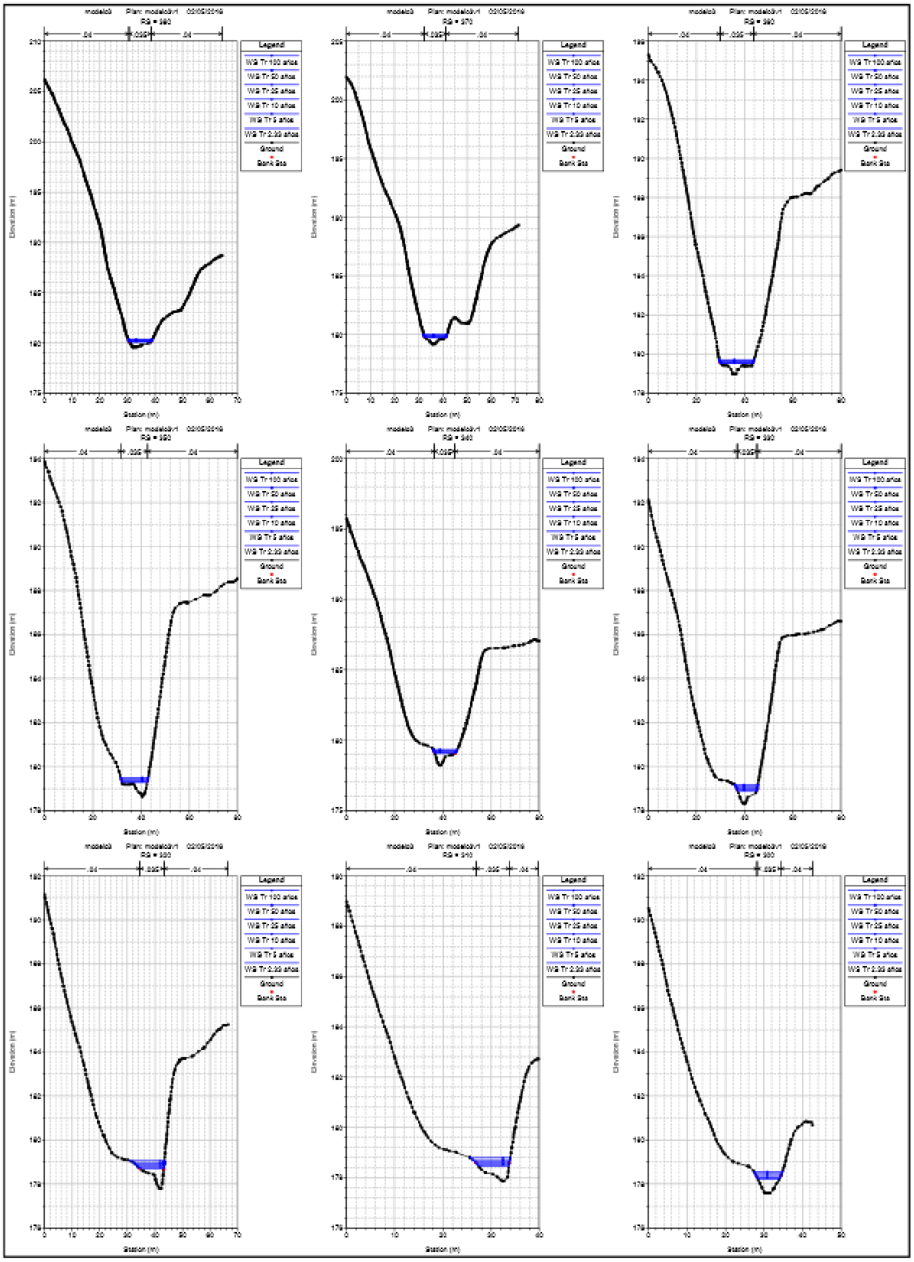
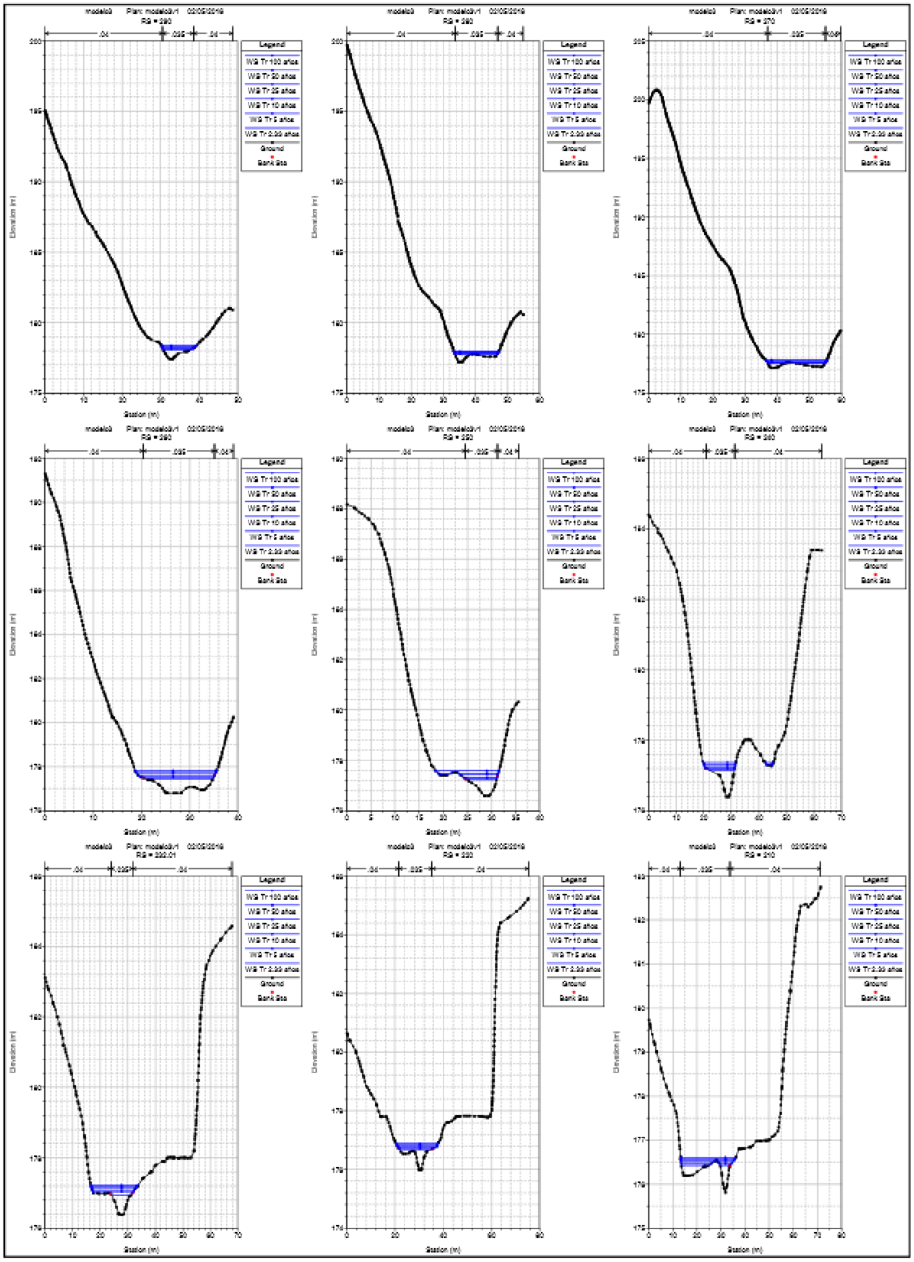


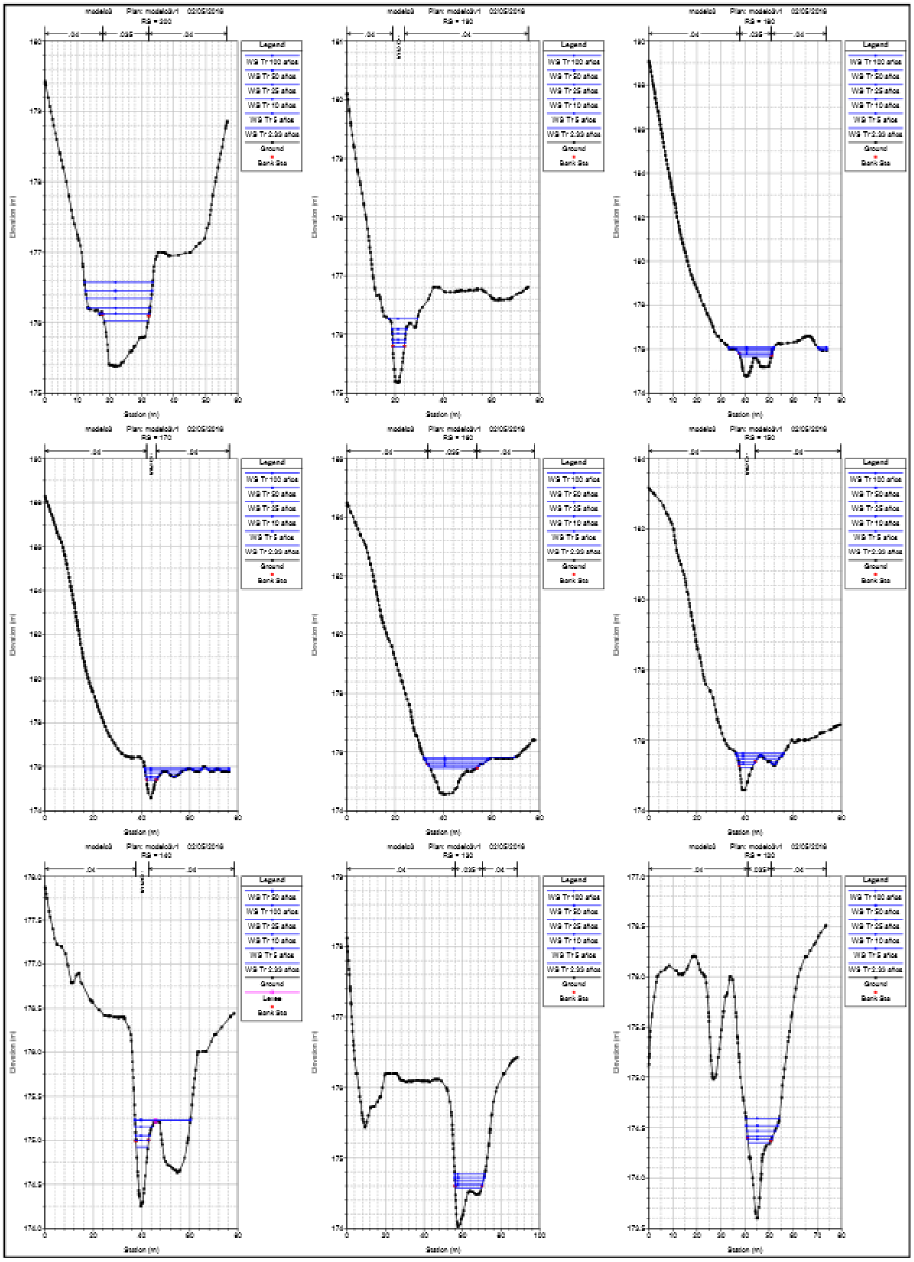
Illustration 5-126. Flow levels for flow of 2.33, 5, 10, 25, 50 and 100 years of return period in each of the sections of the study section.
Source: INGEX, 2016.

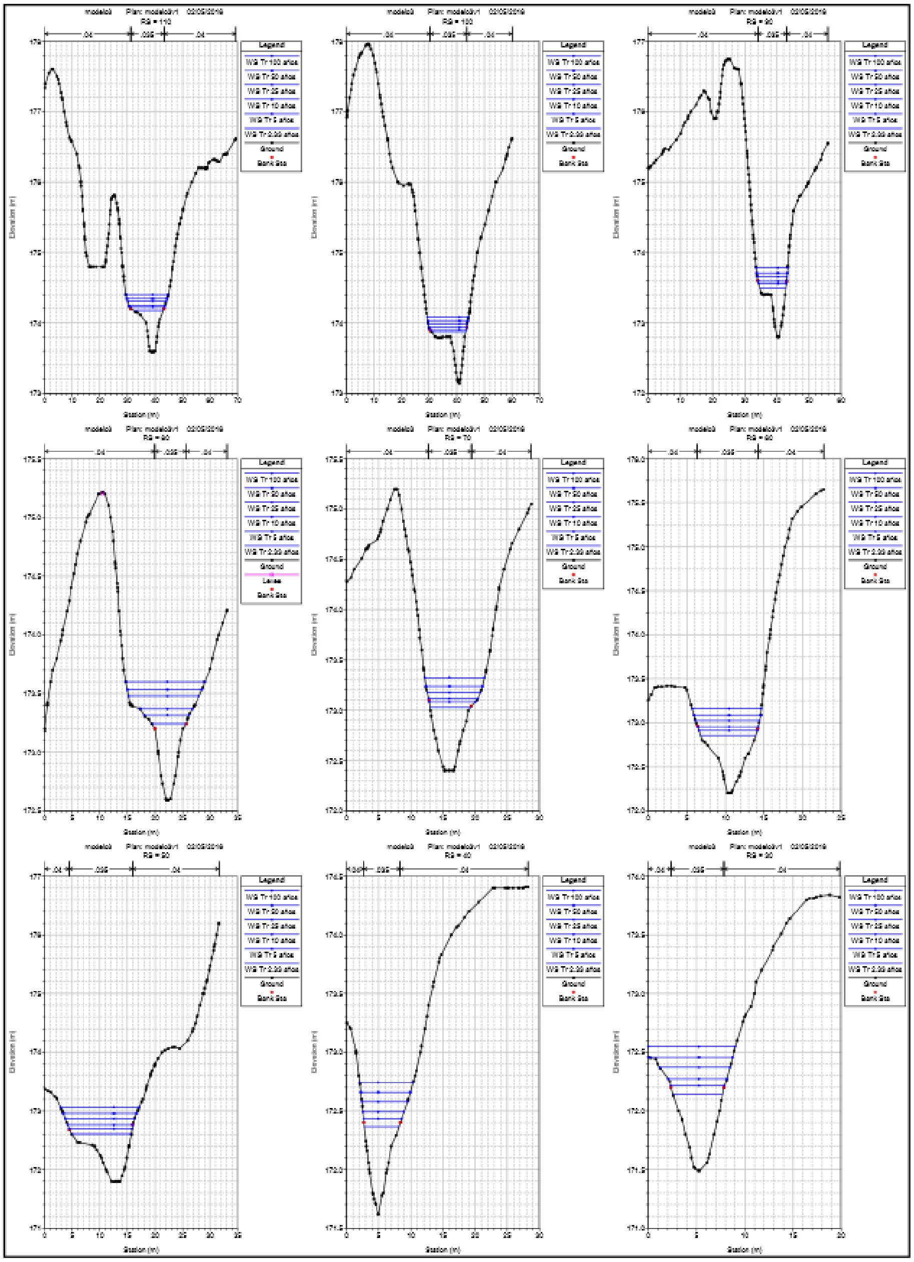











Legend
Ground
Bank Sta
Station (m)

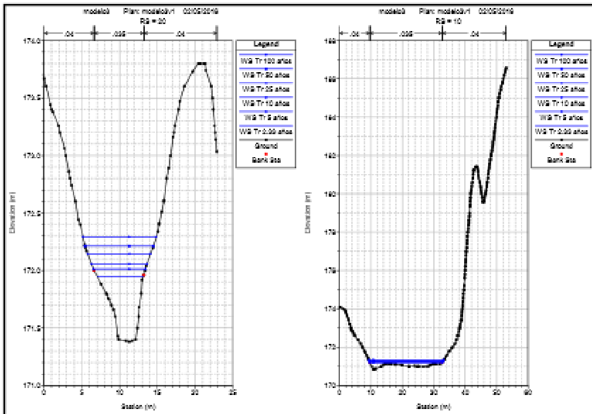


Illustration 5-127. Flow levels for flow of 2.33, 5, 10, 25, 50 and 100 years of return period in each of the sections of the study section.
Source: INGEX, 2015

5.3.2.1.1.8 Flood spots.

Below is the map with the flood spots for a return period of 100 years, for the study section. In this it can be seen that in the areas where the open-pit mines and infrastructure works, the flow is contained in the channel bed.

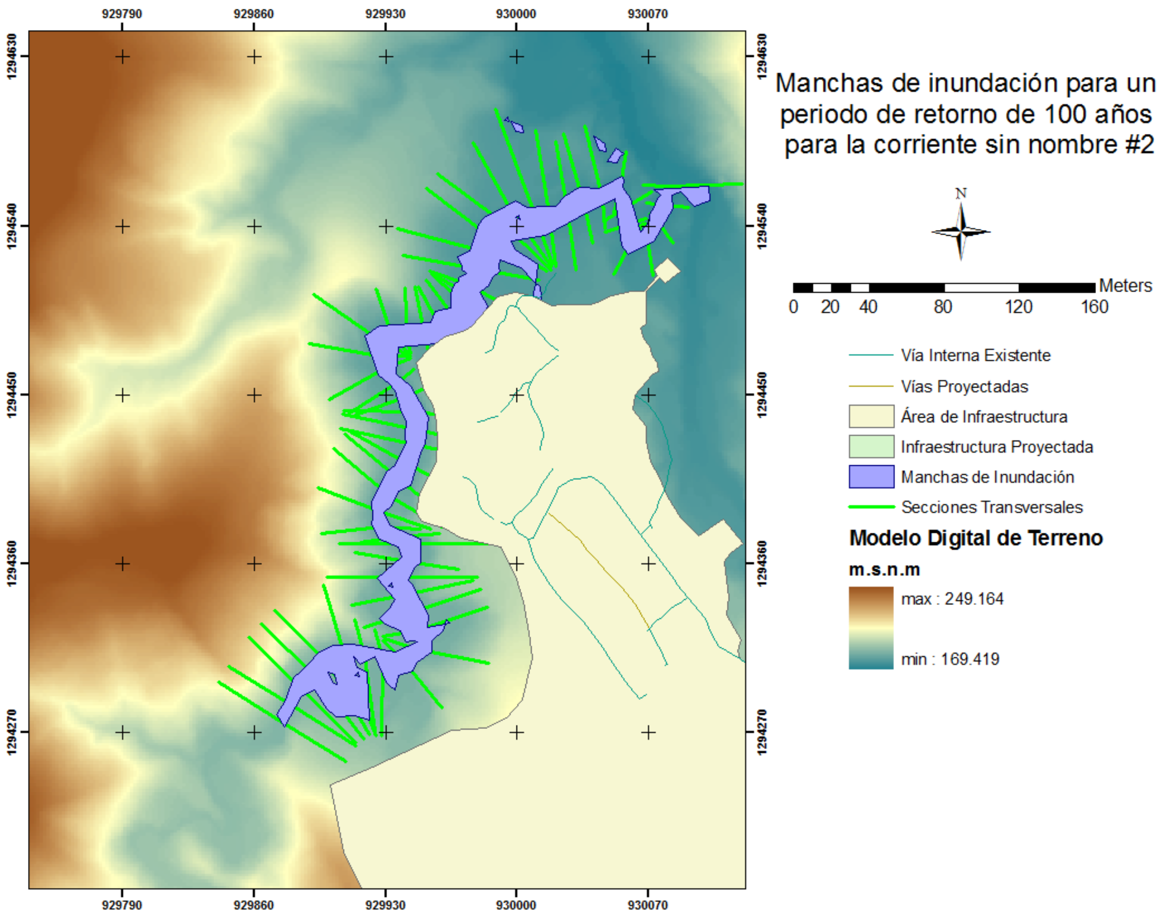


Illustration 5-128. Flood spot for a 100-year return period for the no-name stream # 2.
Source: INGEX, 2016.

