

## CHAPTER 2 GENERAL CONDITIONS OF THE STUDY AREA

### 2.1 Socio-economic Conditions

The Study Area extends from Tequendama Falls to upstream basin area of Bogotá River. The Study Area is comprised of 14% area of Cundinamarca Department (total land area; 24,210km<sup>2</sup>) and 48% area of Bogotá District Capital (Bogotá D.C., total land area; 1,605km<sup>2</sup>). Cundinamarca Department is divided into 15 provinces (provincia). These provinces are divided into 116 municipalities (municipios). The Study Area extends to 7 provinces and 31 municipalities of Cundinamarca Department. The Study Area includes most of the urban localities of Bogotá D.C. The Study Area is 4,268.7 km<sup>2</sup>.

**Table-2.1 Land Area of the Study Area**

Administrative Division	Total Land Area (km <sup>2</sup> )	Study Area		Administrative Division	Total Land Area (km <sup>2</sup> )	Study Area	
		Land Area (km <sup>2</sup> )	Share (%)			Land Area (km <sup>2</sup> )	Share (%)
1 Bogotá	1,605	769.0	8	17 Mosquera	107	107.0	100
2 Bojacá	106	81.6	68	18 Nemocón	99	99.0	100
3 Cajicá	53	53.0	100	19 Pasca	277	28.7	10
4 Chía	76	76.0	100	20 Sesquilé	143	142.7	100
5 Chocontá	302	253.2	83	21 Sibaté	120	98.0	78
6 Cogua	132	131.9	100	22 Soacha	187	185.9	100
7 Cota	52	52.0	100	23 Sopó	103	103.0	100
8 Cucunubá	110	14.3	13	24 Subachoque	207	197.5	85
9 El Rosal	88	73.0	100	25 Suesca	176	123.0	9
10 Facatativá	160	156.1	100	26 Tabio	74	74.0	100
11 Funza	71	71.0	100	27 Tausa	194	142.8	72
12 Gachancipá	44	44.0	100	28 Tenjo	117	117.0	100
13 Guasca	346	213.9	61	29 Tocancipá	72	72.0	100
14 Guatavita	249	157.9	63	30 Villapinzón	235	38.6	70
15 La Calera	340	184.8	54	31 Zipaquirá	194	188.0	100
16 Madrid	120	120.0	100	Total	6,159	4,268.7	69

(Source: Total Land Areas of Administrative Divisions are official figures published by IGAC)

DANE estimated the population of the year 2000 based on the data of the latest population census. According to this estimation, 42.3 million lived in Colombia, 6.4 million or 15% of the national population in Bogotá D.C., and 2.1 million or 5% of the national population in Cundinamarca Department. The population of the whole Study Area including Bogotá D.C. in 2000 totaled to 7.4 million.

As for GRDP of the Study Area, service sector (71%) had the largest share, followed by manufacturing (25%) and agriculture (4%). Approximately 70% of the agricultural production were made by floriculture.

**Table-2.2 Socio-economic Conditions of the Study Area**

Items	Conditions	
Area	: 4,268.7 km <sup>2</sup>	
Population :Year 2000	: 7.4 million	
GRDP :Year 1999	Study Area	Col\$37.6 trillion : 25% of GDP
	Bogotá D.C.	Col\$33.0 trillion : 22% of GDP
	Cundinamarca D.	Col\$ 7.5 trillion : 5% of GDP
GRDP/Capita :Year 1999	Study Area	Col\$5,094 thousands : US\$2,890 (1.4 x GDP/capita)
	Bogotá D.C.	Col\$5,261 thousands : US\$3,000 (1.4 x GDP/capita)
	Cundinamarca D.	Col\$3,594 thousands : US\$2,050 (1.0 x GDP/capita)

## **2.2 Natural Condition**

### **(1) Topography**

Study area is located on a basin which lies on the west slope of Cordillera Oriental running from the south to the north direction in the east part of Colombia. The basin is called as Bogotá Plain with the altitude of 2500m – 2600m, most of whose areas are composed of flat configuration – the average gradient of riverbeds in the plain is around 1/1000. The basin is surrounded with mountains and hills. The basin is bordered with steep slope of Cordillera Oriental in the east and the north. On the other hand, the basin is bordered with low mountains and hills with gentle slope in the south and the west. Toward the further west of the Study Area, the slope again becomes steep descending down to the Magdalena River. Topographical future of the Study area can be classified into five categories shown as below.

