SAN MATÍAS HYDROELECTRIC PROJECT

ENVIRONMENTAL IMPACT STUDY
VOLUME III OF VI
CHAPTER 4

DOCUMENT 2148-12-EV-ST-010-04

REVIEW No. 0

Review	Modifications	Date
0	Original Version	2012-04-13

Drafting – Revision – Approval

Review	Drafted by:		Revised by:		Approved by:	
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4 DEMAND OF NATURAL RESOURCES

4.1 WATER CONCESSION

4.1.1 San Matías River

The San Matías Hydroelectric Project will be supplied with the turbine-driven water from the El Molino hydroelectric project, which extracts a percentage of the volume of flow of the San Matías River for the generation of electric power.

A tank will be located at the exit of the power house of the El Molino hydroelectric project, which will have two functions: the first is to settle the turbine-driven water to bring it to the discharge channel of the El Molino hydroelectric project if the San Matías central is not in operation (stilling tank), and the second is to supply the San Matías project.

The San Matías hydroelectric project will have a capacity of 21 MW for a design volume of flow equivalent to 10 m^3/s and a net jump equivalent to 239.2 m. The conduction facilities are approximately 3.4 km long.

The estimated average volume of flow of the San Matías River at the extraction site of El Molino hydroelectric project is 9.54 m^3/s of good-quality water, as provided in Table 4-1 and Table 4-2.

Table 4-1 Values obtained for the physical and chemical variables of water

Variable	San Matías River Sampling Sites						
	Site 1 - CAP		Site 2 – MED1		Site 3 – MED 2	Site 4 –DES	
	Summer Sampling	Winter Sampling	Summer Sampling	Winter Sampling	Summer Sampling	Winter Sampling	Summer Sampling
Air temperature (°C)	24.00		25.00		26.00	25.00	
Water temperature (°C)	22.70	22.50	22.00	22.00	22.40	21.40	20.20
Electrical conductivity (□S/cm)	43.90	33.80	45.00	28.00	45.00	38.70	43.90
Turbidity (NTU)	2.50	96.90	2.21	315.00	2.30	24.70	27.00
Total solids (mg/l)	56.00	154.00	57.00	512.00	52.00	76.00	88.00
Suspended solids (mg/l)	<7	111.00	<7	477.00	<7	34.00	39.00
Settleable solids (ml/l)	<0.1	43.00	<0.1	35.00	<0.1	0.10	49.00
% of DO saturation	89.50	67.03	92.00	70.95	94.00	95.20	81.74
Dissolved oxygen (DO) (mg O_2/l)	7.69	5.90	8.40	6.30	8.10	8.42	7.50
pH	7.65	7.23	7.40	7.32	7.42	7.35	7.26
Total phosphorus (mg P/l)	<0.020	<0.015	<0.020	0.71	<0.020	0.05	<0.015
Organic phosphorus (mg P/l)	<0.020		<0.020		<0.020	<0.020	
Total orthophosphates (mg PO_4^{3-}/l)	<0.150	0.30	<0.150	0.30	<0.150	<0.150	0.09
Ammoniacal nitrogen (mg N-NH_3/l)	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00

Variable	San Matías River Sampling Sites						
	Site 1 - CAP		Site 2 – MED1		Site 3 – MED 2	Site 4 –DES	
	Summer Sampling	Winter Sampling	Summer Sampling	Winter Sampling	Summer Sampling	Winter Sampling	Summer Sampling
Nitrates (mg N-NH_3/l)	<1.50	<0.9	<1.50	<0.9	<1.50	<1.50	<0.9

Table 4-1 Values obtained for the physical and chemical variables of water (Continuation)

Variable	San Matías River Sampling Sites						
	Site 1 – COL		Site 2 – INTER1		Site 3 – INTER 2	Site 4 –DIS	
	Summer Sampling	Winter Sampling	Summer Sampling	Winter Sampling	Summer Sampling	Winter Sampling	Summer Sampling
Kjeldahl nitrogen (mg N/l)	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
Sulfates (mg SO_4^{2-}/l)	<3.00	5.00	<3.00	5.00	<3.00	<3.00	9.00
Total iron (mg Fe/l)	0.22	3.13	0.19	1.64	0.23	1.24	1.40
Total alkalinity (mg $CaCO_3$/l)	21.00	26.00	21.40	23.00	22.70	20.50	27.00
Total hardness (mg/l $CaCO_3$)	14.40	24.00	14.50	16.00	15.70	16.30	20.00
Total BOD_5 (mg O_2/l)	<4.00	<2.43	<4.00	<2.43	<4.00	<4.00	<2.43
Soluble BOD_5 (mg O_2/l)	<4.00		<4.00		<4.00	<4.00	
Total COD (mg O_2/l)	<12.0	<12.9	<12.0	17.00	<12.0	<12.0	<12.9
Coliforms (NMP/100 ml)	60×10^3	>2419.6	25×10^4	>2419.6	160×10^3	14×10^4	>2419.6
Fecal coliforms (NMP/100 ml)	3.5×10^2	>2419.6	1.3×10^2	866.40	2×10^2	0.2×10^4	648.80
Detergents (mg SAAM/l)	<0.100	0.34	<0.100	0.41	<0.100	<0.100	0.11