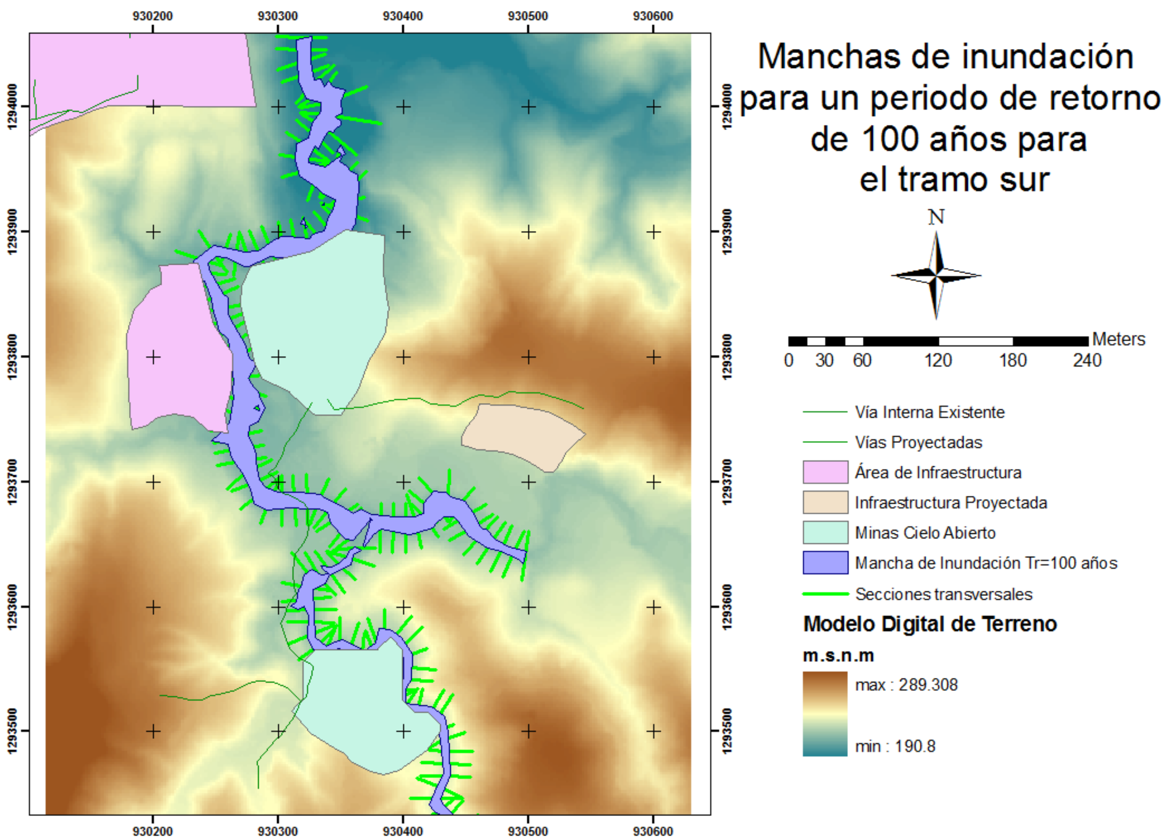


Illustration 5-129. Flood spot for a return period of 100 years for the southern section.
Source: INGEX, 2016.

As identified in Illustration 5-128, the proposed areas are always towards the inner side of the curves and in places where the slope of the terrain is high, the maximum reach for the shore affected does not exceed 5 m in length. Special care must be taken in the flat area to the north of the mining project where the projected works are inside the curve.

In Illustration 5-129, the proposed areas are always towards the inner side of the curves and in places where the slope of the land is high, the maximum reach for the affected shore exceeds 6 m in length.

5.4 FOREST UTILIZATION

For the adequate development of the works to be implemented in the framework of the "El Pescado" mining project of the 5969 mining concession, a single forest use permit is required, in accordance with the in article 5 of Decree-Law 1791 of 1996 compiled in article 2.2.1.1.3.1 of the sole decree regulatory I define as those that *"are made only once, in areas where based on technical studies are shown better aptitude for land use other than forestry or when there are reasons of public utility and social interest. Unique forest uses may contain the obligation to leave the* *land clean, at the end of the use, but not to renew or preserve the forest"*. The forest exploitation, will be carried out according to the specifications of the environmental management presented later in chapter No. 8 "PMA".

5.4.1 FOREST INTERVENTION SITES

The main areas of forest intervention correspond, for the most part, to the coverage of clean grasses (12.19ha = 74.9%), followed by discontinuous urban fabric coverings (2.20 ha = 13.52%), dense lowland forest (1.00 ha = 6.15%) and finally the coverage of secondary vegetation (0.88 ha = 5.41%) (See Table 5-50, Illustration 5-130 and Illustration 5-131). The above for the implementation of the necessary infrastructure, for the adequate development of the project (Laboratories, offices, casino, warehouse, workshops, dumps, heliport, plant processing, power station, micro-soccer field, open pit mines, among others)

Table 5-50. Plant cover affected by the implementation of the works.

COVERAGE	AREA TO INTERVENE (ha)	%
Clean pastures	12,19	74,9
Discontinuous urban fabric	2,20	13,52
Dense low forest of the mainland	1,00	6,15
Secondary vegetation low	0,88	5,41
TOTAL	**16,27**	**100**

Source: INGEX, 2016.

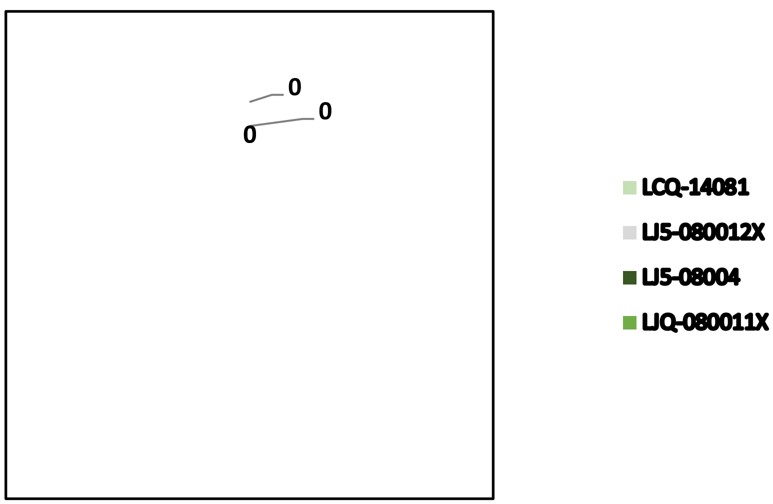


Illustration 5-130. Types of forest cover to take advantage of.
Source: INGEX, 2016.

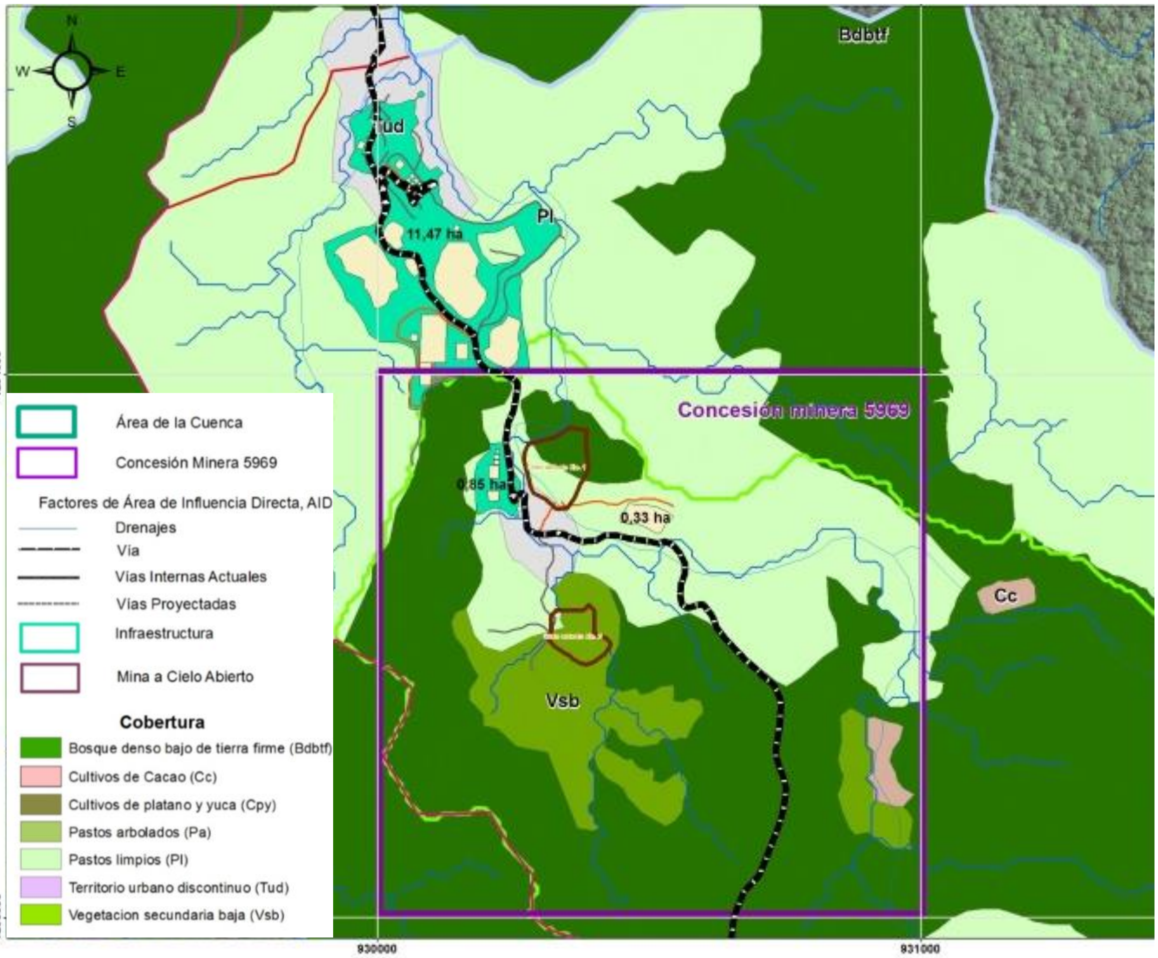


Illustration 5-131. Coverages present in the area of influence.
Source: INGEX, 2016.

5.4.2 VOLUME CALCULATION

For the calculation of total volume, the following equation was used:

$$V = AB * Ht * Ff$$

Where:
V: Volume
AB: Basal Area
Ht: Commercial height expressed in meters
Ff: Form factor = 0,7

This equation was applied to each of the individuals found in the study area, having the area of each one of the coverages to intervene.

Based on the field records of normal diameter and commercial height, the calculation of the timber volume of each tree, totalized by species. However, it is highlight that despite the total commercial volume that will be described below, it is not a total volume of usable wood since many of these individuals are in an advanced state of rot, in addition to being in several cases sprouts that present a high degree of bifurcation, so much is not found volumes considered "usable", notwithstanding the wood that is find in good condition will be used for the manufacture of poles and tables that can be used in works within the same project, clarifying that at no time was the commercialization of this wood.

5.4.3 RESULTS

The vegetation present in the area where they intend to establish in the 5969 mining concession, as the camps, administrative infrastructure (laboratories, offices, casino, warehouse, workshops, among others), dumps, Heliport, processing plant, power plant, field micro-soccer, open-pit mines (north, south), among others; is 472 individuals of 43 species different trees and 27 families, which must necessarily be used, located on the property where the construction of the aforementioned infrastructure will be carried out.

In addition to the schedule and profile that will be carried out for the cleared material and unique use
forest, in accordance with the activities generated by the project, in this it is clearly observed that During the first year and the first ten of the same year, most of the area subject to study list, for the construction of the necessary infrastructure, the open pit mine (North), is will be ready for the second month of the first year and the southern open pit mine is intended for the month 10 of the second year. In this way you will have enough time to carry out the activities of use, in accordance with the proposed specifications of environmental management presented later in chapter No. 8 "PMA".

It is also important to clarify that of these 472 individuals present in the infrastructure of the concession 5969, 158 are saplings, weeds (grasses / weeds) and / or palms without a defined stem (Carludovica palmate); Therefore, as an object of exploitation (usable volume), they have 314 individuals (See Table 5-51 - Table 5-53).

Table 5-51. Tree species found in the southern open pit mine.

N°	FAMILY	SCIENTIFIC NAME	COMMON NAME	INDIVIDUALS
1	URTICACEAE	*Cecropia sp.*	Yarumo	2
2	MELIACEAE	*Cedrela odorata*	Cedro	3
3	BOMBACACEAE	*Ceiba pentandra*	Ceiba	1
4	ULMACEAE	*Celtris trinervia* Lam.	Surrumbo	4
5	RUTACEAE	*Citrus sp*	Limón	1
6	MORACEAE	*Ficus sp.*	Higuerón	3
7	MIMOSACEAE	*Inga sp.*	Guamo	1
8	ANACARDIACEAE	*Ochoterenaea colombiana* F.A. Barkley	Riñon	1
9	BOMBACACEAE	*Ochroma pyramidale*	Balso	9
10	BOMBACACEAE	*Spondias mombin*	Hobo	1
11	BIGNONIACEAE	*Tabebuia ochracea*	Polvillo	1
TOTAL				**27**

Source: INGEX, 2016.

Table 5-52. Tree species found in the north open pit mine.

N°	FAMILY	SCIENTIFIC NAME	COMMON NAME	INDIVIDUALS
1	LAURACEAE	*Aniba sp*	Laurel	4
2	ANNONACEAE	*Annona Cherimola*	Chirimoya	2
3	TILIACEAE	*Apeiba membranacea* Spruce ex Benth	Peine mono	13
4	APOCYNACEAE	*Aspidosperma cruentum*	Carreto	4
5	MELASTOMATACEAE	*Bellucia grossullariodes*	Coronillo	28
6	URTICACEAE	*Cecropia sp*	Yarumo	24
7	MELIACEAE	*Cedrela odorata*	Cedro	3
8	BOMBACACEAE	*Ceiba pentandra*	Ceiba	7
9	ULMACEAE	*Celtris trinervia* Lam.	Surrumbo	7
10	ANACARDIACEAE	*Cespedecia macrophylla*	Pacó	1
11	RUTACEAE	*Citrus sp*	Limón	2
12	MORACEAE	*Cousapoa sp.*	Abraza palo	3
13	BIGNONIACEAE	*Crescentia cujete* L.	Totumo	1
14	SAPOTACEAE	*Crysophyillum cainito*	Caimo	3
15	MORACEAE	*Ficus sp*	Higueron	5
16	MORACEAE	*Ficus zarzalensis* Standl.	Lechero	1
18	HUMIRIACEAE	*Humiriastrum colombianum*	Aceituno	1
19	MIMOSACEAE	*Inga sp.*	Guamo	42
20	BIGNONIACEAE	*Jacaranda copaia*	Chingale	3
21	BIGNONIACEAE	*Jacaranda mimosifolia*	Gualanday	1
22	LACISTEMACEAE	*Lacistema aggregatum*	Hueso	2
23	ANACARDIACEAE	*Mangifera indica*	Mango	3
24	BOMBACACEAE	*Ochroma lagopus*	Pega-pega	20
25	BOMBACACEAE	*Ochroma pyramidale*	Balso	49
26	MELASTOMATACEAE	*Ossaea macrophylla*	Cenicero	11
27	LAURACEAE	*Persea americana*	Aguacate	1
28	URTICACEAE	*Pourouma hirsutipetiolata*	Cirpo	2
29	BOMBACAEAE	*Spondias mombin*	Hobo	1
30	BIGNONIACEAE	*Tabebuia chrysantha*	Guayacan	5
31	ANACARDIACEAE	*Tapira guianensis* Aubl.	Fresno	1
32	MYRISTCACEAE	*Virola flexuosa*	Soto	4
33	HYPERICACEAE	*Vismia baccifera* (L.) Triana & Planch.	Carate	11
34	CLUSIACEAE	*Vismia macrophylla*	Punta de lanza	1
35	MORACEAE	*Zanthoxylum lenticulare* Reynel	Tachuelo	20
TOTAL				286

Source: INGEX, 2016.

Table 5-1. Tree species found where the project infrastructure will be located.

N°	FAMILY	SCIENTIFIC NAME	COMMON NAME	INDIVIDUALS
1	MELASTOMATACEAE	*Clidemia hirta* (L.) D. Don	Mortiño	12
2	POACEAE	*Leersia hexandra*	Lambe-Lambe	40
3	POACEAE	*Andropogon bicornis*	Rabo e zorro	23
4	CYCLANTHACEAE	*Carludovica palmata*	Iraca	2
5	GLEICHENIACEAE	*Sticherus sp*	Helecho Gallinero	20
6	URTICACEAE	*Cecropia sp.*	Yarumo	3
7	RUBIACEE	*Isertia haenkeana* DC.	Coralillo	18
8	HELICONIACEAE	*Heliconia sp*	Platanillo	5
9	RUTACEAE	*Citrus sp*	Naranjo	1
10	VERBENACEAE	*Aegiphila truncata* Moldenke	Tabaquillo	1

N°	FAMILY	SCIENTIFIC NAME	COMMON NAME	INDIVIDUALS
11	ASTERACEAE	*Eupatorium inulae-folium*	Salvia	15
13	HYPERICACEAE	*Vismia baccifera* (L.) Triana & Planch.	Carate	6
14	BIGNONIACEAE	*Jacaranda copaia*	Chingale	2
15	VOCHYSIACEAE	*Vochysia ferruginea* Mart.	Dormilón	1
16	SOLANACEAE	*Solanum jamaicense*	Raja Tetas	9
17	BOMBACEAE	*Ceiba pentandra*	Ceiba	1
TOTAL				**159**

Source: INGEX, 2016.