- Low land around rivers.
- Flat plains of Quaternary, which occupy most of the Bogotá Plain.
- Gentle slopes of colluvial deposits distributing at the foot of the mountains.
- Hills with gentle slopes consisting of mainly Tertiary around Bogotá Plain, some exists isolated within Bogotá Plain.
- Mountains with steep slopes consisting of Cretaceous around Bogotá Plain, some exists within Bogotá Plain.

As Table-2.3 shows, the Cundinamarca Department is stratigraphically underlain by sedimentary rocks from Cambrian to Tertiary time and Quaternary sediments. No igneous rocks are found in this area. The Study area exposes the Chipaque Formation of Cretaceous age and the newer formations than Chipaque. Refer to Figure-2.1.

**Table-2.3 Lithostratigraphy in the Area of the Cundinamarca Department**

Geological Time		Lithostratigraphic Classification		Rock Fancies	
Cenozoic	Quaternary	Holocene	Alluvium	Clay, silt, sand, gravel	
		Pleistocene	Terraza Formation	Clay, silt, fine-grained sand	
			Sabana Formation	Clay, clayey sand, volcanic ash	
			Tilata Formation	Clay, silt, sand-gravel rich, volcanic ash, consolidated in the inferior Tilata	
	Tertiary	Oligocene	Usme Formation	Claystone, iron-containing sandstone,	
		Eocene	Regadera Formation	Med.-coa. grained clayey sandstone	
			Bogotá Formation	Claystone, intercalating thin layers of sandstone	
		Paleocene	Cacho Formation	Sandstone, intercalation of mudstone	
Mesozoic	Cretaceous	Superior	Guadalupe Group	Labor & Tierna Fm.	Fine – coarse grained sandstone
				Plaeners Fm.	Fine grained sandstone, siltstone
				Dura Santstone Fm.	Silicified sandstone
			Chipaque Fm.	Clay stone, siltstone, iron-containing muddy fine sandstone	
		Inferior	Villeta Group	Une Fm.	Fine – coarse grained silicified sandstone
				Fomeque Fm.	Claystone, siltstone, calcareous mudstone, fine grained silicified sandstone
			Caqueza Group	Juntas Sandstone Fm.	Sandstone
				Macanal Shale Fm.	Shale
				Guavio Limestone Fm.	Limestone
			Jurassic		Bata Formation
Paleozoic	Devonian – Carboniferous		Guatiquia Red Bed Fm.	Red sandstone, mudstone	
			Gutierrez Sandstone Fm.	Sandstone, slate	
	Cambrian - Ordovician		Quetame Group	Limestone, sandy claystone, silicified sandstone	

Note: 1) Cretaceous Formations of the western part of Cundinamarca are named the different ones.  
2) Stratigraphy of the Study Area is marked with bold lines.

**(2) Meteorology**

**<Meteorology Network>**

Meteorological observation is carried out by CAR, IDEAM in the Study Area. Observation items are, precipitation, temperature, pan-evaporation, solar radiation, sunshine hours, wind-speed and direction. Precipitation is observed at most of the stations. However, the other items are observed at limited stations.

**<Meteorological Characteristics of the Study Area>**

**Precipitation:**

Average annual precipitation of the Study Area is 600mm-1,300mm. Generally in the Study Area, annual precipitation is higher in hills and mountains bordering the Study Area, and becomes lower toward the center of the Study Area. Seasonal precipitation variation has two maximums of seasonal precipitation around May and November.