Table 4-2 Calculation of the NSF - WQ Index for the San Matías River

Variable	Weight	Site 1- Extraction		Site 2 – Intermediate section 1		Site 3 – Intermediate section 2	Site 4 –discharge	
		Summer	Winter	Summer	Winter	Summer	Winter	Summer
Dissolved oxygen	0.17	95	87	97	91	98	98	93
Coliforms	0.16	32	**17**	41	**23**	37	18	26
pH	0.11	92	92	93	93	93	93	93
BOD	0.11	>61	93	>61	93	>61	>61	93
Temperature	0.1	93	85	93	80	93	93	85
Orthophosphates	0.1	>94	81	>94	**42**	>94	>94	96
Nitrates	0.1	>96	97	>96	96	>96	>96	97
Turbidity	0.08	92	**19**	92	**5**	92	57	55
Solids	0.07	87	78	87	**20**	87	85	84
NFS-WQI		**>79.85**	**71**	**>81.74**	**63**	**63**	**>75.29**	**78**

The construction of the facilities located at the entrance portal of the conduction tunnel requires 20 l/s of the San Matías River, from a sector of the river defined by the following coordinates:

882.885 E 1.160.988 N
883.231 E 1.160.785 N

4.1.2 Stream 5

In addition, to complement the water extracted from the San Matías River, a volume of flow equivalent to 3.0 l/s is required at the front of the entrance portal to the tunnel, which shall be taken from stream 5 at a sector defined by the following coordinates:

882.659 E 1.160.473 N
883.016 E 1.160.637 N

The volume of flow of this stream, with a return period of 2.33 years at the section where the extraction may take place, is 4.24 m^3/s.

4.1.3 Stream NN

A volume of flow equivalent to 3.0 l/s is required for the work front located at the exit portal of the conduction tunnel, which shall be taken from a nameless stream to be crossed by the access road for this work front; the extraction is located at a sector defined by the following coordinates:

883.785 E 1.159.092 N
883.951 E 1.159.101 N

The volume of flow of this stream, with a return period of 2.33 years at the section where the extraction may take place, is 1.18 m^3/s.

Annex 13 contains the water concession request forms.

4.1.4 Cocorná River

A volume of flow equivalent to 3.0 l/s will be extracted from the Cocorná River for the work front located at the power house, from a sector defined by the following coordinates:

884.872 E	1.159.383 N
885.093 E	1.159.503 N

The average volume of flow of the Cocorná River in this section is 20.57 m^3/s.

4.2 WATER CHANNEL OCCUPATION

Each one of the facilities that will affect the water channels of the San Matías River and the minor currents for the development of the San Matías hydroelectric project are described below. Water channel occupation permits have been issued for these facilities. It should be noted that this project will not have collection located at the river.

4.2.1 Facilities at the San Matías River – discharge structure

Turbine-driven waters are delivered to the San Matías at the site identified with coordinates 885.088 E and 1.159.736 N, and at an altitude of 752 meters above sea level (MASL). Initially, the water will be diverted through two box culverts measuring 15.6 m and 5.7 m long, 2.8 m wide and 2 m high, one per unit and with a 0.2% slope. Downstream from the connecting point between the two box culverts, the water will be diverted by a square box culvert measuring 1.8 m on each side and with a 1% slope at a length equivalent to 268.8 m with a free flow operation under a supercritical regime.

The following section is composed of an open channel measuring 11.8 m with a 0.4% slope, where the formation of a hydraulic jump and the establishment of a flow under the subcritical regime prior to the discharge structure are envisaged. This structure is composed of a transition to an open channel with a width of 5 m, a 4.0-m descending ramp, a 5.0-m stilling pool and a 30.4-m energy dissipation structure with a 50% slope and at which base a series of concrete blocks for the dissipation of energy will be arranged (see blueprint 2148-12-CV-DW-042).

4.2.2 Minor currents at the access road to the exit portal of the diversion tunnel

Circular sewer drainage facilities will be installed at the existing minor currents, which are located transversally from the access roads to the project. Blueprint 2148-12-CV-DW-013 presents the location and numbering of the streams within the area of influence of the project.

The designs of the sewers were calculated for a return period of 10 years, as shall be explained in numeral 4.2.3.

Table 4-3 presents the results of the designs of the projected sewers.