Within this group of species, there are those individuals that stand out for their uses timber as they are: cedar Cedrela odorata (Cedro) and Tabebuia chrysanta (Guayacán) and species of low commercial value such as Ficus sp (Higueron), Inga marginata (Guamo churimo), Ochroma lagopus (Balso), Aspidosperma cruentum (Carreto), Jacaranda mimosifolia (Gualanday), Tapira guianensis Aubl (Fresno) and Vochysia ferruginea Mart (Dormilón) (See Table 5-54).

Table 5-54. Record of normal diameters and heights.

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
1	Guamo	*Inga sp.*	MIMOSACEAE	49,70	0,50	11,7	4,1
2	Yarumo	*Cecropia sp*	URTICACEAE	30,4	0,30	9,8	5,3
3	Cedro	*Cedrela odorata*	MELIACEAE	22,80	0,23	9,4	4,2
4	Higueron	*Ficus sp*	MORACEAE	0,99	0,01	14,6	5,2
5	Higueron	*Ficus sp*	MORACEAE	1,08	0,01	15,2	6,3
6	Yarumo	*Cecropia sp*	URTICACEAE	17,8	0,18	11,3	6
7	Limón	*Citrus sp*	RUTACEAE	19,8	0,20	4,5	
8	Higueron	*Ficus sp*	MORACEAE	1,02	0,01	13,8	4,3
9	Cedro	*Cedrela odorata*	MELIACEAE	26,4	0,26	7	2,4
10	Cedro	*Cedrela odorata*	MELIACEAE	27,9	0,28	10,4	6,1
11	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	12,9	0,13	6,8	2
12	Ceiba	*Ceiba pentandra*	BOMBACACEAE	73,21	0,73	11,3	5,2
13	Balso	*Ochroma pyramidale*	BOMBACACEAE	12,4	0,12	8,4	6,3
14	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	10,9	0,11	7,8	4,2
15	Hobo	*Spondias mombin*	BOMBACACEAE	13,4	0,13	6,3	3,9
16	Balso	*Ochroma pyramidale*	BOMBACACEAE	14,3	0,14	8,8	7,6
17	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,4	0,15	9,3	4,5
18	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	10,6	0,11	6,8	4,2
19	Balso	*Ochroma pyramidale*	BOMBACACEAE	11,4	0,11	9,2	5,1
20	Riñón	*Ochoterenaea colombiana* F.A. Barkley	ANACARDIACEAE	15,3	0,15	8,3	2
21	Balso	*Ochroma pyramidale*	BOMBACACEAE	12,3	0,12	7,8	7
22	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,4	0,15	8,5	4,5
23	Balso	*Ochroma pyramidale*	BOMBACACEAE	13,2	0,13	9,4	3,8
24	Balso	*Ochroma pyramidale*	BOMBACACEAE	11,2	0,11	7,9	4,1
25	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	9,2	0,09	6,4	3,2
26	Balso	*Ochroma pyramidale*	BOMBACACEAE	8,9	0,09	5,6	2,8
27	Polvillo	*Tabebuia ochracea*	BIGNONIACEAE	3,2	0,03	2,8	
28	Chingale	*Jacaranda copaia*	BIGNONIACEAE	11,3	0,11	10,2	8,7
29	Punta de lanza	*Vismia macrophylla*	CLUSIACEAE	14,4	0,14	5,7	1,8
30	Higueron	*Ficus sp*	MORACEAE	15,1	0,15	8,4	5,3
31	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	18,4	0,18	9,5	6,2
32	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	19,5	0,20	7,6	3,4
33	Higueron	*Ficus sp*	MORACEAE	117,77	1,18	15,8	8,6
34	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	20,3	0,20	6,9	2,3
35	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	23,6	0,24	6,1	3,4
36	Chingale	*Jacaranda copaia*	BIGNONIACEAE	14,3	0,14	8,7	6,2
37	Guayacan amarillo	*Tabebuia chrysantha*	BIGNONIACEAE	8	0,08	6,4	2,6

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
38	Guayacan amarillo	*Tabebuia chrysantha*	BIGNONIACEAE	11,2	0,11	6,7	4,4
39	Gualanday	*Jacaranda mimosifolia*	BIGNONIACEAE	25,6	0,26	10,2	6,3
40	Naranjo	*Citrus sp*	RUTACEAE	12,3	0,12	5,8	
41	Mango	*Mangifera indica*	ANACARDIACEAE	32,3	0,32	6,7	1,9
42	Chirimoya	*Annona Cherimola*	ANNONACEAE	18,4	0,18	5,9	1,2
43	Guamo	*Inga sp.*	MIMOSACEAE	49,4	0,49	7,3	2
44	Aguacate	*Persea americana*	LAURACEAE	14,3	0,14	5,7	1,6
45	Yarumo	*Cecropia sp*	URTICACEAE	20,3	0,20	7,4	3,7
46	Yarumo	*Cecropia sp*	URTICACEAE	10,3	0,10	8,2	3,83
47	Guamo	*Inga sp.*	MIMOSACEAE	11,3	0,11	6,7	2
48	Cedro	*Cedrela odorata*	MELIACEAE	23,2	0,23	10,8	4
49	Guamo	*Inga sp.*	MIMOSACEAE	35,4	0,35	9,6	3,5
50	Mango	*Mangifera indica*	ANACARDIACEAE	2,2	0,02	7,4	1,9
51	Cedro	*Cedrela odorata*	MELIACEAE	16,2	0,16	8,7	4
52	Yarumo	*Cecropia sp*	URTICACEAE	20,3	0,20	9,85	4,8
53	Cedro	*Cedrela odorata*	MELIACEAE	26,2	0,26	8,23	5,36
54	Mango	*Mangifera indica*	ANACARDIACEAE	46,4	0,46	6,49	2
55	Chirimoya	*Annona Cherimola*	ANNONACEAE	11,2	0,11	5,12	1,94
56	Naranjo dulce	*Citrus sp*	RUTACEAE	11,3	0,11	6	
57	Guamo	*Inga sp.*	MIMOSACEAE	27,2	0,27	6,67	1,65
58	Guayacan	*Tabebuia chrysantha*	BIGNONIACEAE	15,3	0,15	8,24	4
59	Totumo	*Crescentia cujete* L.	BIGNONIACEAE	18,3	0,18	5,86	1,8
60	Yarumo	*Cecropia sp*	URTICACEAE	18,2	0,18	10,47	4,56
61	Guayacan	*Tabebuia chrysantha*	BIGNONIACEAE	16,2	0,16	8,7	2,13
62	Guayacan	*Tabebuia chrysantha*	BIGNONIACEAE	11,2	0,11	8,79	2,45
63	Guamo	*Inga sp.*	MIMOSACEAE	34,23	0,34	5,6	1,47
64	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	10,25	0,10	7,89	4,3
65	Yarumo	*Cecropia sp*	URTICACEAE	10	0,10	8,36	4,1
66	Balso	*Ochroma pyramidale*	BOMBACACEAE	21,23	0,21	9,74	5,16
67	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,36	0,15	8,96	4,7
68	Balso	*Ochroma pyramidale*	BOMBACACEAE	23,33	0,23	10,23	6,4
69	Higueron	*Ficus sp*	MORACEAE	24,96	0,25	8,27	4,23
70	Caimo	*Crysophyillum cainito*	SAPOTACEAE	21,4	0,21	11,12	5,68
71	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	28,67	0,29	11,7	3,84
72	Ceiba	*Ceiba pentandra*	BOMBACACEAE	19,24	0,19	9,85	4,79
73	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	12,3	0,12	5,96	3,62
74	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	12,35	0,12	9,21	5,12
75	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	38,3	0,38	15,23	8,36
76	Ceiba	*Ceiba pentandra*	BOMBACACEAE	34,6	0,35	14,65	9,2
77	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	12,43	0,12	7,89	2,3
78	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	33	0,33	12,13	8,45
79	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	16,4	0,16	10	6,1
80	Balso	*Ochroma pyramidale*	BOMBACACEAE	13,2	0,13	9,7	8
81	Balso	*Ochroma pyramidale*	BOMBACACEAE	18,45	0,18	12,45	6,78
82	Ceiba bruja	*Ceiba pentandra*	BOMBACACEAE	19,83	0,20	10,5	4,52
83	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	13,52	0,14	8,96	5,7
84	Balso	*Ochroma pyramidale*	BOMBACACEAE	12,33	0,12	8,75	5,2
85	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	13,26	0,13	10,32	6,45
86	Yarumo	*Cecropia sp*	URTICACEAE	18,95	0,19	11,64	5,7
87	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,24	0,15	10,13	4,62
88	Yarumo	*Cecropia sp*	URTICACEAE	18,51	0,19	12,36	10,52
89	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	11,23	0,11	8,79	4,11
90	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	11,36	0,11	6,92	4,3
91	Balso	*Ochroma pyramidale*	BOMBACACEAE	13,6	0,14	10,1	7,15
92	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	33,47	0,33	12,6	5,3
93	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	15,29	0,15	11,28	6,43
94	Cirpo	*Pourouma hirsutipetiolata*	URTICACEAE	24,33	0,24	12,31	4
95	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	16,72	0,17	9,8	5,8

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
96	Balso	*Ochroma pyramidale*	BOMBACACEAE	30,6	0,306	10,23	4
97	Ceiba bruja	*Ceiba pentandra*	BOMBACACEAE	36,4	0,364	14,89	10,25
98	Hobo	*Spondias mombin*	BOMBACACEAE	24,2	0,242	12,4	6
99	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	35,3	0,353	15,7	7,87
100	Higueron	*Ficus sp*	MORACEAE	127,3236567	1,273236567	18,43	9,76
101	Balso	*Ochroma pyramidale*	BOMBACACEAE	33,21	0,3321	12,24	7,82
102	Balso	*Ochroma pyramidale*	BOMBACACEAE	16,45	0,1645	11,87	8,12
103	Cirpo	*Pourouma hirsutipetiolata*	URTICACEAE	10,43	0,1043	7,93	5,18
104	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	12,52	0,1252	9,47	7,32
105	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	12,36	0,1236	8,89	7,49
106	Balso	*Ochroma pyramidale*	BOMBACACEAE	16,24	0,1624	10,47	8,12
107	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	11,2	0,112	7,23	4,75
108	Ceiba bruja	*Ceiba pentandra*	BOMBACACEAE	31,5	0,315	11,15	7,43
109	Balso	*Ochroma pyramidale*	BOMBACACEAE	19,2	0,192	10,56	6,18
110	Yarumo	*Cecropia sp*	URTICACEAE	12,3	0,123	10,54	6,76
111	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	13,28	0,1328	9,73	6
112	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	14,32	0,1432	12,1	5,74
113	Balso	*Ochroma pyramidale*	BOMBACACEAE	10,2	0,102	8,39	4,93
114	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	20,4	0,204	9,63	6,47
115	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	15,3	0,153	11,42	7,33
116	Guamo	*Inga sp.*	MIMOSACEAE	13,1	0,131	10,47	5,12
117	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	13,5	0,135	11,15	7,47
118	Ceiba bruja	*Ceiba pentandra*	BOMBACACEAE	11,3	0,113	12,73	4,12
119	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	14,32	0,1432	12,41	7,4
120	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	13,56	0,1356	10,35	6,74
121	Chingale	*Jacaranda copaia*	BIGNONIACEAE	10,21	0,1021	9,47	4,23
122	Yarumo	*Cecropia sp*	URTICACEAE	12,24	0,1224	10,94	8
123	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	10,36	0,1036	10,45	8,24
124	Guamo	*Inga sp.*	MIMOSACEAE	22,2	0,222	8,2	4,12
125	Balso	*Ochroma pyramidale*	BOMBACACEAE	11,27	0,1127	12,53	6
126	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	26,45	0,2645	10,32	4,53
127	Yarumo	*Cecropia sp*	URTICACEAE	13,22	0,1322	11,23	6,82
128	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	14,2	0,142	10,63	8
129	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	22,3	0,223	10,57	6,15
130	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	23,5	0,235	12,25	7,34
131	Guamo	*Inga sp.*	MIMOSACEAE	16,5	0,165	9,9	5,83
132	Guamo	*Inga sp.*	MIMOSACEAE	19,6	0,196	8,76	4,69
133	Guamo	*Inga sp.*	MIMOSACEAE	19,3	0,193	9,8	4,83
134	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	17,6	0,176	8,14	5,25
135	Soto	*Virola flexuosa*	MYRISTICACEAE	11,2	0,112	9,47	4,47
136	Carreto	*Aspidosperma cruentum*	APOCYNACEAE	20,4	0,204	13,28	10,42
137	Guamo	*Inga sp.*	MIMOSACEAE	11,6	0,116	9,2	4,3
138	Guamo	*Inga sp.*	MIMOSACEAE	26,4	0,264	11,15	5,22
139	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	15,3	0,153	9,93	4
140	Guamo	*Inga sp.*	MIMOSACEAE	55,4	0,554	13,52	6
141	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	12,5	0,125	9,64	7,13
142	Balso	*Ochroma pyramidale*	BOMBACACEAE	17,5	0,175	10,23	9
143	Yarumo	*Cecropia sp*	URTICACEAE	12,2	0,122	10	8,3
144	Yarumo	*Cecropia sp*	URTICACEAE	11,2	0,112	12,4	8,57
145	Yarumo	*Cecropia sp*	URTICACEAE	10,6	0,106	10,4	8,1
146	Yarumo	*Cecropia sp*	URTICACEAE	13,3	0,133	10,85	6,83
147	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	17,1	0,171	9,83	2,64
148	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	18,2	0,182	9,65	
149	Balso	*Ochroma pyramidale*	BOMBACACEAE	18,3	0,183	11,43	5,74
150	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	10,1	0,101	8,27	4,17
151	Balso	*Ochroma pyramidale*	BOMBACACEAE	16,6	0,166	9,79	7,43
152	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	18,1	0,181	10,21	6,17
153	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	16,5	0,165	12,35	7,12

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
154	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	20,3	0,203	10,29	5,37
155	Lechero	*Ficus zarzalensis* Standl.	MORACEAE	13,6	0,136	9,72	3,85
156	Soto	*Virola flexuosa*	MYRISTICACEAE	11,1	0,111	7,89	2,7
157	Soto	*Virola flexuosa*	MYRISTICACEAE	13,4	0,134	9,15	4,37
158	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	25,3	0,253	12,47	3,15
159	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	28,9	0,289	13,79	4,21
160	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	20,3	0,203	11,47	7,71
161	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	26,5	0,265	12,3	8
162	Guamo	*Inga sp.*	MIMOSACEAE	31,3	0,313	16,27	10,15
163	Balso	*Ochroma pyramidale*	BOMBACACEAE	26,8	0,268	11,47	6,73
164	Guamo	*Inga sp.*	MIMOSACEAE	12,2	0,122	10,23	6
165	Guamo	*Inga sp.*	MIMOSACEAE	13,1	0,131	9,87	7,1
166	Balso	*Ochroma pyramidale*	BOMBACACEAE	16,4	0,164	10	6,3
167	Balso	*Ochroma pyramidale*	BOMBACACEAE	12,4	0,124	9,57	7,94
168	Balso	*Ochroma pyramidale*	BOMBACACEAE	17,2	0,172	10,76	6,97
169	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	11,2	0,112	10,3	8,15
170	Balso	*Ochroma pyramidale*	BOMBACACEAE	14,6	0,146	6	10,23
171	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	15,2	0,152	10	11,9
172	Balso	*Ochroma pyramidale*	BOMBACACEAE	21,2	0,212	8,2	11,89
173	Balso	*Ochroma pyramidale*	BOMBACACEAE	17,5	0,175	8,6	5
174	Yarumo	*Cecropia sp*	URTICACEAE	15,8	0,158	10,43	6,7
175	Yarumo	*Cecropia sp*	URTICACEAE	10,8	0,108	8,79	11,23
176	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	18,3	0,183	6,62	11,85
177	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	14,3	0,143	9,87	3,74
178	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	30,1	0,301	12,63	9,49
179	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	14,3	0,143	9,42	4,35
180	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	12,4	0,124	7,84	3,12
181	Balso	*Ochroma pyramidale*	BOMBACACEAE	30,6	0,306	12,72	9,44
182	Balso	*Ochroma pyramidale*	BOMBACACEAE	10,8	0,108	8,15	4,17
183	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	11,4	0,114	8,39	5,12
184	Laurel	*Aniba sp*	LAURACEAE	12,2	0,122	9,62	4,93
185	Higueron	*Ficus sp*	MORACEAE	13,3	0,133	9,13	7,84
186	Guamo	*Inga sp.*	MIMOSACEAE	30,6	0,306	10,97	3,82
187	Balso	*Ochroma pyramidale*	BOMBACACEAE	21,4	0,214	10,49	9,81
188	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	17,8	0,178	10,32	7,15
189	Balso	*Ochroma pyramidale*	BOMBACACEAE	31,2	0,312	12,54	2,12
190	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	23,6	0,236	11,39	7,32
191	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	13,2	0,132	7,83	4,15
192	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	15,3	0,153	9,47	5,39
193	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	12,4	0,124	7,98	4,1
194	Yarumo	*Cecropia sp*	URTICACEAE	22,1	0,221	8,94	4
195	Balso	*Ochroma pyramidale*	BOMBACACEAE	17,2	0,172	7,89	5,29
196	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	18,3	0,183	7,92	4,13
197	Balso	*Ochroma pyramidale*	BOMBACACEAE	12,3	0,123	8,32	5,1
198	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	19,2	0,192	7,94	2,14
199	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	12,5	0,125	8,15	6,1
200	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	13,6	0,136	6,49	3,18
201	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	20,4	0,204	9,47	6,32
202	Guamo	*Inga sp.*	MIMOSACEAE	12,5	0,125	8,3	6,18
203	Surrumbo	*Celtris trinervia Lam.*	ULMACEAE	12,3	0,123	7,82	4,2
204	Guamo	*Inga sp.*	MIMOSACEAE	18,2	0,182	10,45	10
205	Balso	*Ochroma pyramidale*	BOMBACACEAE	17,2	0,172	10,15	6
206	Balso	*Ochroma pyramidale*	BOMBACACEAE	16,2	0,162	10,2	5,83
207	Pacó	*Cespedecia macrophylla*	ANACARDIACEAE	14,3	0,143	10,12	6,12
208	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	11,2	0,112	8,47	4,15
209	Guamo	*Inga sp.*	MIMOSACEAE	22,3	0,223	12,84	8,2
210	Balso	*Ochroma pyramidale*	BOMBACACEAE	30,6	0,306	15,18	10,3
211	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	13,2	0,132	11,49	6,23