**Temperature:**

Average temperature of the Study Area is 10 ~ 14 . Eastern area has a little higher temperature than western area in the Study Area. Seasonal temperature variation shows the maximum in March – April and in November.

**Pan-evaporation:**

The average of annual pan-evaporation is 800mm ~ 1,200mm in the Study Area. Pan-evaporation seems higher in the northern part and lower in southern part of the Study Area.

**(3) Hydrology**

**<River System>**

River basin division of the Study Area is shown in Figure-2.2. The Study Area was divided into 20 river basins. River basins of Bogotá- 1 to Bogotá-9 are divided along Bogotá River. The others are tributaries of Bogotá River.

**<Hydrological Observation Network>**

CAR is responsible for hydrological observation in the Study Area. IDEAM and EAAB also carry out hydrological observation in the some parts of the Study Area.

**<Water Flow Condition>**

Bogotá Rive is the main river in the Study Area. Many tributaries join Bogotá River in the Study Area, and Bogotá River finally goes out from the Study Area around the Tequendama Fall. Average annual discharge of this point is estimated at 31m<sup>3</sup>/s. Water from Chingaza Dam that is located in out of the Study Area is conveyed to the Study area. The amount of the conveyed water is estimated 12m<sup>3</sup>/day, which is used for water supply to Bogotá City by EAAB. Sewage that occurs from this water supply enters into Bogotá River. Besides, large amount of river water is pumped up for irrigation and water supply all alone Bogota River.

Seasonal variation of the discharge of Bogotá River has two peaks in between May and July, and November. This variation is similar to seasonal variation of precipitation. Seasonal variation patter of the tributaries is also similar to seasonal variation of precipitation in each tributary.