Table 4-3 Results of the designs of the sewers for the projected roads Tr = 10 years

Abscissa	Road	Coordinates (m)		Stream - Point	Work type	Length (m)	Slope (%)
		X(E)	Y(N)				
Km 0+155.67m	To the exit portal of the tunnel	884.089 884.135	1.159.155 1.159.165	Stream 1 - A	**Circular sewer** ø(m)=1.20	10	2.00
Km 0+298.44m	To the exit portal of the tunnel	884.029 884.067	1.159.108 1.159.149	Stream 1 - B	**Circular sewer** ø(m)=1.20	7	2.00

4.2.3 Hydraulic Studies

With the purpose of determining the dimensions of the structures to be designed and the correct hydraulic operation, with the information from the maximum volumes of flow, and the sections of the San Matías River and the affected currents, it was evaluated the crescent levels of different return periods, and with this information, it was possible to verify the operation of the structures affecting the water channels (see Table 4-4).

Table 4-4 Design volumes of flow of the San Matías River and currents intercepting the roads of the San Matías hydroelectric project

River/Stream	Point	Road/Project Site	Return period Tr (years)					
			2,33	5	10	25	50	100
San Matías River	-	Discharge	366	488	623	845	1.050	1.291
Stream 1	A	To the exit portal of the tunnel	1.33	1.67	2.02	2.64	3.24	4.01
Stream 1	B	To the exit portal of the tunnel	1.18	1.49	1.8	2.36	2.89	3.58

4.2.3.1 Facilities at the discharge area of the San Matías River

This numeral presents the hydraulic verification of the discharge channel towards the San Matías River.

The hydraulic model was made with HEC-RAS 4.0 software, both from the US Army Corps of Engineers. The discharge channel was modeled by taking into account a Manning's n value equivalent to 0.014, while the roughness of the San Matías River was established at 0.035.

The volume of flow of the discharge channel is equivalent to 10 m^3/s, corresponding to the design volume of flow of the project. For the San Matías River, however, different volumes of flow associated with different return periods were assessed, which were estimated based on the rain-runoff model proposed by the Soil Conservation Service (SCS).

Table 4-5 presents the volumes of flow for different return periods at the San Matías River.

Table 4-5 Modeled volumes of flow in the San Matías River at the discharge site

Tr (years)	2,33	5	10	25	50	100
Q (m³/s)	366	488	623	845	1.050	1.291

The design of the energy dissipation structure at the end of the discharge channel ensures a slight influence on the dynamics of the San Matías River, as shown in Table 4-6, which shows the levels and speeds of the river with and without a project at the confluence site with the discharge channel.

Table 4-6 Levels and flow speeds at the confluence of the discharge channel with the San Matías River

Tr (years)	Volume of flow (m^3/s)		Speed (m/s)		Water level (masl)	
	Without the project	With the project	Without the project	With the project	Without the project	With the project
50	1.050	1.060	7.41	7.8	759.17	759.19
100	1.291	1.301	8.02	7.9	759.40	759.41

4.2.3.2 Minor currents at the projected access roads

Table 4-7 presents the results of the designs for the facilities intended for the new road, for volumes of flow with return periods equivalent to 10 years.

Table 4-7 Results of the designs of the sewers for the projected road Tr = 10 years

Abscissa	Road	Design volume of flow Q_{10} (m^3/s)	Stream - Point	Work Type/ Dimension	Strap of flow Y(m)	y/do	Q/Qll
Km 0+155.67m	At the exit portal of the tunnel	2.02	Stream 1 - A	**Circular sewer** ø(m)=1.20	0.50	0.42	0.37
Km 0+298.44m	At the exit portal of the tunnel	1.80	Stream 1 - B	**Circular sewer** ø(m)=1.20	0.47	0.39	0.33

4.2.4 Undermining

With the purpose of assessing the safety of the structures due to the effects of undermining, we determined the need for a potential deepening of the level of the bottom of the water channel where the structures are located.

Undermining was calculated as the sum of the general erosion and the erosion caused by the contraction of the water channel. Alternative procedures were applied for this purpose and averages were obtained from all of the results.

The maximum undermining of the discharge structure is 2.0 m, given that the rock substrate is expected to be found quickly. Undermining corresponds to the effect of crescents when no

control measures are adopted. Depending on such measures the excavations could decrease.

4.2.5 River dynamics of the affected sectors

An assessment of each one of the structures analyzed in the present numeral from the point of view of the modifications that could take place in the river dynamics is made below.

In general terms, the design criteria sought to control the speed at the end of the facilities to avoid headward undermining processes due to the effect of high discharge speeds.

The facilities being proposed correspond to permanent currents, from the point of view of river dynamics, and none of the alignments were modified, due to which the discharge is made to the natural beds with competent materials.

The gear type dissipation structures in each one of the facilities guarantee that the speeds at the deliveries under flooding conditions will be tolerable by the riverbed materials.

The flows in all facilities for the existing currents are under the turbulent supercritical regime; the slopes with which the box culverts and the circular sewers projected were designed, also generate regimes of this type for all facilities. There are no changes in the river dynamics of the currents due to the effect of the projected sewers.