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
212	Balso	*Ochroma pyramidale*	BOMBACACEAE	11,4	0,114	8,35	4,1
213	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	14,1	0,141	10,14	8,2
214	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,1	0,151	8,15	3,3
215	Yarumo	*Cecropia sp*	URTICACEAE	22,3	0,223	12,3	9,15
216	Balso	*Ochroma pyramidale*	BOMBACACEAE	23,6	0,236	14,2	10,18
217	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	18,2	0,182	12,15	7,4
218	Balso	*Ochroma pyramidale*	BOMBACACEAE	21,2	0,212	12,84	9,2
219	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	16,2	0,162	12,49	7,1
220	Yarumo	*Cecropia sp*	URTICACEAE	18,2	0,182	12,63	6,13
221	Guamo	*Inga sp.*	MIMOSACEAE	13,1	0,131	9,18	4,1
222	Guamo	*Inga sp.*	MIMOSACEAE	24,2	0,242	9,84	5,19
223	Balso	*Ochroma pyramidale*	BOMBACACEAE	19,4	0,194	10,32	3,83
224	Balso	*Ochroma pyramidale*	BOMBACACEAE	17,9	0,179	9,89	7,34
225	Balso	*Ochroma pyramidale*	BOMBACACEAE	13,3	0,133	10,23	6,17
226	Caimo	*Crysophyillum cainito*	SAPOTACEAE	19,2	0,192	12,18	7,43
227	Yarumo	*Cecropia sp*	URTICACEAE	13,4	0,134	10,15	6,12
228	Guamo	*Inga sp.*	MIMOSACEAE	14,1	0,141	8,94	6
229	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	28,6	0,286	10,84	5,12
230	Yarumo	*Cecropia sp*	URTICACEAE	12,1	0,121	9,34	3,18
231	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	16,2	0,162	9,73	6,49
232	Caimo	*Crysophyillum cainito*	SAPOTACEAE	18,1	0,181	10,26	7,37
233	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	17,5	0,175	8,94	4,18
234	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	21,2	0,212	11,85	7,6
235	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,1	0,151	10,12	5,8
236	Laurel	*Aniba sp*	LAURACEAE	13,2	0,132	8,1	6,12
237	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	26,2	0,262	12,18	8,1
238	Laurel	*Aniba sp*	LAURACEAE	17,2	0,172	8,34	4,97
239	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	12,2	0,122	8,73	6,4
240	Carreto	*Aspidosperma cruentum*	APOCYNACEAE	23,4	0,234	11,34	10,12
241	Yarumo	*Cecropia sp*	URTICACEAE	17,2	0,172	9,97	4,1
242	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	18,1	0,181	9,83	4,3
243	Hueso	*Lacistema aggregatum*	LACISTEMACEAE	14,2	0,142	9,87	5,2
244	Hueso	*Lacistema aggregatum*	LACISTEMACEAE	37,2	0,372	14,2	10,3
245	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	21,4	0,214	11,43	9,84
246	Balso	*Ochroma pyramidale*	BOMBACACEAE	15,1	0,151	10,5	8,15
247	Carreto	*Aspidosperma cruentum*	APOCYNACEAE	20	0,2	11,47	9,2
248	Carreto	*Aspidosperma cruentum*	APOCYNACEAE	17,8	0,178	10,37	8,12
249	Soto	*Virola flexuosa*	MYRISTICACEAE	15,3	0,153	10,15	9,37
250	Yarumo	*Cecropia sp*	URTICACEAE	21,8	0,218	11,29	9,8
251	Guamo	*Inga sp.*	MIMOSACEAE	20,2	0,202	10,24	5,18
252	Balso	*Ochroma pyramidale*	BOMBACACEAE	17	0,17	11,43	7,36
253	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	15,2	0,152	9,76	6,34
254	Balso	*Ochroma pyramidale*	BOMBACACEAE	31,2	0,312	12,76	10,18
255	Guamo	*Inga sp.*	MIMOSACEAE	23,1	0,231	11,89	6,15
256	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	14,3	0,143	9,97	6,2
257	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	13,2	0,132	8,93	4,18
258	Balso	*Ochroma pyramidale*	BOMBACACEAE	18,2	0,182	9,15	6,12
259	Guamo	*Inga sp.*	MIMOSACEAE	21,2	0,212	7,18	3,2
260	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	17	0,17	6,82	1,3
261	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	12,4	0,124	6,97	1,62
262	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	13,2	0,132	8,15	5,3
263	Guamo	*Inga sp.*	MIMOSACEAE	19,2	0,192	9,36	4,53
264	Guamo	*Inga sp.*	MIMOSACEAE	20,2	0,202	9,12	2,3
265	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	21,3	0,213	10,36	6,12
266	Guamo	*Inga sp.*	MIMOSACEAE	26,9	0,269	8,63	2,83
267	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	17,3	0,173	10,86	6
268	Guamo	*Inga sp.*	MIMOSACEAE	13,2	0,132	8,17	3,76
269	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	29,2	0,292	10,97	6

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
270	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	22,3	0,223	12,04	7,54
271	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	21,2	0,212	10,37	6,82
272	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	15,2	0,152	5,87	4,12
273	Abraza palo	*Cousapoa sp.*	MORACEAE	13,4	0,134	6,98	2,7
274	Guamo	*Inga sp.*	MIMOSACEAE	21,2	0,212	9,15	4,15
275	Guamo	*Inga sp.*	MIMOSACEAE	28,1	0,281	10,12	6,18
276	Guamo	*Inga sp.*	MIMOSACEAE	32	0,32	12,37	2,4
277	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	11,3	0,113	7,83	4,72
278	Balso	*Ochroma pyramidale*	BOMBACACEAE	14,2	0,142	11,46	8,13
279	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	20,6	0,206	11,1	9,18
280	Ceiba bruja	*Ceiba pentandra*	BOMBACACEAE	31,2	0,312	12,89	9
281	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	12,8	0,128	9,73	4,52
282	Guamo	*Inga sp.*	MIMOSACEAE	18,3	0,183	10	2,7
283	Guamo	*Inga sp.*	MIMOSACEAE	11,6	0,116	7,8	2
284	Peine mono	*Apeiba membranacea* Spruce ex Benth	TILIACEAE	12,3	0,123	10,93	3,7
285	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	32,2	0,322	13,15	9,86
286	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	12,3	0,123	8,5	6,12
287	Guamo	*Inga sp.*	MIMOSACEAE	14,3	0,143	9,83	1,97
288	Guamo	*Inga sp.*	MIMOSACEAE	14,4	0,144	9,76	4,18
289	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	16,1	0,161	10,11	6,37
290	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	11,6	0,116	9,87	5,32
291	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	12,3	0,123	9,7	6,1
292	Abraza palo	*Cousapoa sp.*	MORACEAE	11	0,11	10,3	7,8
293	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	14,3	0,143	11,1	4,3
294	Cenicero	*Ossaea macrophylla*	MELASTOMATACEAE	10,3	0,103	8,17	5,17
295	Aceituno	*Humiriastrum colombianum*	HUMIRIACEAE	34,2	0,342	15,12	12,3
296	Guamo	*Inga sp.*	MIMOSACEAE	14,3	0,143	9,17	6,12
297	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	12,2	0,122	9,73	3,82
298	Guamo	*Inga sp.*	MIMOSACEAE	12,4	0,124	8,32	5,15
299	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	14,2	0,142	9,18	6,7
300	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	21,6	0,216	6,73	3,2
301	Coronillo	*Bellucia grossullariodes*	MELASTOMATACEAE	11,1	0,111	10,2	8,45
302	Balso	*Ochroma pyramidale*	BOMBACACEAE	16,6	0,166	9,12	8
303	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE	27,6	0,276	12,36	10,2
304	Abraza palo	*Cousapoa sp.*	MORACEAE	14,6	0,146	11,2	6,18
305	Laurel	*Aniba sp*	LAURACEAE	39,7	0,397	14,89	10,37
306	Guamo	*Inga sp.*	MIMOSACEAE	10	0,1	9,15	6,2
307	Guamo	*Inga sp.*	MIMOSACEAE	12,6	0,126	7,1	4,12
308	Guamo	*Inga sp.*	MIMOSACEAE	12,2	0,122	10,15	9,13
309	Tachuelo	*Zanthoxylum lenticulare* Reynel	MORACEAE	12,6	0,126	6,4	3,12
310	Freno	*Tapira guianensis Aubl.*	ANACARDIACEAE	17,6	0,176	8,42	5,2
311	Yarumo	*Cecropia sp*	URTICACEAE	20,6	0,206	6,18	4
312	Pega-Pega	*Ochroma lagopus*	BOMBACACEAE	20,2	0,202	10,3	6,12
313	Balso	*Ochroma pyramidale*	BOMBACACEAE	22,6	0,226	10,7	7,3
314	Mortiño	*Clidemia hirta* (L.) D. Don	MELASTOMATACEAE				
315	Lambe-Lambe	*Leersia hexandra*	POACEAE				
316	Rabo e zorro	*Andropogon bicornis*	POACEAE				
317	Iraca	*Carludovica palmata*	CYCLANTHACEAE			3,12	
318	Helecho Gallinero	*Sticherus sp*	GLEICHENIACEAE				
319	Yarumo	*Cecropia sp*	URTICACEAE			0,98	
320	Coralillo	*Isertia haenkeana* DC.	RUBIACEE			1,2	
321	Platanillo	*Heliconia sp*	HELICONIACEAE				
322	Naranjo	*Citrus sp*	RUTACEAE			0,43	
323	Tabaquillo	*Aegiphila truncata* Moldenke	VERBENACEAE				
324	Salvia	*Eupatorium inulae-folium*	ASTERACEAE				
325	Carate	*Vismia baccifera* (L.) Triana & Planch.	HYPERICACEAE			0,56	
326	Chingale	*Jacaranda copaia*	BIGNONIACEAE			0,82	

N°	COMMON NAME	SCIENTIFIC NAME	FAMILY	DAP (cm)	DAP (m)	Ht (m)	Hc (m)
327	Dormilón	*Vochysia ferruginea* Mart.	VOCHYSIACEAE	15,2	0,152	5,72	2
328	Raja Tetas	*Solanum jamaicense*	SOLANACEAE				
329	Ceiba	*Ceiba pentandra*	BOMBACACEAE			1,32	

Source: INGEX, 2016.

5.4.3.1 TOTAL VOLUME

After carrying out field work, we proceed to calculate the total volume, for each individual registered in the inventory, by applying the formula previously stated in the methodology. The results obtained are clearly related in Table 5-55.

Table 5-55. Record of the number and total volume by species found in the area of interest.

SCIENTIFIC NAME	INDIVIDUALS	Vt (m^3)
Aegiphila truncata Moldenke	1	
Andropogon bicornis	23	
Aniba sp	4	1,582
Annona Cherimola	2	0,145
Apeiba membranacea Spruce ex Benth	13	5,472
Aspidosperma cruentum	4	1,078
Bellucia grossullariodes	28	3,800
Carludovica palmata	2	
Cecropia sp	29	4,238
Cedrela odorata	6	1,738
Ceiba pentandra	9	7,194
Celtris trinervia Lam.	11	1,096
Cespedecia macrophylla	1	0,114
Citrus sp	4	0,187
Clidemia hirta (L.) D. Don	12	
Cousapoa sp.	3	0,269
Crescentia cujete L.	1	0,108
Crysophyillum cainito	3	0,712
Eupatorium inulae-folium	15	
Ficus sp	8	28,955
Ficus zarzalensis Standl.	1	0,099
Heliconia sp	5	
Humiriastrum colombianum	1	0,972
Inga sp.	43	14,038
Isertia haenkeana DC.	18	
Jacaranda copaia	5	0,224
Jacaranda mimosifolia	1	0,368
Lacistema aggregatum	2	1,190
Leersia hexandra	40	
Mangifera indica	3	1,154
Ochoterenaea colombiana F.A. Barkley	1	0,107
Ochroma lagopus	20	3,321
Ochroma pyramidale	58	11,938
Ossaea macrophylla	11	1,216
Persea americana	1	0,064
Pourouma hirsutipetiolata	2	0,448
Solanum jamaicense	9	0,000
Spondias mombin	2	0,461

SCIENTIFIC NAME	INDIVIDUALS	Vt (m^3)
Sticherus sp	20	
Tabebuia chrysantha	5	0,361
Tabebuia ochracea	1	0,002
Tapira guianensis Aubl.	1	0,143
Virola flexuosa	4	0,340
Vismia baccifera (L.) Triana & Planch.	17	3,067
Vismia macrophylla	1	0,065
Vochysia ferruginea Mart.	1	0,073
Zanthoxylum lenticulare Reynel	20	4,491
TOTAL	472	100,82

Source: INGEX, 2016.

In the previous table, it can be observed that the species with the greatest abundance are Ochroma pyramidale (Balso) with a total of 58 individuals, followed by Inga sp (Guamo) with 43 individuals, Bellucia grossullariodes (Coronillo) with 28 individuals, Cecropia sp (Yarumo) with 29 individuals, the Ochroma lagopus (Balso) and Zanthoxylum lenticulare Reynel (Tachuelo) with 20 individuals, Apeiba Spruce ex Benth (monkey comb) with 13 individuals and the Vismia baccifera (L.) Triana & Planch (Carate) with 17 individuals and those with the lowest abundance were the species Aegiphila truncata Moldenke, Cespedecia macrophylla, Clidemia hirta (L.) D. Don, Crescentia cujete L., Digitaria insularis, Ficus zarzalensis Standl., Heliconia sp, Humiriastrum colombianum, Isertia haenkeana DC., Jacaranda mimosifolia, Ochoterenaea colombiana F.A. Barkley, Persea americana, Solanum jamaicense, Tabebuia ochracea, Tapira guianensis Aubl., Vismia macrophylla, Vochysia ferruginea Mart., with 1 species each.

The largest volume is presented by the species Ficus sp (Higueron) with a total of 28.95 m3 (See Illustration5-132), distributed in 8 individuals, this because the individuals present are diameters large and large.

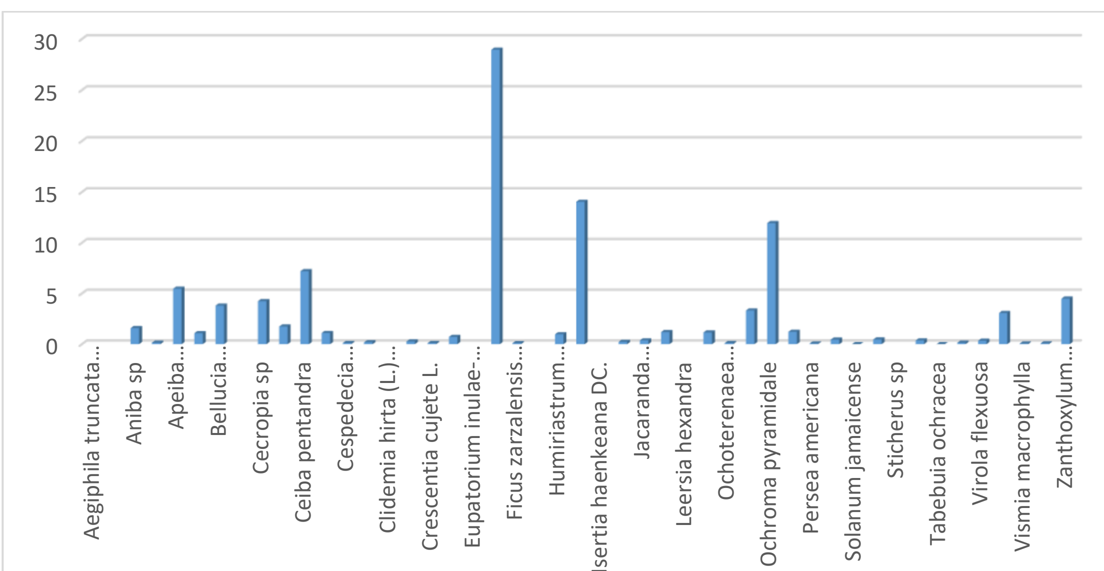


Illustration 5-132. Histogram of the distribution of the total volumes in cubic meters to be harvested found by species.
Source: INGEX, 2016.

Illustration 5-133. Ficus sp.
Source: INGEX, 2016.

5.4.3.2 ADVANCABLE VOLUME

Once the calculations of total volumes have been made and the criteria clarified to perform the calculation of the volume to be exploited, the following results were obtained.

Table 5-56. Record of number of individuals and commercial volume for each species found in the area of interest.

SCIENTIFIC NAME	INDIVIDUALS	Vc (m^3)
Aegiphila truncata Moldenke	1	
Andropogon bicornis	23	
Aniba sp	4	1,0784
Annona Cherimola	2	0,0357
Apeiba membranacea Spruce ex Benth	13	2,8209
Aspidosperma cruentum	4	0,8868
Bellucia grossullariodes	28	2,2539
Carludovica palmata	2	
Cecropia sp	29	
Cedrela odorata	6	0,8514
Ceiba pentandra	9	3,9956
Celtris trinervia Lam.	11	0,6153
Cespedecia macrophylla	1	0,0688
Citrus sp	4	0
Clidemia hirta (L.) D. Don	12	
Cousapoa sp.	3	0,151
Crescentia cujete L.	1	0,0331
Crysophyillum cainito	3	0,4263

SCIENTIFIC NAME	INDIVIDUALS	Vc (m^3)
Eupatorium inulae-folium	15	
Ficus sp	8	15,5455
Ficus zarzalensis Standl.	1	0,0391
Heliconia sp	5	
Humiriastrum colombianum	1	0,7909
Inga sp.	43	6,0867
Isertia haenkeana DC.	18	
Jacaranda copaia	5	0,155
Jacaranda mimosifolia	1	0,227
Lacistema aggregatum	2	0,8413
Leersia hexandra	40	
Mangifera indica	3	0,3462
Ochoterenaea colombiana F.A. Barkley	1	0,0257
Ochroma lagopus	20	2,2759
Ochroma pyramidale	58	7,6638
Ossaea macrophylla	11	0,5591
Persea americana	1	0,018
Pourouma hirsutipetiolata	2	0,1612
Solanum jamaicense	9	0
Spondias mombin	2	0,2317
Sticherus sp	20	
Tabebuia chrysantha	5	0,1386
Tabebuia ochracea	1	0
Tapira guianensis Aubl.	1	0,0886
Virola flexuosa	4	0,2128
Vismia baccifera (L.) Triana & Planch.	17	2,0999
Vismia macrophylla	1	0,0205
Vochysia ferruginea Mart.	1	0,0254
Zanthoxylum lenticulare Reynel	20	2,301
TOTAL	**472**	**55,643**

Source: INGEX, 2016.

The total usable volume found in the area was 55.64 m3. Which is not significant in relation to the total area that is intended to be restored by the project, in this same way areas devoid of vegetation and the low abundance of most of the species, they contributed to the fact that the volumes of harvestable wood in the area are not representative.