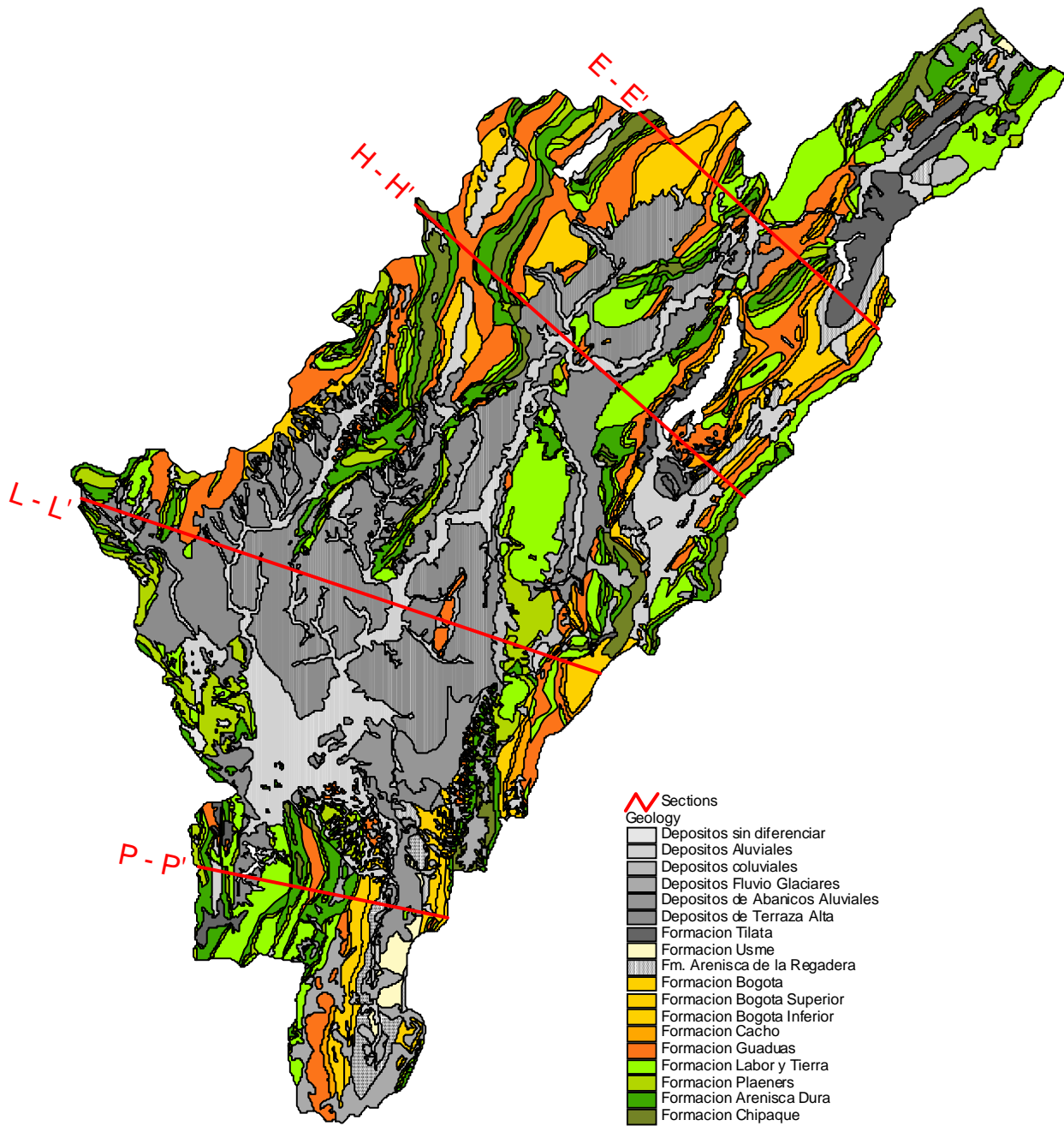


Figure-2.1 Geological Map of Study Area (INGEOMINAS)