Annex 14 presents the water channel occupation permit forms.

4.3 WASTEWATER DISCHARGE

Before the discharge, domestic and industrial wastewater will be treated by means of grease traps, sand removers, septic tanks and anaerobic filters, which will decrease the pollutant load of the wastewater and will ensure compliance with the current environmental regulations (article 72 of Decree 1594 of 1984).

The treatment of domestic wastewater generated at the offices shall consist of a composite system composed of a septic tank and an anaerobic filter, which scheme is presented in Figure 4-1. Grease traps (see Figure 4-2) and settling tanks (see Figure 4-3) will be used in the case of industrial wastewater.

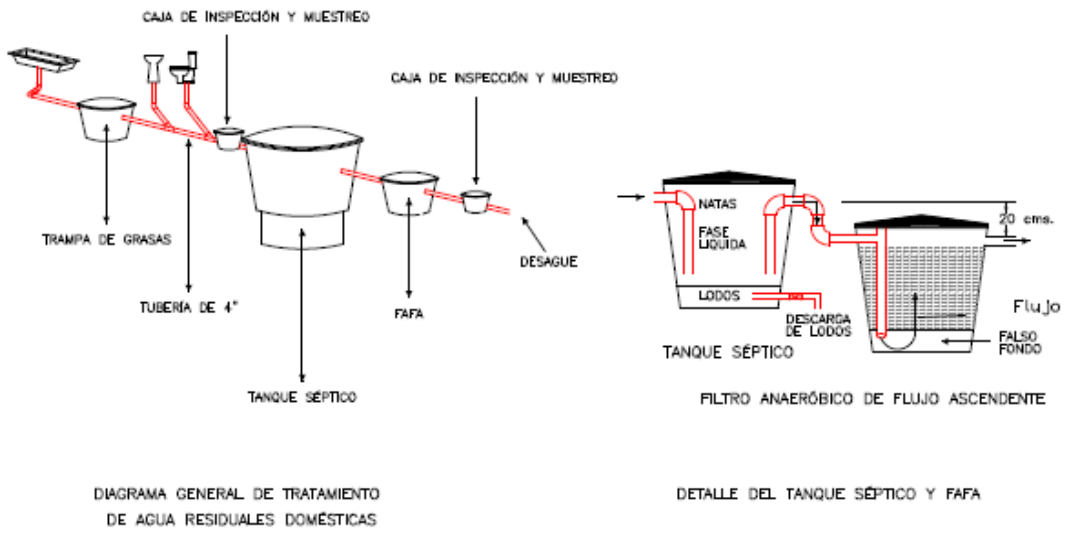

Figure 4-1 General Scheme of the Treatment System

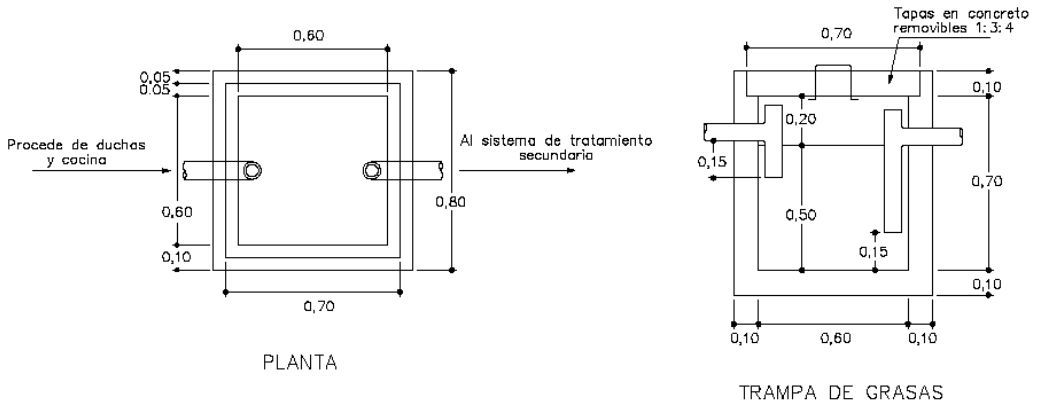

Figure 4-2 Grease Trap Scheme

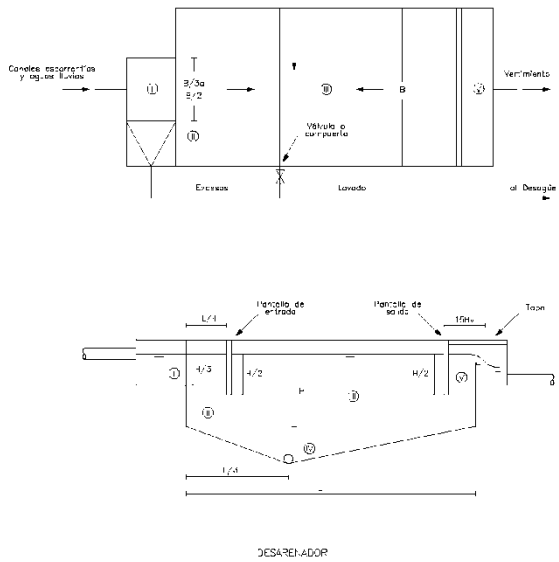

Figure 4-3 Settling Tank Scheme

- **Settling Tank Design**

The definitions contained in the RAS 2000, which guarantees compliance with the parameters of the established provisions, will be applied to the definition of the dimensions of the settling tanks:

– **Settling Speed**. Defined by the following equation:

$$V_s = \frac{(\rho_s - \rho) g d^2}{18\mu}, \text{ where}$$

- ρ_s : Specific weight of the sand.
- ρ: Specific weight of the water.
- g= gravity.
- μ: Kinematic viscosity
- d = diameter of the particles.

– **Settling Time.** Estimated as follows:

$$t_s = \frac{h}{V_s}, \text{ where}$$

- h: useful depth of the settling tank
- Vs: settling speed

– **Hydraulic retention time.** Expressed by means of the following equation:

$$TRH = \phi \times t_s$$, **where**

- **Φ: Diameter of the particle to be removed**
- **ts: Settling time**

– **Tank volume**. Calculated as follows:

$$v = Q \times TRH$$, **where**

- **Q: design volume of flow**
- **TRH: hydraulic retention time**

– **Surface area.** Calculated by means of the following expression:

$$A_s = \frac{v}{H}$$, **where**

- **v: Tank volume**
- **H: Useful depth of the tank**

– **Tank width.** Calculated by means of the following equation:

$$B = \sqrt{\frac{A_s}{4}}$$

where A_s is the surface area

– **Length of the tank**. Estimated with the following ratio L: B, 4:1

Table 4-8 presents the coordinates of the section of the currents where are wastewater generated discharge during the construction and operation of the San Matías hydroelectric project will take place, as well as the useful depth and depth of the settling area, taking the following into account:

Table 4-8 Location of wastewater discharge sites at the San Matías hydroelectric project

Infrastructure	Current	System	Coordinates of the Section		Useful Depth (m)	Depth of the Settling Zone (m)	Volume of flow (l/s)
			X (East)	Y (North)			
Area of the entrance portal of the diversion tunnel	San Matías River	Septic tank, anaerobic filter, grease trap, settling tank	882.998 883.198	1.160.908 1.160.822	1.5	1.0	**0.7**
Deposit SM1	Stream NN	Settling tank	884.218 884.367	1.159.576 1.159.751	1.5	0.75	**0.1**
Exit portal of the tunnel – weir	Stream NN	Septic tank, anaerobic filter, grease trap, settling tank	884.029 884.067	1.159.108 1.159.149	1.5	1.5	**0.7**

Machine room	Cocorná River	Septic tank, anaerobic filter, grease trap, settling tank	884.891 885.142	1.159.398 1.159.537	1.5	1.5	1.5

- Water temperature: 22°C.
- Diameter of the particle to be removed: 0.005 cm
- % of removal = 87.5%
- Length of the settling tank: 4 m

The dimensions being proposed may be modified if the developer changes the Length – Width ratio. However, the developer must always comply with the provisions of Decree 1594 of 1984 in terms of the characteristics of the effluent defined in article 72.

The following considerations must be taken into account in the estimation of the volumes of flow to be discharge:

- In the case of domestic wastewater, it is assumed a return coefficient of 80% for a population with a demand of water equivalent to 140 liters per inhabitant/day.
- It is assumed that 90% of the water used in the washing of sand and gravel returns as wastewater.
- 40% of the water used for road dampening, car washing and facilities maintenance will return as wastewater.
- 80% of the water used for the construction of the tunnel and the window will return as wastewater.

Annex 15 presents the wastewater discharge permit forms, and Annex 16 contains a pre-manufactured treatment system that may be used at the portals of the tunnels and at the machine room.

4.4 FORESTRY

Coverages from open forest, dense bamboo forest, high secondary vegetation, low secondary vegetation, wooded pastures, weedy pastures, and clean pastures were identified within the area of influence of the project.

Table 4-9 to Table 4-16 contain the species recorded in each one of the identified coverages.