The species with the highest usable volume found was *Ficus sp* (Higuerón) with a volume total of 15.56 m3, that is, 27.65% of the total usable wood; followed by the species *Ochroma pyramidale* (Balso) with a total of 7.66 m3and the species Inga sp (Guamo) with a volume of 6.09 m3. On the other hand, the other species found had little commercial valuesignificant with respect to the others and with values lower than 5.01 cubic meter of wood, as shown in Illustration 5-134

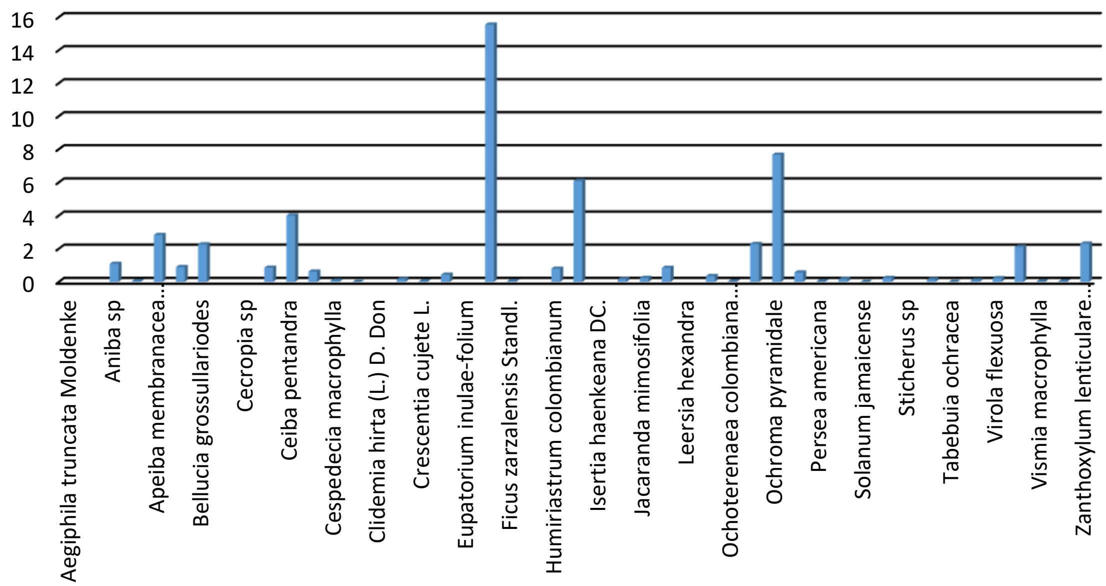


Illustration 5-134. Histogram of the distribution of the total volume of usable wood in cubic meters per species in the area of interest.
Source: INGEX, 2016.

It is also worth noting that due to the characteristics of the species Cecropia sp (Yarumo), a usable wood value of zero (0) cubic meters was considered, even so it is possible to use the remains of plant material that are considered useful in minor tasks.

5.4.3.3 TOTAL VOLUME BY VEGETABLE COVERAGE

The results of volume calculations are directly related to the states of growth that occur in each of the coverages (falls, sapling and seeding), the calculations were based mainly on the fall state, since the saplings and seeding did not have the necessary measures to perform the calculations regarding volume; therefore, it qualified by presence and/or absence.

At a general level and carrying out the weighting of the volumes for each of the coverages plants used for harvesting, the forest inventory allowed to establish that the volume the average total found is 27.15m³/ha. Regarding the average commercial volume found in the four plant coverings it is 15.13m³/ha.

5.4.3.3.1 Clean pastures

The coverage of clean grasses with 12.19 ha represents 74.92% of the area to be harvested, relate the data for this unit.

Table 5-57. Calculations of total and usable volume for the coverage of clean Pastures (Pl).

SPECIES	Vt (m³/ha)	Vc (m³/ha)
Aegiphila truncata Moldenke		
Annona Cherimola	0,145128549	0,035715116
Carludovica palmata		
Cecropia sp	0,629309707	0,297955696
Cecropia sp.		
Cedrela odorata	1,456235999	0,844198153
Ceiba pentandra	0	0
Citrus sp	0,09036305	0
Clidemia hirta (L.) D. Don		
Crescentia cujete L.	0,107891873	0,033140848
Digitaria insularis		
Eupatorium inulae-folium		
Ficus sp	14,31075876	8,369809456
Heliconia sp		
Inga marginata	0,058882373	0,03463669
Inga sp	0,768589196	0,263681195
Inga sp.	1,959153114	0,590622936
Isertia haenkeana DC.		
Jacaranda copaia	0,169414762	0,130778423
Jacaranda mimosifolia	0,367509897	0,226991407
Leersia hexandra		
Mangifera indica	1,154459348	0,346216643
Ochroma pyramidale	0,463132253	0,267681944
Ossaea macrophylla	0,678818699	0,34269948
Persea americana	0,064081972	0,017987922
Solanum jamaicense	0	0
Spondias mombin	0,303743114	0,179318224
Sticherus sp		
Tabebuia chrysantha	0,360919311	0,138600704
Vismia baccifera (L.) Triana & Planch.		
Vismia macrophylla	0,064981357	0,020520429
Vochysia ferruginea Mart.	0,07265611	0,025404234
SUM	23,22602944	12,1659595

Source: INGEX, 2016.

The total and estimated commercial volumes, produced by the forest use for coverage of Clean Pastures (PI) is presented in Illustration 5-135. Illustration 5-135. Total volumes and commercial in the coverage of clean pastures.

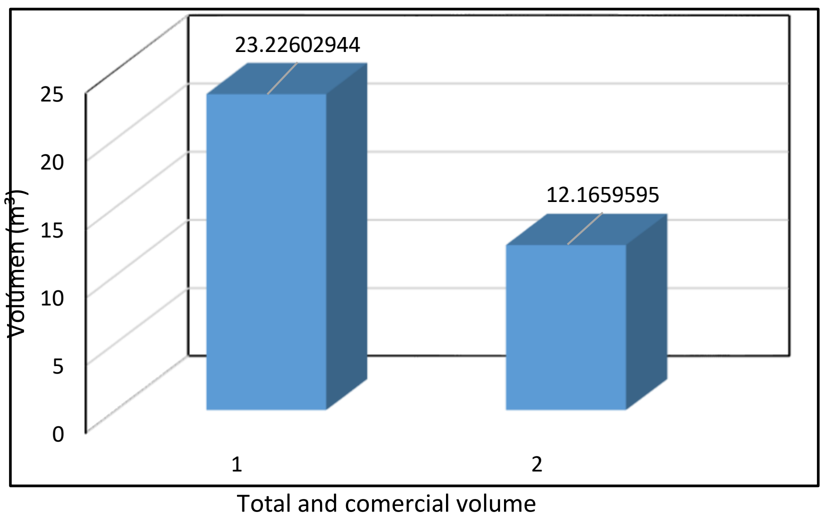


Illustration 5-135. Total and commercial volumes in the coverage of clean pastures.
Source: INGEX, 2016.

5.4.3.3.2 Discontinuous urban fabric

The discontinuous urban fabric coverage with 2.20 ha represents 13.52% of the area to be exploited, in Table 5-58, the data for this unit is related.

Table 5-58. Volume calculations for discontinuous urban fabric coverage.

SPECIE	Vt (m^3)	Vc (m^3)
Cedrela odorata	3,31088868	1,888324
Tabebuia chrysanta	0,03527246	0,01306387
SUM	3,34616113	1,90138787

Source: INGEX, 2016.

The total and estimated commercial volumes, product of the forest use for coverage of discontinuous urban tissue (Tud) is presented in Illustration 5-136.

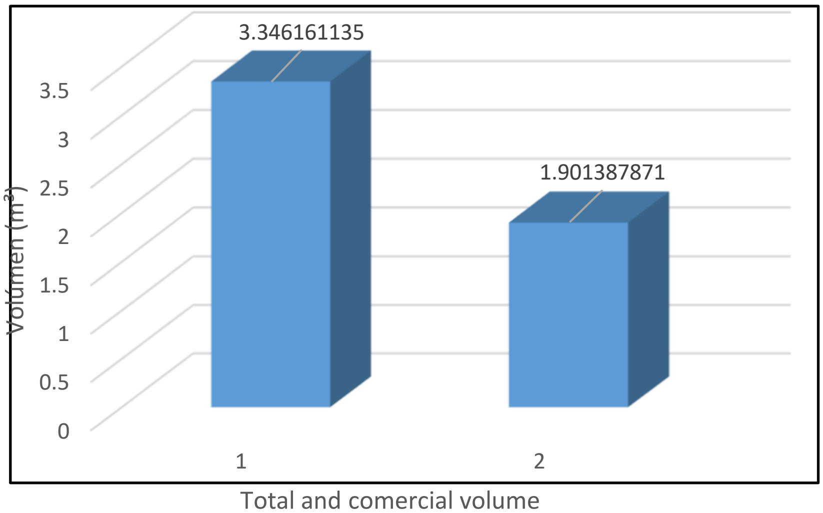


Illustration 5-136. Total and commercial volumes in discontinuous urban fabric coverage.
Source: INGEX, 2016.

5.4.3.3.3 Dense forest of the mainland

The coverage of dense lowland forest with 1.00 ha represents 6.14% of the area take advantage, in Table 5-59, the data for this unit is related.

Table 5-59. Volume calculations for discontinuous urban fabric coverage.

SPECIE	Vt (m^3/ha)	Vc (m^3/ha)
Aniba sp	1,58218275	1,07836643
Apeiba 153 embranácea Spruce ex Benth	5,4724582	2,82090868
Aspidosperma cruentum	1,07809472	0,88681907
Bellucia grossullariodes	3,80006546	2,25386826
Cecropia sp	2,91393303	1,89960666
Ceiba pentandra	3,86379468	2,46327377
Celtris trinervia Lam.	0,91110642	0,5287174
Cespedecia macrophylla	0,11377361	0,0688038
Cousapoa sp.	0,26867863	0,15096633
Crysophyillum cainito	0,71162583	0,42633755
Ficus sp	16,7980737	8,91988003
Ficus zarzalensis Standl.	0,09884006	0,03914961
Humiriastrum colombianum	0,97228355	0,79094496
Inga sp.	10,4898747	4,93933515
Jacaranda copaia	0,05427382	0,02424269
Lacistema aggregatum	1,18976322	0,84127775
Ochroma lagopus	3,32063152	2,27587749
Ochroma pyramidale	11,2369186	7,23622817
Ossaea macrophylla	0,53739589	0,21640108
Pourouma hirsutipetiolata	0,44804625	0,16115709
Spondias mombin	0,39924672	0,1931839
Tapira guianensis Aubl.	0,14339248	0,08855592
Virola flexuosa	0,33971078	0,21284646

SPECIE	Vt (m³/ha)	Vc (m³/ha)
Vismia baccifera (L.) Triana & Planch.	3,06673722	2,09993453
Zanthoxylum lenticulare Reynel	4,49127822	2,30099124
SUM	74,30218	42,917674

Source: INGEX, 2016.

The total and estimated commercial volumes, product of the forest use for coverage of dense lowland forest (Bdbtf) is presented in Illustration 5-137.

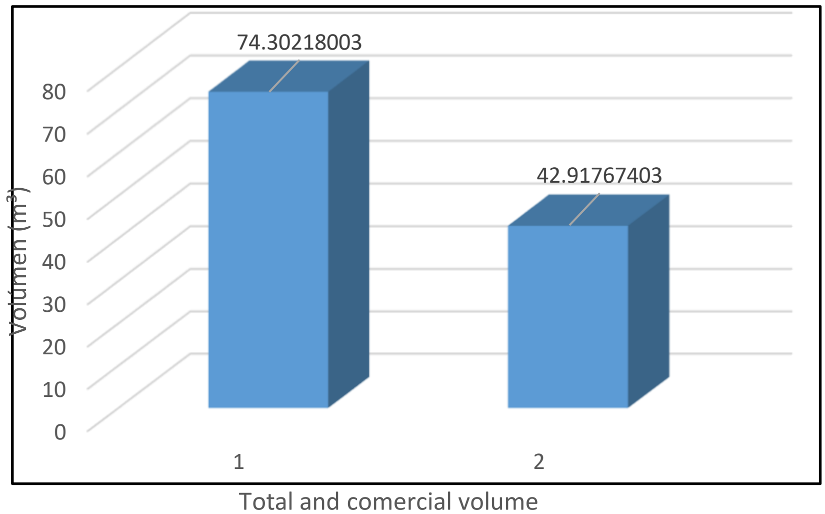


Illustration 5-137. Total and commercial volumes in the dense forest cover of the mainland.
Source: INGEX, 2016.

5.4.3.3.4 Low secondary vegetation

The coverage of secondary vegetation low with 0.88 ha represents 5.41% of the area to be exploited, in Table 5-60. Volume calculations for coverage of low secondary vegetation. Are related the data for this unit.

Table 5-60. Volume calculations for low secondary vegetation coverage.

SPECIE	Vt (m³)	Vc (m³)
Cecropia sp.	0,694760285	0,37380026
Cedrela odorata	0,981944465	0,47304902
Ceiba pentandra	3,329823975	1,532308378
Celtris trinervia Lam.	0,184948741	0,086567369
Citrus sp	0,096991088	0
Ficus sp	0,002547516	0,000929323
Inga sp.	1,588867114	0,556782493
Ochoterenaea colombiana F.A. Barkley	0,10681934	0,0257396
Ochroma pyramidale	0,701554796	0,42757941
Spondias mombin	0,062192653	0,038500214
Tabebuia ochracea	0,001576329	0
SUM	7,752026301	3,515256066

Source: INGEX, 2016.

The total and estimated commercial volumes, product of the forest use for coverage of low secondary vegetation (Vsb) is presented in Illustration 5-138.

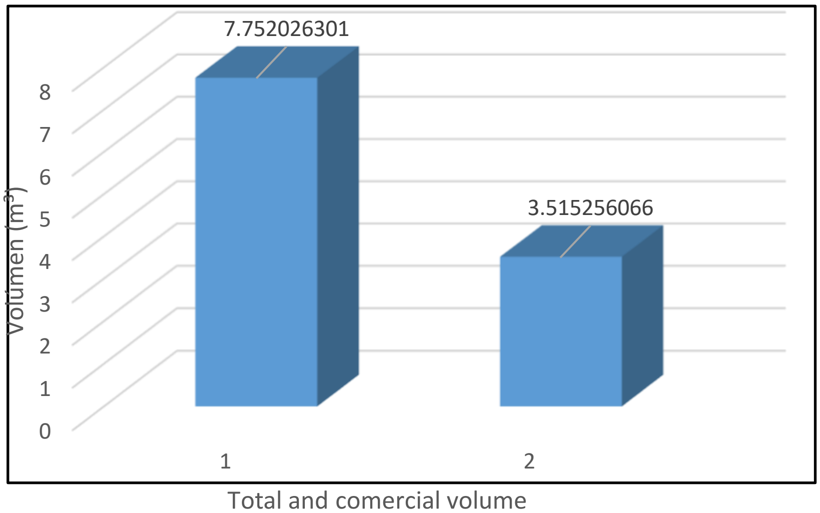


Illustration 5-138. Total and commercial volumes in the coverage of low secondary vegetation.
Source: INGEX, 2016.

5.4.3.3.5 Stand of trees and saplings

For the growth states (stand of trees and sapling), their volume was not quantified because their morphological dimensions did not allow it, the following is the record of the number of individuals by species found.

It was found that the highest values, both for the total and commercial volume to be removed and / or take advantage for the establishment of the necessary infrastructure in the mining project "El Pescado" in concession 6055, corresponds to the unit of clean pastures (Pl), which is because its area is larger compared to the other coverages (Tud, Bdbtf and Vsb).

Table 5-61. Stand of trees and saplings objective of exploitation.

Nº	COVERAGE	COMMON NAME	FAMILY	SPECIE	INDIVIDUALS	OBSERVATIONS
1	Pl	Mortiño	MELASTOMATACEAE	*Clidemia hirta* (L.) D. Don	12	Seeding, its heights vary from 0,30 - 0,90mts
2	Pl	Lambe-Lambe	POACEAE	*Leersia hexandra*	40	Seeding, its heights vary from 0,30 - 0,50mts
3	Pl	Rabo e zorro	POACEAE	*Digitaria insularis*	23	Seeding, heights from 0,50 - 1,0mts
4	Pl	Helecho Gallinero	GLEICHENIACEAE	*Sticherus sp*	20	Seeding, heights from 0,40 - 0,70
5	Pl	Yarumo	URTICACEAE	*Cecropia sp.*	3	Seeding, heights from 0,60 - 1,10mts
6	Pl	Coralillo	RUBIACEAE	*Isertia haenkeana* DC.	18	Seeding, Heights from 0,80 - 0,95
7	Pl	Iraca	CYCLANTHACEAE	*Carludovica palmata*	2	Sapling, Heights from 2,40 - 3,56
8	Pl	Platanillo	HELICONIACEAE	*Heliconia sp*	5	Heights from 1,43mts
9	Pl	Naranjo	RUTACEAE	*Citrus sp*	1	Sapling, Heights from 3,6mts
10	Pl	Tabaquillo	VERBENACEAE	*Aegiphila truncata* Moldenke	1	Seeding, Heights from 0,65 - 1,12mts

Nº	COVERAGE	COMMON NAME	FAMILY	SPECIE	INDIVIDUALS	OBSERVATIONS
11	Pl	Salvia	ASTERACEAE	*Eupatorium inulae-folium*	15	Seeding, Heights from 0,30 - 0,52
12	Pl	Carate	HYPERICACEAE	*Vismia baccifera* (L.) Triana & Planch.	6	Sapling, Heights from 1,12 - 1,60
13	Pl	Chingale	BIGNONIACEAE	*Jacaranda copaia*	2	Seeding, Heights from 2,47 - 4
14	Pl	Raja Tetas	SOLANACEAE	*Solanum jamaicense*	9	Seeding, Heights 0,30 - 0,42
15	Pl	Ceiba	BOMBACEAE	*Ceiba pentandra*	1	Seeding, Heights 1,20mts

Source: INGEX, 2016.

5.5 ATMOSPHERIC EMISSIONS

For the application for the emissions permit, the following aspects are included in this section: related exclusively during the mining operation, the operation of the beneficiation plant and the pits the information that is related below corresponds to the modeling performed by the company "Specialists in engineering, environment and services S.A.S".

5.5.1 Sources of emission.

Within the area of influence of the "El Pescado" mining project, a quality analysis of air and sound pressure levels, in accordance with current environmental regulations. Through modeling the dispersion of pollutants, which allow obtaining baseline data of the area under study without a project, and the evaluation with the project in operation. Annex 5.4 contains the modeling of air quality and sound pressure.

The AERMOD modeling methodology is developed for air quality, considering the meteorological, climatic and geomorphological factors. The information entered into the model is determines: for linear, area and mobile sources, in relation to particulate material: PST and PM10 based on EPA's AP-42 particle emission factors.