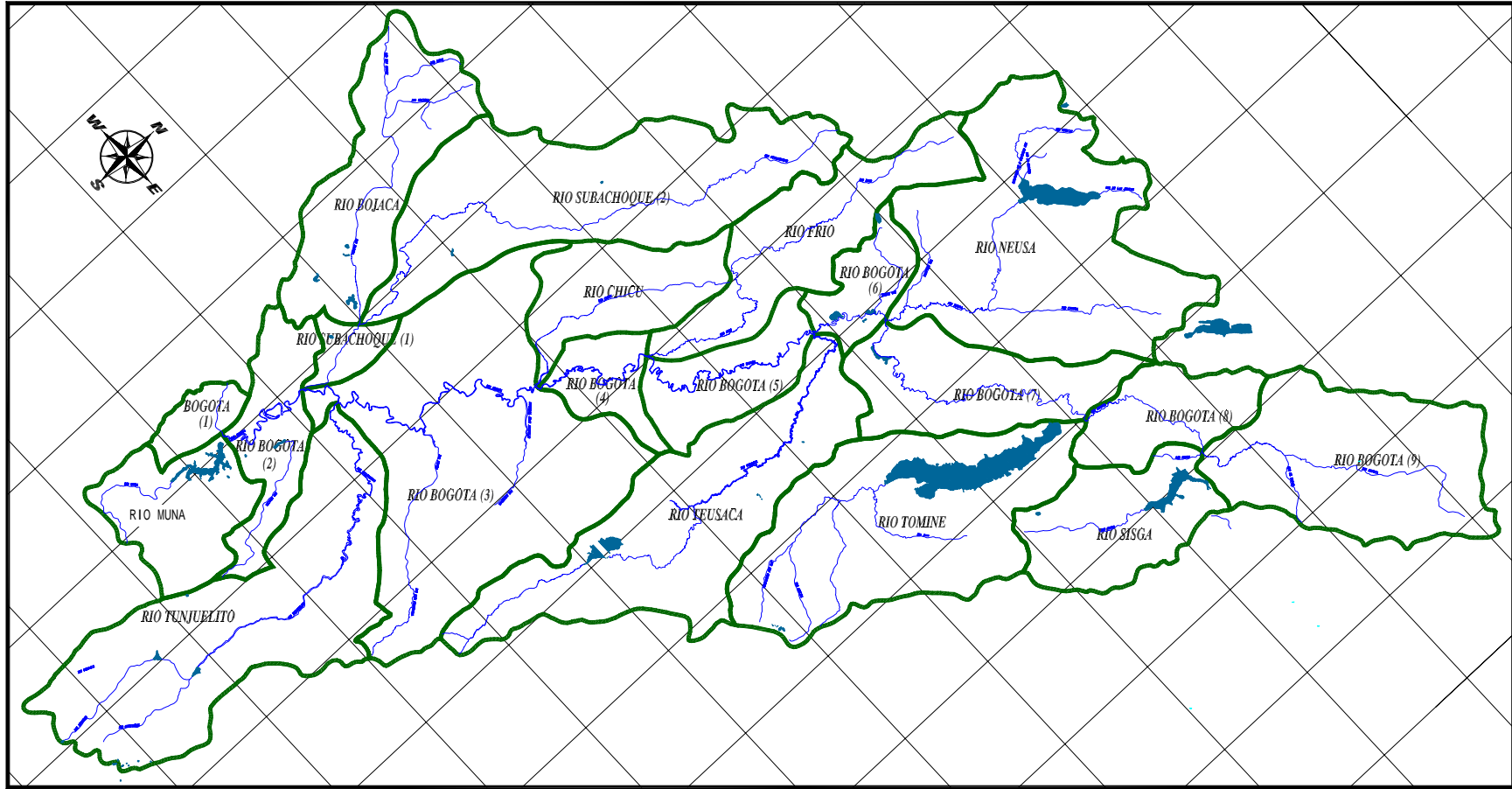


Figure-2.2 River Basin Division of the Study Area

## 2.3 Water Resources Management

### (1) Current Legislation on Water Resources Management

The 1991 Constitution of the Republic vests the ownership of subsoil, and of natural and renewable resources on the state. Major decrees, laws, resolutions related to water resources management are as follows.

#### <Decree-Law No. 2811 of 1974-National Code of Renewable Natural Resources and Environmental Protection>

Decree-Law 2811 of December 18, 1974, named as “National Code of Renewable Natural Resources and Environment Protection”, is the fundamental law of water resources management. All water resources in any condition and any location within the territory are recognized as renewable natural resource. In the Code, renewable natural resources are deemed as common property of the nation, and the state shall participate in their preservation and management as social interests. Conservation, improvement and rational use of them shall be made with *maximum social participation* to assure harmonic development for the benefits of health and well-being of present and future nation.

#### <Decree No. 1541 of 1978>

Decree No. 1541 of 1978 gives provisions on non-marine water based on the National Code of Renewable Natural Resources and Environmental Protection. The Decree defines types of domains, such as public or private, of non-marine water as well as riverbeds. Main part of the decree destined for manners and procedure for giving rights to use non-marine water and watercourses to individual persons, including juridical ones.

#### <Law No. 99 of 1993>

Law No. 99 of 1993 institutes organizations for public administration of environmental protection and conservation as well as renewable natural resources management, such as Ministry of Environment, National Council of Environment, Institute of Hydrology, Meteorology and Environmental Study (IDEAM), Regional Autonomous Corporations. The Law also provides duties and jurisdictions of the relevant organizations. The Law stipulates that Regional Autonomous Corporations with financial independence and their own properties administer environment and renewable natural resources according to the laws and polices of the Ministry.

Study Area, the Upper Bogotá River Basin, falls under the in the territory of CAR with a exception of the small area, which belong to the territory of the Regional Autonomous Corporation of Guavio, south to the Tomine Lake. In case an ecosystem or a water basin extends to territories of two or more regional autonomous corporations, there will be a join commission for coordinated management. In case of a large urban center with a population of one million or more, environmental authority of the local government of the area take same functions as the regional autonomous corporation of the area with in the urban zone. The provision is applied in the Study Area, and DAMA take the duties of environmental and renewable natural resources management.