Table 4-9 Species recorded for dense forest

#	Scientific name	Common name	Family	Number of individuals
1	*Goethalsia meiantha*	Combo	Malvaceae	8
2	*Miconia trinervia*	Tuno blanco	Melastomataceae	14
3	*Pourouma hirsutipetiolata*	Cirpo	Urticaceae	4
4	*Cecropia peltata*	Yarumo blanco	Urticaceae	4

#	Scientific name	Common name	Family	Number of individuals
5	*Chrysochlamys weberbaueri*		Clusiaceae	3
6	*Euterpe precatoria*	Palmiche	Arecaceae	3
7	*Ficus sp. 1*	Sueldo	Moraceae	1
8	*Schefflera morototoni*	Arracacho	Araliaceae	1
9	*Rollinia edulis*	Majagüa	Annonaceae	1
10	*Inga sp. 2*	Guamo	Fabaceae	1
11	*Psychotria capitata*		Rubiaceae	1
12	*Casearia silvestris*		Salicaceae	1
13	*Casearia mariquitensis*		Salicaceae	1
14	*Gloeospermum sphaerocarpum*	Guayabito de mico	Violaceae	1
General Total				**44**

Table 4-10 Species recorded for dense bamboo forest

#	Scientific name	Common name	Family	Number of individuals
1	*Guadua angustifolia*	Guadua	Poaceae	138
2	*Miconia elata*	Mortiño colorado	Melastomataceae	6
3	*Cupania cinerea*	Cariseco, mestizo	Sapindaceae	1
4	*Persea americana*		Lauraceae	1
5	*Ocotea macropoda*	Laurel	Lauraceae	1
6	*Rollinia edulis*	Majagüa	Annonaceae	1
7	*Cinnamomum triplinerve*	Laurel perillo	Lauraceae	1
8	*Ficus maxima*	Caucho	Moraceae	1
9	*Miconia decurrens*	Mortiño blanco	Melastomataceae	1
General Total				**151**

Table 4-11 Species recorded for open forest

#	Scientific name	Common name	Family	Number of individuals
1	*Euterpe precatoria*	Palmiche	Arecaceae	20
2	*Goethalsia meiantha*	Combo	Malvaceae	6
3	*Pourouma hirsutipetiolata*	Cirpo	Urticaceae	6
4	*Schefflera morototoni*	Arracacho	Araliaceae	4
5	*Myrsine pellucidopunctata*	Espadero	Primulaceae	4
6	*Calophyllum brasiliense*	Aceite maria	Calophyllaceae	3
7	*Piptocoma discolor*	Gallinazo	Asteraceae	2
8	*Abarema jupunba*	Carbonero	Fabaceae	2
9	*Iryanthera sp.*		Myristicaceae	3
10	*Cyathea andina*	Sarro	Cyatheaceae	2
11	*Pseudelephantopus spiralis*	Suelda	Asteraceae	1
12	*Indet. 3*		Indet. 3	1
13	*Vismia macrophylla*	Siete cueros	Hypericaceae	1
14	*Graffenrieda galeottii*	Nigüito blanco	Melastomataceae	1

#	Scientific name	Common name	Family	Number of individuals
15	*Cecropia peltata*	Yarumo blanco	Urticaceae	1
16	*Erythroxylum citrifolium*	Coca	Erythroxylaceae	1
17	*Cupania cinerea*	Cariseco	Sapindaceae	1
18	*Dendropanax arboreus*	Platero	Araliaceae	1
19	*Rollinia edulis*	Majagüa	Annonaceae	1
20	*Miconia decurrens*	Mortiño blanco	Melastomataceae	1
General Total				**62**

Table 4-12 Species recorded for high secondary vegetation

#	Scientific name	Common name	Family	Number of individuals
1	*Pourouma hirsutipetiolata*	Cirpo	Urticaceae	38
2	*Schefflera morototoni*	Arracacho	Araliaceae	15
3	*Bellucia pentamera*	Guayabo de mico	Melastomataceae	8
4	*Hedyosmum racemosum*	Silbo silbo	Chloranthaceae	9
5	*Hasseltia sp.*		Salicaceae	10
6	*Vismia sp. 2*	Puntae´ lanza	Hypericaceae	6

Table 4-12 Species recorded for high secondary vegetation (Continuation)

#	Scientific name	Common name	Family	Number of individuals
7	*Castilla elastica*	Caucho negro	Moraceae	7
8	*Piptocoma discolor*	Gallinazo	Asteraceae	7
9	*Miconia elata*	Mortiño colorado	Melastomataceae	7
10	*Vismia macrophylla*	Siete cueros	Hypericaceae	5
11	*Guatteria boliviana*	Garrapato	Annonaceae	5
12	*Miconia decurrens*	Mortiño blanco	Melastomataceae	5
13	*Inga thibaudiana*		Fabaceae	4
14	*Guadua angustifolia*	Guadua	Poaceae	5
15	*Cordia dwyeri*	Brazo de tigre	Boraginaceae	4
16	*Hyptidendron arboreum*	Aguanoso	Lamiaceae	3
17	*Ficus nymphaeifolia*	Caucho	Moraceae	1
18	*Cinnamomum triplinerve*	Laurel perillo	Lauraceae	3
19	*Cecropia angustifolia*	Yarumo negro	Urticaceae	3
20	*Rollinia edulis*	Majagüa	Annonaceae	2
21	*Inga alba*	Churimo	Fabaceae	2
22	*Gloeospermum sp.*		Violaceae	2
23	*Jacaranda copaia*	Chingalé	Bignoniaceae	2
24	*Vismia baccifera*	Carate	Hypericaceae	2
25	*Nectandra sp. 1*		Lauraceae	1
26	*Unonopsis sp.*		Annonaceae	1
27	*Indet. 2*		Indet. 2	1
28	*Solanum cyathophorum*		Solanaceae	1