For the specific case of the study area of the concession 5969, sources of pollutants depending on the phase of the project, for the baseline the traffic is considered vehicular through the unpaved tertiary roads that cross the study area.

During the construction process, the main emissions are defined as those derived from material loading and circulation of dump trucks with material, in addition to all the works required in the project. The roads correspond to roads uncovered that have been adequate and expanded for the proper movement of equipment.

The AERMOD model is applicable to rural and urban areas, flat and complex terrain, and high surfaces, with multiple sources (including point, area and volume sources). It has been designed with the purpose of avoiding discontinuities in the formulation of the model, in which the large changes in concentrations are the result of small changes in the parameters of entry.

Unlike the existing regulatory models, AERMOD accounts for the lack of vertical homogeneity of the PBL in its dispersion calculations. This is achieved by "averaging" the parameters of the current PBL, in the "effective" parameters of a homogeneous equivalent PBL.

For the input data to the AERMOD model, it must be considered that this requires both information from the study area (directional characteristics and wind speed, topography) as information of the involved processes that need to be modeled, in this case, the process of exploitation and benefit of gold ore in the different phases of the extractive schedule (short, medium and long-term mining) of the El Pescado mining project, in the Municipality of Segovia - Antioquia.

5.5.2 Information of the study area

Regarding the information of the study area, AERMOD mainly requires detailed meteorological and cartographic information, which is pre-processed by the packages AERMET (meteorology) and AERMAP (cartography).

The meteorological information used for the study was obtained through Lakes Environmental, company that offers the services of sale of meteorological information modeled for any place in the world, information obtained through the implementation of NCAR MM5 (5th generation of model of mesoscale) weather forecast model for a place and domain site specified.

Once the MM5 pre-processing has been completed, the MM5 output file becomes a format recognized by the AERMET model (meteorological preprocessor for the model AERMOD). The final output is generated by the creation of a pseudo meteorological station in the location of the specified site, with the format files: SAMSON and TD-6201.

5.5.3 Meteorological information

The meteorological information of the study area, obtained between January 1 and December 31 of 2014, it is pre-processed through the AERMET system, with the information from Meteorological Data and Station that are presented below, which were acquired through the execution of the NCAR MM5 (5th generation mesoscale model) by Lakes Environmental.

Table 5-62. Meteorological information.

Order #:	MET157493
Ordered by:	Leon Andres Gomez Aristizabal
Company:	Modelaciones
Met Data Type:	AERMET-Ready (Surface & Upper Air Data)
Start-End Date:	Jan 01, 2014 - Dec 31, 2014
Latitude:	7.254078 N
Longitude:	74.709328 W
Datum:	WGS 84
Site Time Zone:	UTC/GMT UTC - 5 hour(s)
Closest City & Country:	segovia - Colombia

Source: Specialists in engineering, environment and services S.A.S, 2016.

Table 5-63. Information of the station.

Anemometer Height:	14 m
Station Base Elevation:	401 m
Upper Air Adjustment:	+5 hour(s)

Source: Specialists in engineering, environment and services S.A.S, 2016.

Table 5-64. Description of the information obtained.

MM5-Processed Grid Cell	- Information center (latitude, longitude): 7.254078º N, 74.709328 ºW. - Dimension of the cell: 5km x 5km. - Departure period: January 1, 2014 - December 31, 2014.
Surface meteorological data by hour	- Format: SAMSON (Surface met data for preprocessing by AERMET). - Anemometer height: 14 meters. - Base elevation above sea level: 401 m.a.s.l

Source: Specialists in engineering, environment and services S.A.S, 2016.

In the following table, the main parameters of the annual information (2014) loaded are presented to the model, the hourly values of each one of the parameters entered and obtained through mesoscale information.

Table 5-65. Description of the information obtained.

Column	Parameter	Unit
6	Total cloud cover	Tenths
7	Coverage of opaque clouds	Tenths
8	Dry bulb temperature	Celsius degrees (ºC)
9	Dew point temperature	Celsius degrees (ºC)
10	Relative humidity	Percentage (%)
11	Atmospheric Pressure	Mill bars (mb)
12	Wind direction	Degrees (deg)
13	Wind speed	Meters per second (m/s)
15	Ceiling height	Meters (m)
21	Amount of hourly precipitation	Hundredths of inches

Source: Specialists in engineering, environment and services S.A.S, 2016.

After this, the meteorological information obtained, is processed with the AERMET software, through of the execution of NCAR MM5 (5th generation of the mesoscale model). Both in the format SAMSON as the TD-6201.

In addition to identifying the values of the albedo, Bowen radius and terrain roughness coefficient. The output files are in PROFILE format. PFL and SURFACE .SFC, generated by the processing of meteorological information, which are considered input elements for the AERMOD model.

Likewise, the Rose of the Winds is presented, which indicates the direction of the winds in the Northeast Antioquia, where the following wind speed ranges are 2.10 m/s to 3.60 m/s with 52.6%, followed by the speed range between 0.50 m/s to 2.1 m/s with 31.8%, according to the frequency distribution for the wind classes, as it is related in the Illustration 5-139 - Illustration 5-140.

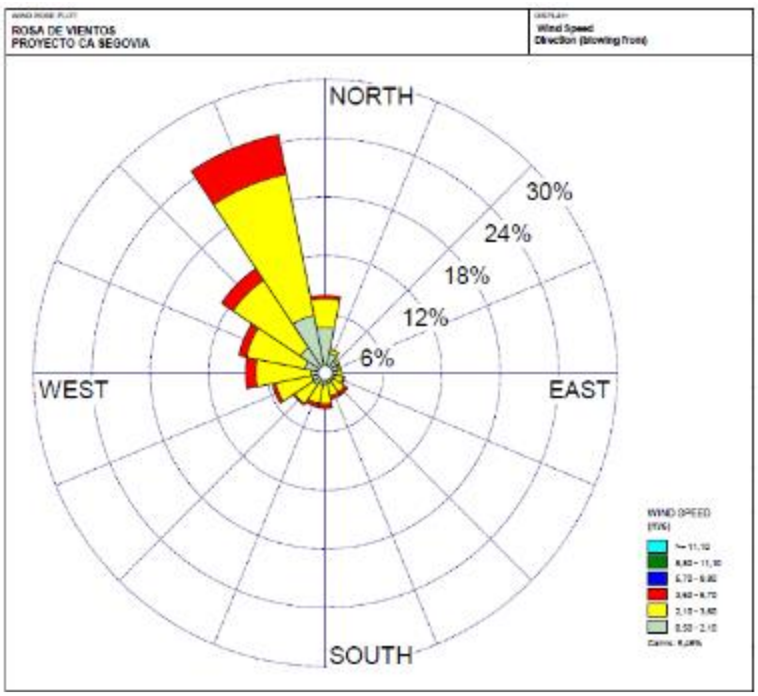


Illustration 5-139. Rose of winds.
Source: Specialists in engineering, environment and services S.A.S, 2016.

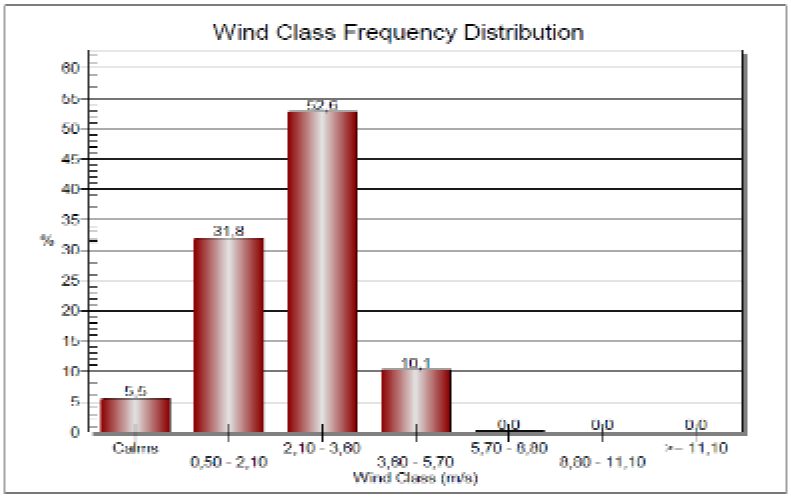


Illustration 5-140. Frequency distribution.
Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.4 Cartographic information

With the basic and thematic cartography of the project, the information is pre-processed map, generating the Digital Elevation Model (DEM) of the Study Area through the AERMAP software.

This DEM will allow the AERMOD to obtain information about the surface and topography of the land, for optimal processing of the dispersion of pollutants, altitudes of concentrations, and location of sources and receivers (Illustration 5-141 - Illustration 5-142).

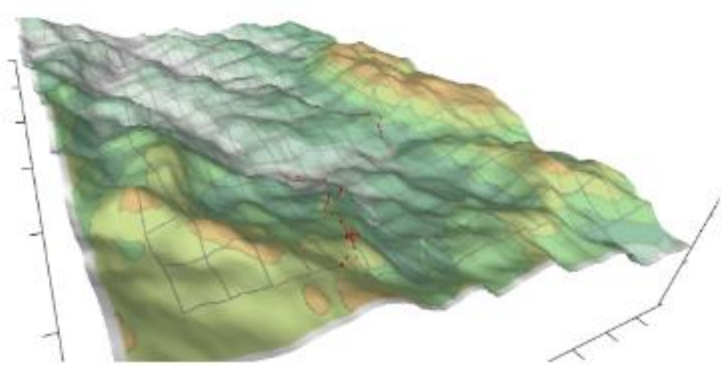


Illustration 5-141. Top view in 3D.
Source: Specialists in engineering, environment and services S.A.S, 2016.

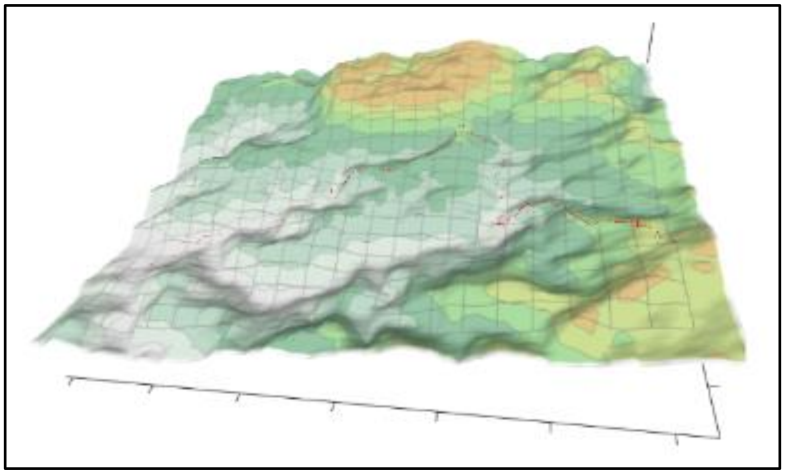


Illustration 5-142. Front view in 3D.
Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.5 Sources identified in the study area.

For each of the sources that could be evaluated, secondary information was analyzed, concerning the calculation of the respective emission factors, considering the values of input and calculation for US EPA AP-42 and EMEP / EEA methodologies.

5.5.5.1 Unpaved roads

These sources include all types of roads passable by motor vehicles of combustion internal, which cover the internal and external areas of the project. Considering the possibility of cover the greatest amount of extension for the sources analyzed, line modeling is considered base contemplating the routes that arrive and leave the study area, to and from the municipality of

The types of roads identified in the area, according to the IGAC classification, are: Track type 3 with one approximate total daily circulation of 2 vehicles.

5.5.5.2 Unpaved roads

This source is directly related to the movement of dump trucks through the routes that are proposed for expansion and for the exploitation areas.

5.5.5.3 Management of aggregates, upload and download

This source is directly related to the handling of the cleared material, excavation, and aggregates that must be mobilized during exploitation.

5.5.6 Inventory of emissions

The inventory of sources is based on the methodology suggested in number 4.4.2 of the chapter Initial Review of the Design Manual for Air Quality Surveillance Systems 1, which indicates that for a general inventory of emissions the use of emission factors is feasible. In this inventory, the following considerations are taken into account:

i. Classification of all pollutants and emission sources in the study area.

ii. Identification and collection of information on the emission factors for each of the pollutants and identified sources.

iii. Determination of material handled, processed or burned. Or relevant information about activities identified as individual sources.

iv. Calculation of emission rates.

v. Sum of the emissions of specific pollutants for each of the identified sources.

5.5.6.1 Classification of pollutants and emission sources

This study models the current and future concentrations of the area under study, encompassing the greatest number of sources susceptible to contribution to the concentrations of pollutants in the area of influence of the project. When the area corresponds to a rural area, the following are considered aspects.

i. Low biogenetic emissions.

ii. The low population in the area.

iii. Low circulation of light and heavy vehicles.

The following sources are taken into account for each of the phases of the project:

i. Extension of existing roads to a final width of 8 meters.
ii. Circulation of light vehicles and dump trucks on unpaved roads, transporting material.
iii. Exploitation of quarries in the open for the extraction of material.

5.5.6.2 *Determination of material handled, processed or burned. Or information relevant to the activities identified as individual sources.*

The amount of material that is projected to be processed during the modeling period corresponds to 928,000 tons of production of usable material and 74,667 tons of sterile material for deposit in dumps, this corresponding to open sky. For portal they are going to process.758,550 tons and 61,367 tons of sterile.

This material subject to processing and manipulation in the plant, in addition to the activity of the necessary equipment for the different operations, are considered as emissions mainly of particulate-type atmospheric pollutants, specifically Suspended Particles Totals (PST) and the smaller particles at 10 µm (PM10).

5.5.6.3 *Pollutants analyzed*

Considering the productive processes of the different phases that will be carried out in the project El Pescado - Mining Title 5969 in the municipality of Segovia, mainly represented for the exploitation and benefit of gold ore, it is identified that the main pollutant susceptible to be generated corresponds to the particulate material, specifically for Particles Total Suspended (PST) and Minor Particles at 10 µm (PM10).

In the following table, the type of source associated to each of the phases of the project is presented (line base and operation), and the type of pollutant is related to each of the sources:

Table 5-66. Pollutants to be evaluated by source.

Phases	Sources	Main contaminants susceptible to be analyzed and methodologies	
		PM_{10}	PST
Base line	Unpaved roads	AP-42 Section 13.2.2 Unpaved Roads	
Operation	Unpaved roads	AP-42 Section 13.2.2 Unpaved Roads – Industrial	
	Movement of materials and handling of aggregates	AP-42 Section 13.2.4	

Source: INGEX, 2016.

5.5.6.3.1 Compilation of the emission factors

An emission factor is a representative value that attempts to relate the quantity of a pollutant released into the atmosphere with an associated activity in the emission of said pollutant. Usually these factors are expressed as the weight of the contaminant on a unit of weight, volume, distance, or duration of the activity emitting the contaminant. (US EPA, 1990).

When the AERMOD model is applied to linear or area sources, it is necessary to establish or calculate emissions of pollutants from these sources, for which the factors of AP-42 emission of the EPA, of the European Economic Community, or similar. The methodologies for establish the emission factors of the sources, depend on different factors for each type of source or process, such as unpaved roads, handling of materials, aggregates and batteries storage.

5.5.6.3.2 Calculations of emission factors AP-42 US EPA

The general equation for the estimation of emissions is:

E=A x EF x (1-ER/100)

Where:

E= Emissions.
A= Activity rate.
EF= Emission factor.
ER= Complete emission reduction efficiency, %.
Emission factors are generally developed to represent long-term averages of emission, since the measurements are usually made during standard operating conditions.

The AP-42 emission factors are classified into different categories that represent reliability of said factor, this classification is assigned based on the estimated reliability of the tests used to develop the factor, both about the quantity and the representative characteristics of these data.

Factors based on many observations, or on more widely accepted methodologies they have assigned the highest categories. The classification of the AP-42 factors does not imply limits of statistical error or confidence intervals related to each emission factor.

Table 5-67. Classification of the EPA factors.

A	B	C	D	E
Excellent	Above average	Average	Below average	Poor

Source: INGEX, 2016.

- **Unpaved roads:** The methodology for calculating emission factors for roads not paved rural and industrial, consider variables such as: moisture, silt content, weight of the vehicles, average speed of transit, among other aspects.

  To calculate the emission factors for industrial roads (routes of exploitation), and roads rural areas (existing unpaved roads), the following equations are used:

Equation 1.

$$E = k\ (s/12)^a\ (W/3)^b$$

Equation 2.

$$E = \frac{k\ (s/12)^a\ (W/3)^b}{(M/0.5)^c}$$

Where:

k, a, b, c y d= Empirical constants.

E= Emission factor for the respective particle size (lb/VMT).
s= Silt content on the soil surface (%).
W= Average vehicle weight (Ton).
M= Moisture content on the soil surface (%).
S= Average vehicle speed (mph).
C= Emission factor for vehicles after the 80s for engines, tires and brakes.

Complementing the variables with average silt contents of 3% and average humidity of the 23% area, the Emission Factors are calculated through equations 1 and 2.

- Management of aggregates and storage in Batteries: The methodology allows calculating factors of emission for the management of aggregates and storage in piles of a process of exploitation of material, considering variables such as: average wind speed, humidity, silt content, in other aspects.

  To calculate the emission factors for handling aggregates and storage in piles of a material exploitation process, the following equations are used:

  Equation 3:

$$E = k\ (0.0016)\ \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \ (kg/megagram\ [Mg])$$

  Equation 4:

$$E = k\ (0.0032)\ \frac{\left(\frac{U}{5}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}\ \ (pound\ [lb/ton])$$

Where:

E= Emission factor for the respective particle size.
k= Multiplier for the particle size (dimensionless).
U= Average wind speed (m/s).
M= Material moisture content (%).

Complementing the variables with average silt contents which are presented in 3%, a speed mean of the wind of 2.13 m / s and 10% of average humidity of the material the emission factors are calculated through equation 3.

- **Baseline:**

- **Unpaved roads**: When applying the equations of the AP-42 method for this type of source, the following results for the respective particle sizes, in units of pound per mile traveled of vehicle (lb/VMT) and in grams per kilometer traveled vehicle (g/VKT). The model is entered emission factors for PM10 and PST.

Table 5-68. Emission factors resulting from public roads.

Type	PM_{10}	PST	Unit
Emission factor	0,191	0,450	lb/VMT
Emission factor	53,7	126,8	g/VKT

Source: Specialists in engineering, environment and services S.A.S, 2016.

- **Operation:**

- **Unpaved roads:** After applying the respective equations, the following results are obtained for the respective particle sizes, in units of pound per vehicle traveled mile (lb/VMT) and in grams per kilometer traveled by vehicle (g/VKT).

For this process, the emission and emission factors based on the circulation of dump trucks are calculated the entry and internal routes.