#### <Law No. 373 of 1997>

Law No. 373 of 1997 provides programs for efficient use and saving of water. All municipalities shall elaborate five-year program in cooperation with entities of water supply, sewerage, irrigation, electrical generation etc., to be approved by respective regional autonomous corporation and to be submitted to the Ministry of Environment.

### **<Accord of CAR No. 8 of 2000>**

Accord of CAR No. 8 of 2000, determines water right charge. Basic charges by municipality are calculated taking account of factors on i) aridity, ii) unsatisfied basic necessity, as socio-economic conditions, iii) availability of water resources. Pressures on water resource potential, i.e. percentage of granted volume to half of mean discharge in dry seasons in case surface water and recharge in case of groundwater, is also a factor for the calculation. For groundwater the charge is lower when the depth of the well is deeper.

### **<Resolutions of DAMA on Groundwater Management>**

Resolution No. 250 of DAMA, 1997, determines formula to calculate rate for abstraction of groundwater. The resolution gives higher rate for shallow borehole less than a depth of 120m and 400m. The resolution No. 251 of 1997 gives obligation of registration of wells located in the urban zones of Capital District to DAMA. According to DAMA, some 300 wells are registered. No. 815 of 1997 gives obligation of metering for well owners.

### **<Recent Decrees on Water Basin Management>**

Decree No. 1604 of 2002 stipulates the members of the Joint Commission and its functions based on Law No. 99 of 1993. The members include directors, or their delegates, of regional autonomous corporation(s) and the environmental authority of the large urban center. Functions of the joint commission are coordinating activities on i) formulation of regulation and management plan of the water basin, ii) approval of the plan, iii) set up mechanism for the implementation of the plan, iv) implementation of programs of economic instruments. The Decree allows the commission to establish a technical commission for the support to carry out its functions.

Decree No. 1729 of the same year gives provisions of concept, objectives, compositions, implementation, and financing for the implementation of the regulation and management plan. The plan has a) diagnostic, b) prospective, c) formulation, d) implementation, and e) monitoring and evaluation phases.

## **(2) Relevant Organizations**

Organizations in charge of water resources management in the Study Area are as follows.

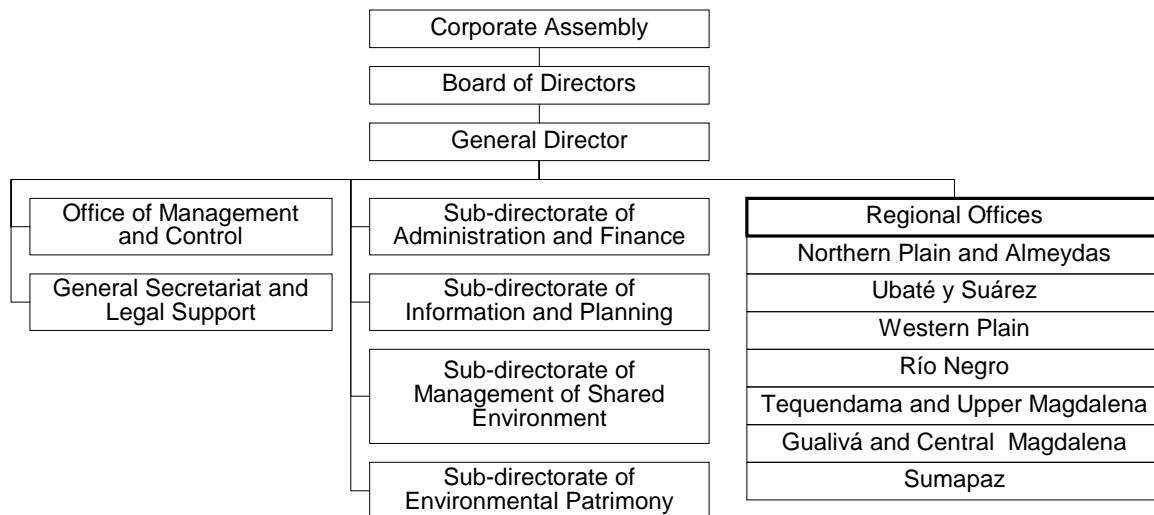
### **<Ministry of Environment>**

Ministry of Environment is in charge of management of environment and renewable natural resources, such as water resources. The ministry formulates policies of the matters at national level, while regional entities, such as CAR or DAMA is in charge of policy formulation and implementation for the management for their jurisdictions.