#	Scientific name	Common name	Family	Number of individuals
29	*Welfia regia*	Mil pesos	Arecaceae	1
30	*Miconia dolichorrhyncha*	Mortiño blanco	Melastomataceae	1
31	*Ocotea macropoda*	Laurel	Lauraceae	1
32	*Miconia affinis*	Nigüito	Melastomataceae	1
33	*Hieronyma sp.*	Leño	Phyllanthaceae	1
34	*Alchornea megalophylla*		Euphorbiaceae	1
35	*Casearia arborea*	Escobo	Salicaceae	1
36	*Inga sp. 8*		Fabaceae	1
37	*Erythroxylum citrifolium*	Coca	Erythroxylaceae	1
38	*Euterpe precatoria*	Palmiche	Arecaceae	1
39	*Lacistema aggregatum*	Café de monte	Lacistemataceae	1
General Total				**170**

Table 4-13 Species recorded for low secondary vegetation

#	Scientific name	Common name	Family	Number of individuals
1	*Tococa guianensis*	Hormiguero	Melastomataceae	11
2	*Vismia baccifera*	Carate	Hypericaceae	6
3	*Vismia sp. 2*	Punta´e lanza	Hypericaceae	6
4	*Miconia decurrens*	Mortiño blanco	Melastomataceae	4
5	*Miconia theaezans*	Nigüito	Melastomataceae	4
6	*Bellucia pentamera*	Guayabo de mico	Melastomataceae	2

Table 4-13 Species recorded for low secondary vegetation (Continuation)

#	Scientific name	Common name	Family	Number of individuals
7	*Myrsine pellucidopunctata*	Espadero	Primulaceae	2
8	*Piptocoma discolor*	Gallinazo	Asteraceae	2
9	*Vismia macrophylla*	Siete cueros	Hypericaceae	1
10	*Psidium guajava*	Guayabo	Myrtaceae	1
11	*Miconia elata*	Mortiño colorado	Melastomataceae	1
12	*Cecropia peltata*	Yarumo blanco	Urticaceae	1
13	*Indet. 4*		Indet. 4	1
14	*Cecropia angustifolia*	Yarumo negro	Urticaceae	1
General Total				**43**

Table 4-14 Species recorded for clean pastures

#	Scientific name	Common name	Family	Number of individuals
1	*Psidium guajava*	Guayabo	Myrtaceae	5
2	*Myrsine pellucidopunctata*	Espadero	Primulaceae	3
3	*Miconia elata*	Mortiño colorado	Melastomataceae	3
4	*Hymenaea courbaril*	Algarrobo	Fabaceae	1
5	*Piptocoma discolor*	Gallinazo	Asteraceae	1

#	Scientific name	Common name	Family	Number of individuals
6	*Schefflera morototoni*	Arracacho	Araliaceae	1
7	*Miconia trinervia*	Tuno blanco	Melastomataceae	1
8	*Ficus popayanensis*	Sueldo	Moraceae	1
9	*Jacaranda copaia*	Chingalé	Bignoniaceae	1
10	*Pera arborea*	Cucharo	Euphorbiaceae	1
11	*Ficus sp. 2*	Lechudo	Moraceae	1
General Total				**19**

Table 4-15 Species recorded for wooded pastures

#	Scientific name	Common name	Family	Number of individuals
1	*Piptocoma discolor*	Gallinazo	Asteraceae	46
2	*Psidium guajava*	Guayabo	Myrtaceae	6
3	*Jacaranda copaia*	Chingalé	Bignoniaceae	7
4	*Schefflera morototoni*	Arracacho	Araliaceae	2
5	*Myrsine pellucidopunctata*	Espadero	Primulaceae	2
6	*Vismia baccifera*	Carate	Hypericaceae	1
7	*Hymenaea courbaril*	Algarrobo	Fabaceae	1
8	*Vismia sp. 2*	Punta´e lanza	Hypericaceae	1
9	*Nectandra cuspidata*	Laurel pavito	Lauraceae	1
10	*Rhodostemonodaphne kunthiana*		Lauraceae	1
11	*Vismia macrophylla*	Siete cueros	Hypericaceae	1
12	*Bellucia pentamera*	Guayabo de mico	Melastomataceae	1
General Total				**70**

Table 4-16 Species recorded for weedy pastures

#	Scientific name	Common name	Family	Number of individuals
1	*Schefflera morototoni*	Arracacho	Araliaceae	5
2	*Psidium guajava*	Guayabo	Myrtaceae	2
3	*Myrsine pellucidopunctata*	Espadero	Primulaceae	2
4	*Vismia macrophylla*	Siete cueros	Hypericaceae	2
5	*Piptocoma discolor*	Gallinazo	Asteraceae	1
6	*Cinnamomum triplinerve*	Laurel perillo	Lauraceae	1
7	*Cespedesia spathulata*	Pacó	Ochnaceae	1
8	*Vismia* sp. 2	Puntae´ lanza	Hypericaceae	1
General Total				**15**

Table 4-17 shows the volume estimates per hectare and to be extracted, and Annex 17 contains the forest exploitation application.