Table 5-69. Emission factors

Type	PM_{10}	PST	Unit
Emission factor	380,8	1640,9	g/VKT

Source: Specialists in engineering, environment and services S.A.S, 2016.

- **Management of aggregates and storage batteries**: When applying Equation 3, the following are obtained results for the respective particle sizes, in units of kilograms per megagram of exploited material (Kg/Mg).

For this process, they calculate the emissions resulting from the start, movement and discharge of material. It is considered a planning of natural and logistic controls for 50% of emissions in the different processes of the material.

Table 5-70. Emission factors resulting from material handling.

Type	$PM_{2.5}$	PM_{10}	PST	Unit
Emission factor	0,005	0,036	0,075	Kg/Mg

Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.6.3.3 Calculation of emission rates

The emission rates were calculated through the equations and factors presented previously, for each of the activities likely to generate atmospheric emissions of particulate material was generated the respective calculation, then the results are presented for the different emission factors calculated for both PST and PM_{10}.

Table 5-71. Emission factors calculated for PM10

Type	Emission	Unit	Emissions of control	Unit
Quarry north	0,1060	g/s	0,07429	g/s
Quarry South	0,1222	g/s	0,08556	g/s
Via section 1	-	g/s	0,0249	g/s
Via section 2	0,1851	g/s	0,1296	g/s
Via section 3	0,1983	g/s	0,1388	g/s

Source: Specialists in engineering, environment and services S.A.S, 2016.

Table 5-72. Emission factors calculated for PST

Type	Emission	Unit	Emissions of control	Unit
Quarry north	0,2244	g/s	0,1571	g/s
Quarry South	0,2584	g/s	0,1809	g/s
Via section 1	-	g/s	0,0587	g/s
Via section 2	0,7976	g/s	0,5584	g/s
Via section 3	0,8546	g/s	0,5982	g/s

Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.7 Receiver information

The AERMOD model allows entering the receivers to calculate the immission concentrations, the most practical and effective method to enter the area of receivers is the distribution of a mesh or grid, which generates a total of 441 receivers to interpolate the concentrations distributed in the modeling area.

5.5.8 Air quality modeling

For air quality modeling, all the information regarding the model must be entered into the model each of the emission sources, in addition to all the files generated for meteorology and DEM.

It is important to mention that the AERMOD models the concentrations of pollutants derived from specific sources, such as chimneys, area sources such as quarries and exploitation mines open sky, linear sources such as roads uncovered. Therefore, the concentrations obtained when running the model, they correspond exclusively to the information loaded for the sources of analysis, without considering external or distant sources not included within the study area. Thus, all the results will correspond to the direct emissions of the productive process.

5.5.9 Results of the models for air quality

Below, each of the results obtained for the baseline and for the operation in each of the three phases of the mining project, specifically related to the mining title 5969.

5.5.9.1 Baseline models

In the result of dispersion modeling of particles smaller than 10 micrometers PM10 for the baseline of the project, very low concentrations are observed in the study area an average between 0,010 µg/m 3 y 0,625 µg/m 3 for the study area, 0,625 µg/m was obtained as the maximum value 3 for the entire modeled period.

It is important to highlight that the concentrations of the area are very low and that the highest is presented in the vicinity of the unpaved roads, while moving away from the roads were reported lower values, as shown in the following illustration.

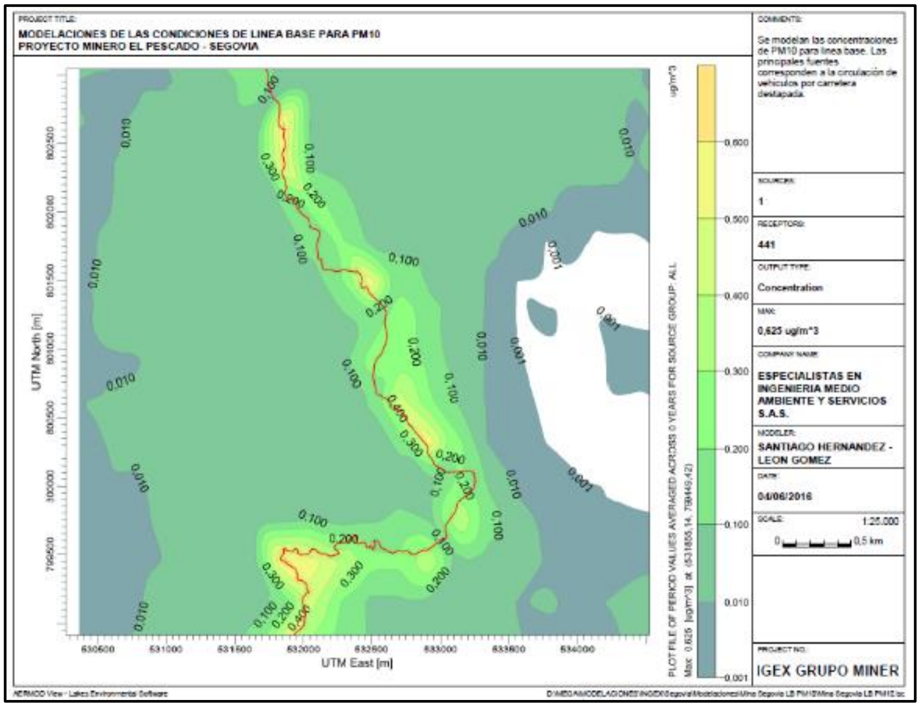


Illustration 5-143. Model PM10 annual Baseline.
Source: Specialists in engineering, environment and services S.A.S, 2016.

In the results for total suspended particles PST from the project baseline, we observe concentrations in a large percentage of the study area between 0,01 y 1,47 µg/m^3, as a value maximum 1,47 µg/m^3 was obtained for the entire modeled period.

It is important to note that the highest concentrations are located in the immediate vicinity of the paved, while the further away from the tracks these concentrations decrease considerably.

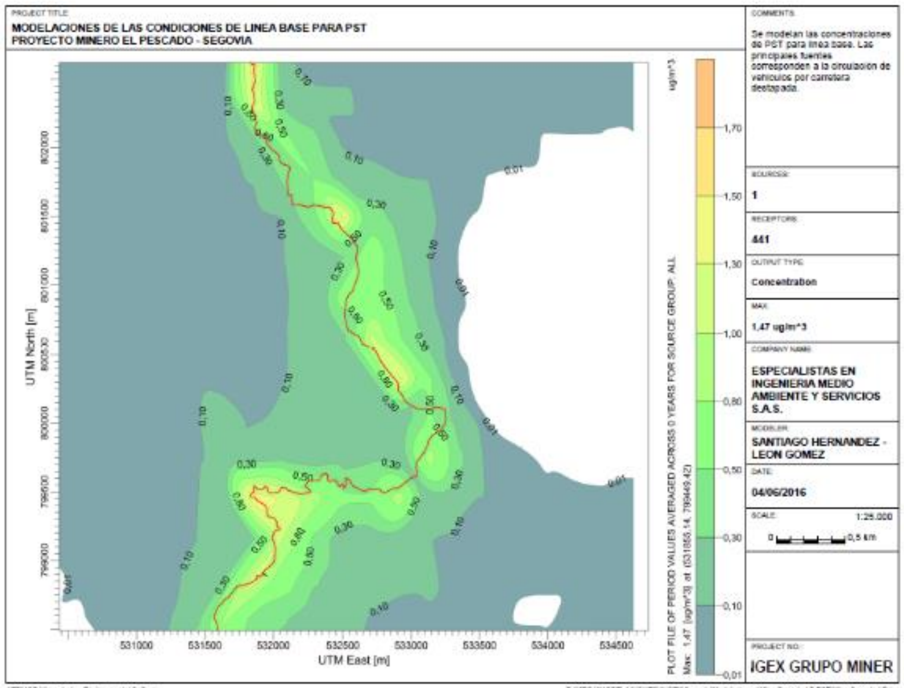


Illustration 5-144. Annual baseline PST model.
Source: Specialists in engineering, environment and services S.A.S, 2016.

Taking into account the provisions of Resolution 610 of 2010, the permissible values for PM_{10}, correspond to 50 µg/m^3/ daily and 100 µg/m^3/ annual and for PST 100 µg/m^3/ daily and 300 µg/m^3/ annual, which allows us to infer that the air quality will be maintained during the exploitation and abandonment phase of the "El Pescado" mining project.

5.5.9.2 Models operation phase

As in the Base Line, the annual models are generated for the operation phase, both for PM10 as PST.

For the short, medium and long-term annual models, concentrations mostly fluctuate between 1µg/m 3 and 20 µg/m 3 for PM10 and between 10 µg/m 3 and 40 µg/m 3 for PST. The maximum concentrations that are presented are 22,8 µg/m 3 and 76,4 µg/m 3, respectively for PM10 and PST.

Due to the operating characteristics projected for the operation of the mine, the following maps.

- Short term operation.

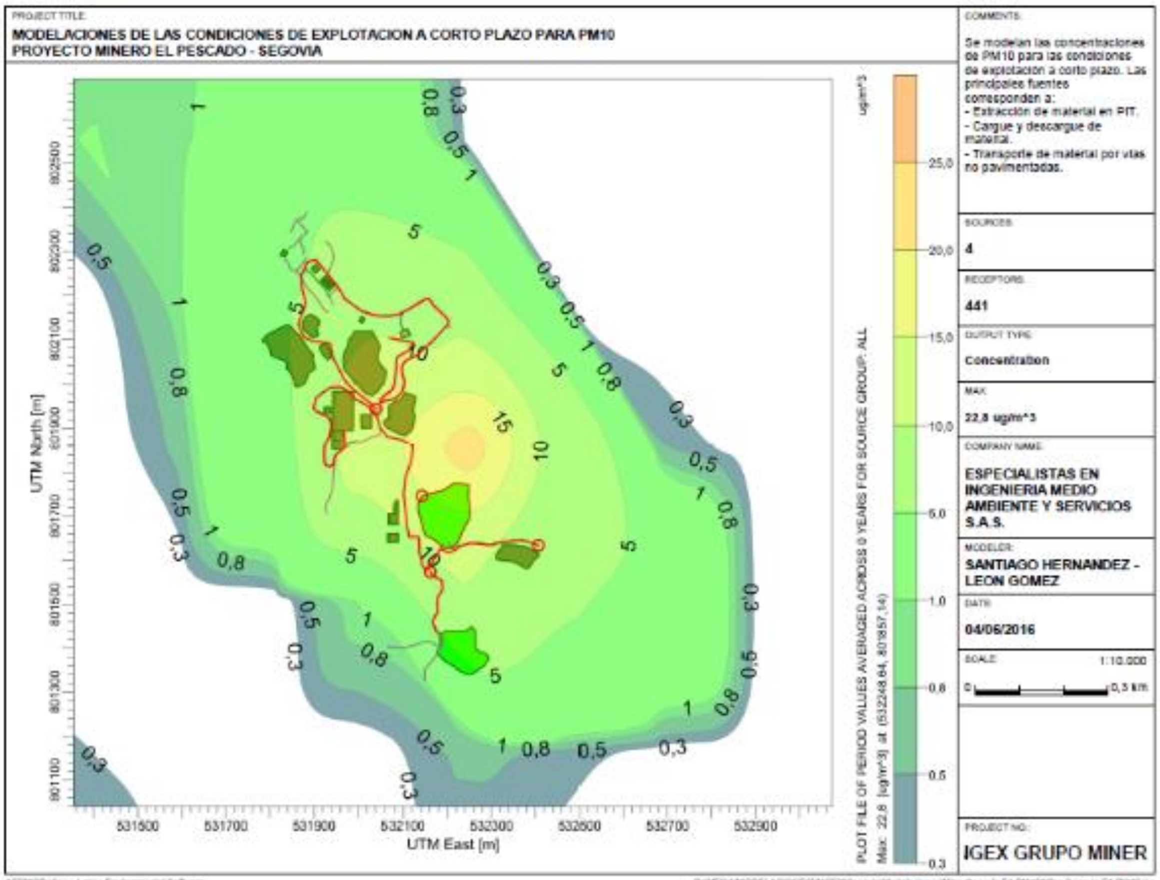


Illustration 5-145. Model PM_{10} Annual short term.
Source: Specialists in engineering, environment and services S.A.S, 2016.

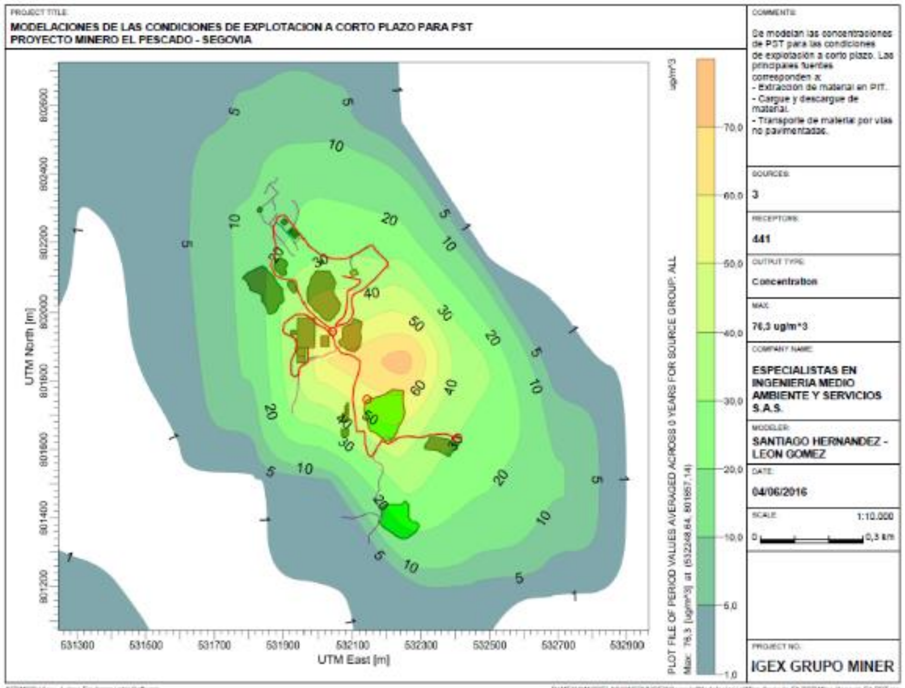


Illustration 5-146. Model PM_{10} Annual short term.

Source: Specialists in engineering, environment and services S.A.S, 2016.

- Medium-term operation.

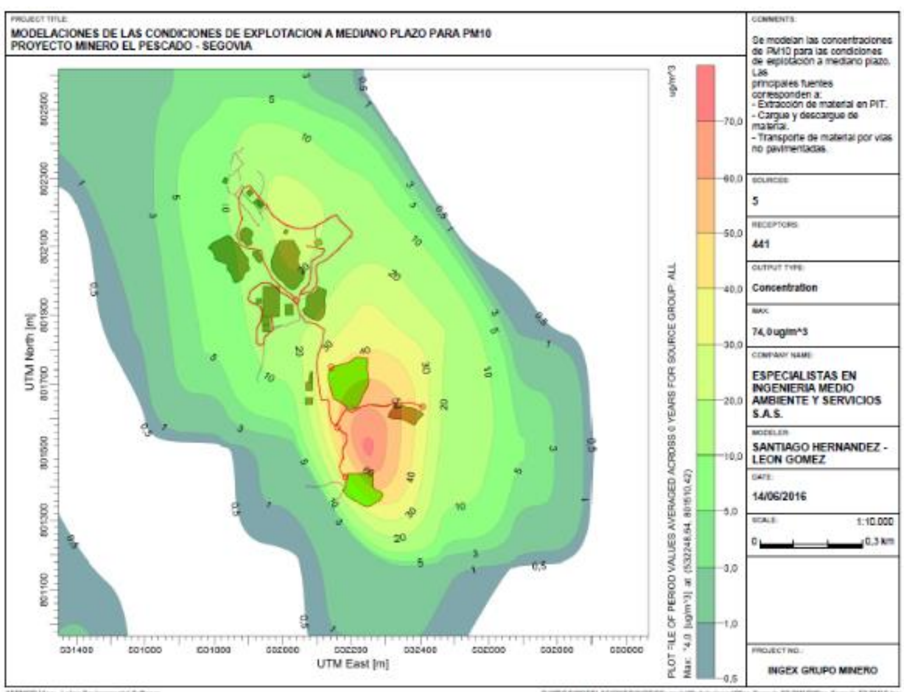


Illustration 5-147. Model PM_{10} medium-term annual.

Source: Specialists in engineering, environment and services S.A.S, 2016.

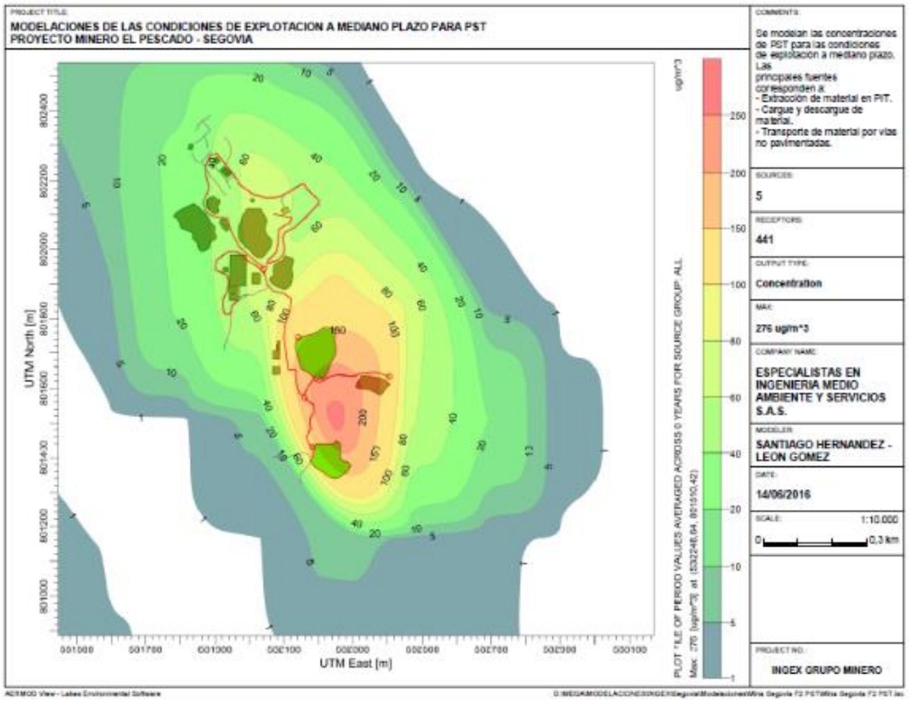


Illustration 5-148. Annual medium-term PST model.

Source: Specialists in engineering, environment and services S.A.S, 2016.

- Long-term operation.