Table 4-17 Estimates of the basal area and coverage volumes in the area of intervention of the project

Coverage	AA	Inventoried volumes				Values per hectare			Values to be extracted		
		AIS	TV	CV	BA	TV	CV	BA	TV	CV	BA
Open forest	0.570	0.10	0.57	0.33	0.05	5.74	3.32	0.50	3.27	1.89	0.29
Dense forest	0.080	0.10	0.98	0.63	0.07	9.84	6.30	0.72	0.79	0.50	0.06
High secondary vegetation	3.080	0.30	0.16	0.09	0.02	0.55	0.30	0.07	1.69	0.93	0.21
Low secondary vegetation	1.310	0.20	0.03	0.02	0.01	0.16	0.08	0.03	0.22	0.10	0.04
Clean pastures	4.320	0.60	0.03	0.02	0.01	0.06	0.03	0.01	0.24	0.11	0.04
Wooded pastures	2.140	0.40	0.03	0.02	0.01	0.08	0.04	0.01	0.18	0.09	0.03
Weedy pastures	1.520	0.20	0.01	0.01	0.00	0.06	0.03	0.01	0.09	0.04	0.02
Dense forest (Bamboo)	0.210	0.10	0.42	0.01	0.04	4.21	0.11	0.41	0.88	0.02	0.09
Total	**13.23**	**2.00**	**2.25**	**1.12**	**0.20**	**20.70**	**10.20**	**1.76**	**7.35**	**3.69**	**0.76**

Where: AA: affected area in ha, AIS: area inventoried in the sampling in ha, BA= basal area expressed in square meters; CV = commercial volume in cubic meters; TV = total volume in cubic meters

4.5 ATMOSPHERIC EMISSIONS

The concrete mixers to be used in the construction of the San Matías hydroelectric project will be of two sacks each one and a useful mixing capacity of 255 liters. These mixers will be located within the area of the portals of the diversion tunnel and in the sector of the power house.

The tick-granular material necessary for the construction will come from the project's underground excavations and will be processed in two crushing plants located at each one of the portals of the diversion tunnel.

The areas where the equipment is located are defined by the coordinates presented in Table 4-18.

Table 4-18 Location coordinates of the crushing plants and the concrete mixers

Crushing plant	X(E)	Y(N)
Entrance portal of the diversion tunnel (concrete mixer and crushing machine)	882.961 882.963 882.922 882.961	1.160.648 1.160.650 1.160.692 1.160.693
Power house (concrete mixer)	884.895 884.880 884.921 884.944	1.159.535 1.159.581 1.159.600 1.159.567

Crushing plant	X(E)	Y(N)
Exit portal of the diversion tunnel (concrete mixer and crushing machine)	883.908 883.923 883.948 883.942 883.917	1.159.241 1.159.265 1.159.250 1.159.231 1.159.228

These plants usually operate with electric power. The processed material will be dampened to control emissions.

4.6 SOLID WASTE

The final disposal of each type of waste must comply with the provisions of Colombian law; non-recyclable waste will be deposited at the landfill of the municipality of Cocorná. The provisions of Decree 4741 of 2005 must be complied with in terms of hazardous waste

4.7 CONSTRUCTION MATERIALS

The tick-granular and fine granular materials necessary for the construction of the facilities making up the Project will come from the exploitations that have been legally constituted in the area, with the current corresponding mining and environmental permits and licenses. In addition, part of the thick-granular material obtained from the underground excavations of the Project will be used, which is estimated at 10.000 m^3 and will be processed by two grinding machines at the portals of the diversion tunnels

We estimate a total demand equivalent to 5.500 m^3 of sand and 7.000 m^3 of aggregates.

No new explorations fronts or extractions of gravel and sand from the water channels are scheduled at this time.

4.8 STORAGE AREAS

A storage area located in the intermediate part of the hill, on the left margin of the road leading to the exit portal of the tunnel, 500 m from where this road detaches to the power house will be used for the construction of the hydroelectric project. The storage volume is approximately 158.000 m^3, and the bare soil area will be equivalent to 30.000 m^2. The slopes will be formed with a pendant of 2H:1V, beginning at an altitude of 882 MASL and ending at an altitude of 912 MASL, with two ledges of 5.0 meters each, every 10 meters.

Blueprint 2148-12-CV-DW-061 presents the plant and the sections of the SM1 materials storage area.