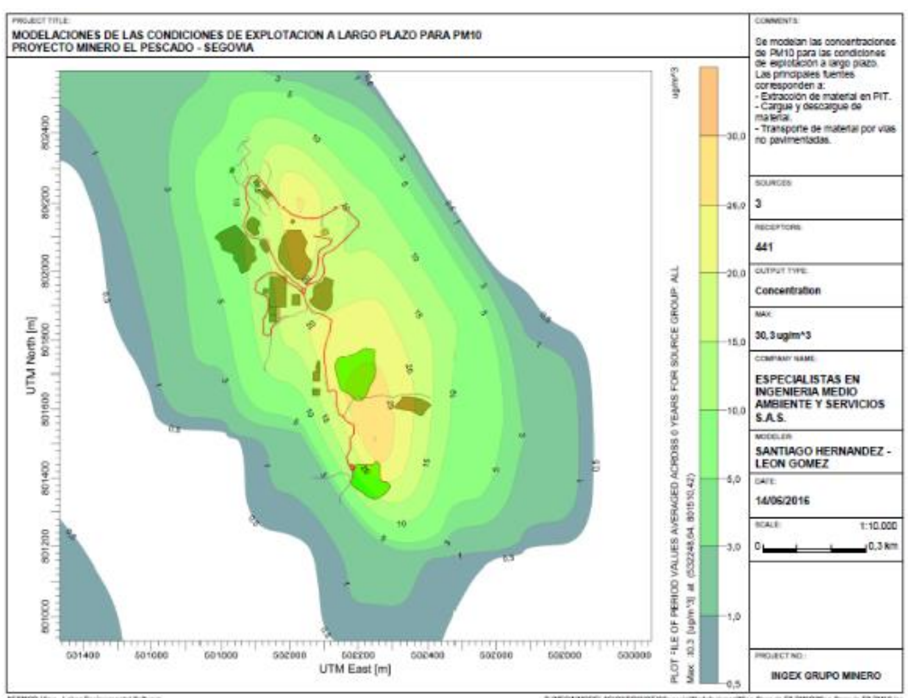


Illustration 5-149. Model PM_{10} annual long term.

Source: Specialists in engineering, environment and services S.A.S, 2016.

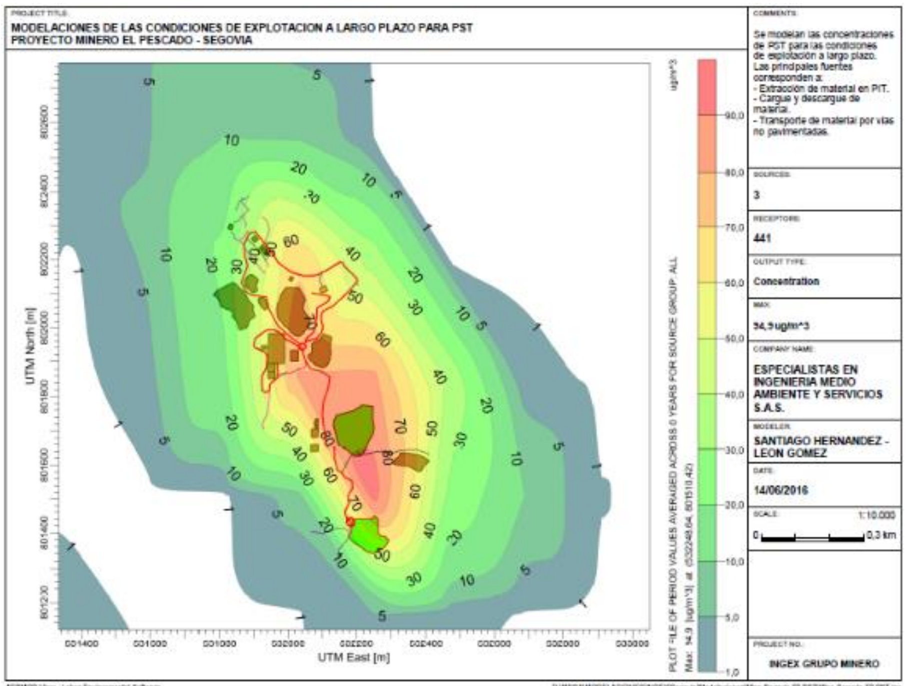


Illustration 5-150. Long-term annual PST model.
Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.10 NOISE

The evaluation and determination of current sound pressure levels (baseline) and projected (stages of operation) is carried out according to the standards and techniques described in the methodological chapter of Resolution 0627 of 2006. For the evaluation of environmental noise according to Resolution 627 of 2006 of the Ministry of Environment, Housing and Territorial Development, now, Ministry of Environment and Sustainable Development, the methodology "Measurement Procedures, Chapter II, Measurement Procedure for Environmental Noise ", stipulated in the aforementioned standard. Is presented below the main features extracted from the report "Noise assessment environmental project the fish Segovia - Antioquia "prepared by SPECIALISTS IN ENGINEERING, ENVIRONMENT AND SERVICES S.A.S. in December 2015.

5.5.10.1 Description of equipment and materials used.

The environmental noise assessments were carried out with a sound level meter. It is an instrument destined to the objective and repetitive measures of the level of sound pressure. It is based on a microphone, the which consists of a metallic diaphragm of very little mass, mounted parallel and very close to a rigid plate. This arrangement forms an air condenser whose capacity varies when the diaphragm it is displaced when a sound wave impinges on it. When the capacitor is polarized with a voltage continuous, the variations in capacity cause load variations, which translates into variations of electrical tension, which are a faithful replica of the pressure variations that affect the diaphragm. The measurement microphones are designed in different sizes and for different applications (see

Illustration 5-151). The most important features of any microphone are: sensitivity, response in frequency and directivity.

Illustration 5-151. Sound level meter.
Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.10.2 Choice and location of measurement sites.

For the environmental noise assessments, four (4) fixed points of measurement were taken in the surroundings of the El Pescado mining project in the municipality of Segovia - Antioquia. The next table shows the location of the monitoring points.

Illustration 5-152. Map location sampling points.
Source: INGEX, 2016.

Table 5-73. Coordinates monitoring points.

POINT	COORDINATES	
Point 1	07º15'40,9''n	074º44'42,2''o
Point 2	07º16'07,2''n	074º43'00,0''o
Point 3	07º15'09,6''n	074º42'33,3''o
Point 4	07º14'30,7''n	074º42'00,1''o

Source: Specialists in engineering, environment and services S.A.S, 2016.

Illustration 5-153. Measuring sites.
Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.10.3 Reference time intervals.

Equivalent continuous sound pressure level data was captured simultaneously for each second, in the Slow (Slow) and Impulse (Impulse) response type, in addition to the thirds in eighth (1/3), the results are expressed in two profiles as follows:

Table 5-74. Filters and measurement scale.

VARIABLE	PROFILE 1	PROFILE2
Weighting filter	A	A
Response type	Slow	Impulse

Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.10.4 *Results of environmental noise.*

Below are the results found for each point and time of monitoring. The samples were taken at the points described earlier in the week, during daytime.

Table 5-75. Weather conditions week (Day).

POINT	SPEED OF THE WIND (m/s)	DIRECTION OF THE WIND	RAIN	TEMPERATURE (ºC)	BAROMETRIC PRESSURE (mm Hg)	HUMIDITY (%)
1	2.3	W.S	NO	28.8	731.4	65
2	0.7	N.W	NO	25.0	737.0	74
3	0.4	W.S	NO	29.5	725.3	70
4	1.2	E.S	NO	30.5	723.3	68

Source: Specialists in engineering, environment and services S.A.S, 2016.

Table 5-76. Weekly daytime environmental noise assessment

POINT	COORDINATES		Environmental noise evaluated dB (A)	Maximum standard allowed daytime schedule dB(A).
Point 1	07º15'40,9''n	074º44'42,2''o	53,05 ± 3,67	55
Point 2	07º16'07,2''n	074º43'00,0''o	58,85 ± 0,45	55
Point 3	07º15'09,6''n	074º42'33,3''o	57,92 ± 1,77	55
Point 4	07º14'30,7''n	074º42'00,1''o	48,34 ± 2,32	55

Source: Specialists in engineering, environment and services S.A.S, 2016.

5.5.10.4.1 Base Line.

The assessments made of environmental noise in the four (4) points of influence of the PROJECT MINERO EL PESCADO located in Segovia - Antioquia, according to the provisions of the Resolution 0627 of 2006 of the Ministry of Environment, Housing and Territorial Development now Ministry of Environment and Sustainable Development; show that the values of Point 1 (53.05 ± 3.67) and Point 4 (48.34 ± 2.32) comply with the mentioned norm unlike the values evaluated in Point 2 (58.85 ± 0.45) and Point 3 (57.92 ± 1.77) that do not meet the maximum permissible standards of levels of environmental noise in dB (A) for sector D. Suburban or rural zone of tranquility and noise established in Table 2 of Article 17 of Resolution 0627 of 2006, which establishes in 55 dB (A).

5.5.10.4.2 Mining Operation.

For the operation phase, only the movement of the different machinery for the operation in the different stages, the transit through the unpaved road and the management of aggregates, upload and download.

The machinery used for the different phases is described below:

- 2 CAT 725 articulated dump trucks (23.5 tons): Truck with gross power of 2.39 KW with one revolution capacity of 1200 rpm, its nominal payload is 23.6 tons, 6 speeds with 412-liter fuel tank and turning dimensions: steering angle, left / right 45.0 Degrees.

- 1 CAT 422 E Bow Tie: Cat 3054 turbocharged engines, high performance and low consumption, hydraulic system with variable displacement piston pump. Retro curve. High rotation system of the ladle of the retro, shovel capacity of 1 cubic meter.

Illustration 5-154. CAT 725 articulated truck
Source: INGEX, 2015.

Illustration 5-155. CAT 422 E.
Source: INGEX, 2015.

- 1 CAT 185 front loader: Design of arms and front frame in line, mono control with control of transmission and hydraulic system. Hydraulic quick coupling operable from the cab, automatic parallel lift, automatic bucket pickup, transmission neutralizer and Standard air conditioning, bucket capacity of 3.3 cubic meters.

- 1 Sandvick Drill - Tamrock Scout 120 R: It has a compact system, powered by diesel, and four-wheel drive with tires, completely autonomous, are safe, agile, highly productive and very easy to manage.

5.5.10.4.3 Noise maps.

The following graph shows the sound pressure levels obtained for the baseline of the study. For the interpolation, the values obtained during the measurements made in countryside.

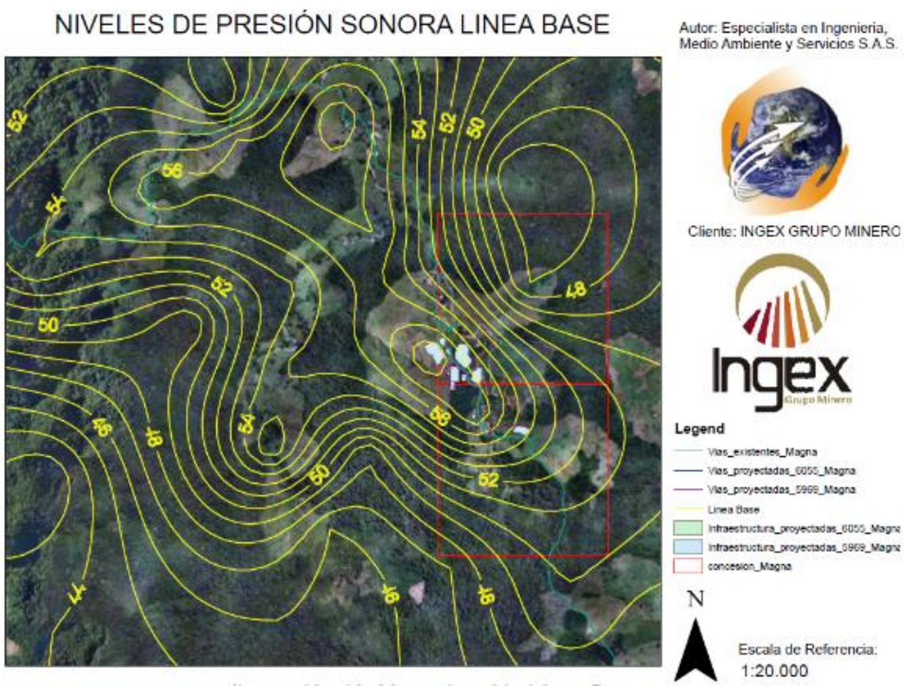


Illustration 5-156. Noise map Baseline.
Source: Specialists in Engineering, Environment and Services S.A.S, 2016.

The noise levels found as baseline in the study area are values according to the expected in a rural area with very little anthropic intervention, values in general are associated with natural sources, in some of the points near roads the noise levels increase slightly.

Within the direct area of mining titles, noise levels varied between 47.0 dB (A) and 56.0 dB(A), before the application of correction factors.

The noise levels modeled as operation phase in the study area are values with those expected in an industrial zone with heavy equipment operation, the values in general they associate with noise sources as engines in medium to high revolutions.

Within the direct area of mining titles, noise levels varied between 47.0 dB (A) and 70.0 dB(A), for all phases of operation of the titles. During the operation, the pressure levels sound outside the mining titles are kept very close to the values of Baseline.

- Short term.

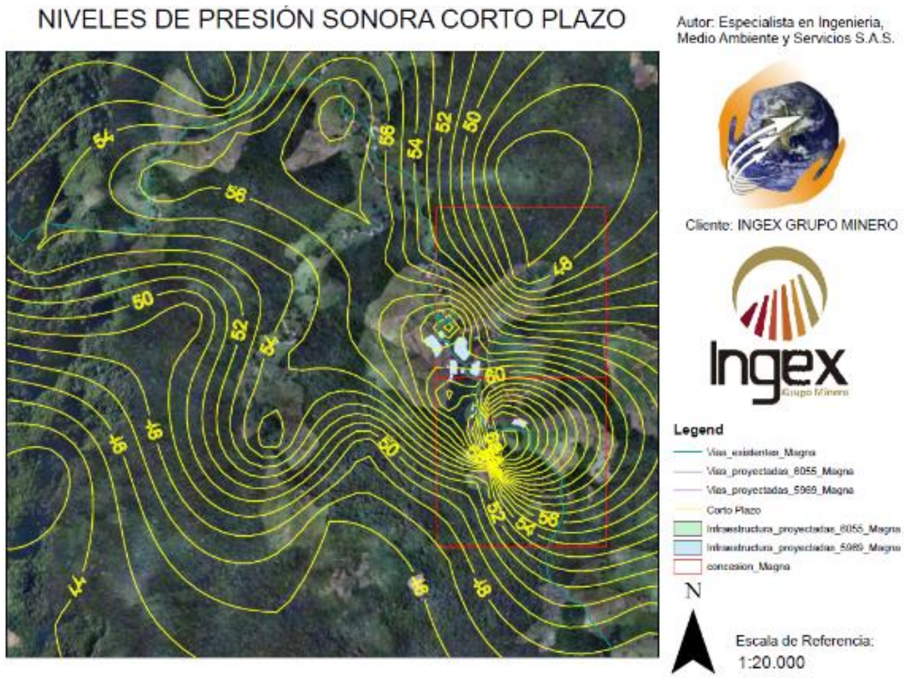


Illustration 5-157. Noise map, short-term operation.
Source: Specialists in Engineering, Environment and Services S.A.S, 2016.

Illustration 5-158. Noise map, medium-term operation.
Source: Specialists in Engineering, Environment and Services S.A.S, 2016.

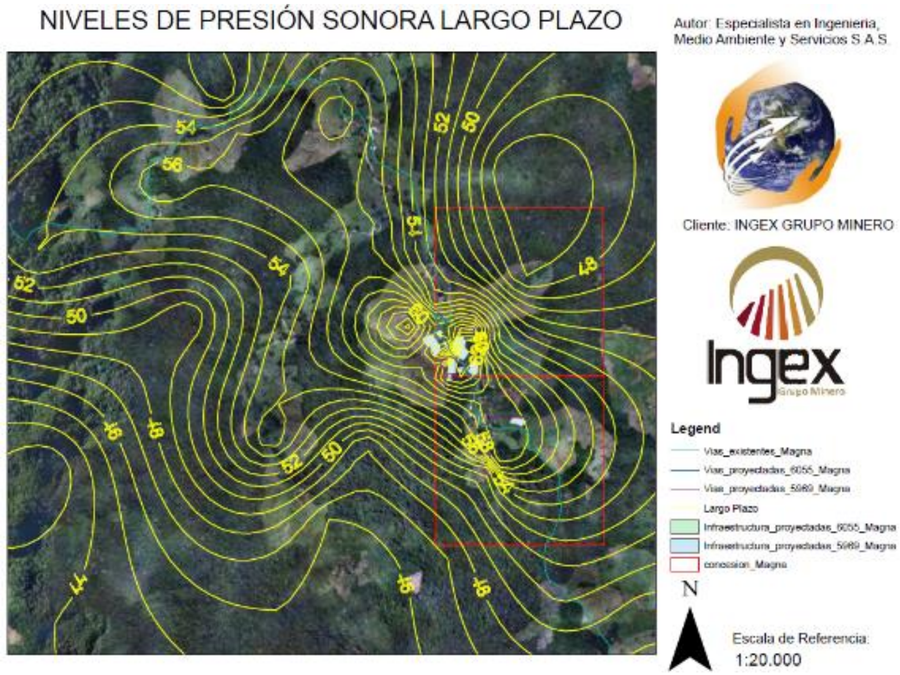


Illustration 5-159. Noise map, long-term operation.
Source: Specialists in Engineering, Environment and Services S.A.S, 2016.

Regarding wildlife species, it is widely accepted that noise pollution; that is, the production of noise at levels higher than those produced under normal conditions, affects negatively the physiology and the animal ethology, directly affecting sexual behaviors, energy and survival (Brown, 2001).

Currently there is a methodological difficulty to estimate to which decibels of noise the different species of fauna are beginning to be affected, however we know that the sensitivity of animals to sound, it is differential, since it varies according to its frequency, duration and volume (Richardson et al., 1995), although some species may adapt to high noise levels, as it is the case of some species of urban birds.

It has been documented that many species of amphibians are highly affected by pollution acoustics; the presence of an external acoustic disturbance may prevent them from detecting predators, in addition if this disturbance is prolonged in the time it can produce alterations in communication during the breeding season (Wollerman & Willey, 2003).

In the case of some birds, mainly of the order Passeriformes, a relationship has been found significant between the frequency of the territorial edge and the proximity to sources of noise; decreasing each time it approaches the emitter focus (Rheindt, 2003). Among other things, it has been shown that a lower density of birds in places near roads or other sources of emission of acoustic contamination (Rejinen et al., 1995). In very general terms, most of the birds are sensitive to noise pollution, at least during the breeding season. On the other hand, the effects they begin to be evident and possible in a range that goes from meters to kilometers (Kaseloo & Tyson, 2004).