### **<CAR>**

CAR takes main role in environmental conservation and management of the renewable natural resources, including water resources. CAR was originally established as a water basin management entity and changed its name as the present one by the Law No. 99 of 1993. Its territory has also been changed from areas of basins to areas of administrative units. Since September 2002 CAR has been reducing the number of employees from nearly 870 to the half.





**Figure 2.3 Organization Structure of CAR**

The revenue of the CAR in 2001 reached Col. \$78.3 billion, while the expenditures are summed up to 103.3 Col. \$ billion, of which operational expenditure, debt service and investment expenditure were Col. \$ 36,1 billion, Col. 15.4 billion and Col. 51,9 billion, respectively.

**<DAMA>**

DAMA is one of the Administrative Technical Department of the Government of Bogotá District (*Alcaldia Mayor*) in charge of management of environment and renewable natural resources within the urban perimeter of Bogotá D.C. In fact, however, DAMA grants water rights of groundwater only due to the scarce availability of good quality of surface water in the area.

DAMA has posts of 156 persons as of 1999, of which more than 100 posts are at manager or professional levels. Since most projects are outsourced, DAMA has a small number of employees at assistant or worker level.

**<EAAB>**

Water Supply and Sewerage Company of Bogotá (EAAB) is a public company, without any private capital, in charge of water supply and sewerage services in Bogotá D.C. and water supply to some surrounding towns, such as Cajicá, Sopó, Tocancipá, La Calera, Gachancipá, Soacha, Funza, Mosquera, Madrid. EAAB has a plan to expand areas for the water supply service. EAAB is also engaged in environmental activities, such as implementation of wetlands conservation projects which are formulated by DAMA. EAAB employs around 2,100 persons. Although EAAB is the counterpart entity for the Study, most of their water sources are surface water. Revenue of EAAB in 2000 was Col. \$ 504 billion and its expenditure pf the same year was Col. \$ 551 billion.

**<IDEAM>**

IDEAM is in charge of hydrological, meteorological and environmental investigations, researches and studies for the policy formulation by the Ministry of Environment.

**<INGEOMINAS>**

INGEOMINAS is a technical center of geology or any matters related underground, including groundwater. INGEOMINAS has staff of more than 600 persons, of which more than 100 persons are at levels of managers or professions.

### (3) Current Status of Higher Education on Hydrogeology and the Professional Group

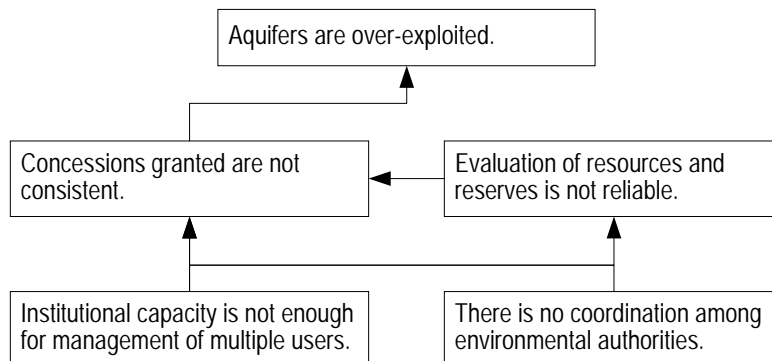
There are quite limited staffs who had higher education on groundwater in public entities for groundwater management of Bogotá Plain. No staff of the entities has master degree on hydrogeology.

There are only two universities in Bogotá which have courses on hydrogeology; National University and Andes University. Courses on hydrogeology for half a year are provided for students of civil, sanitary and environmental engineering, as a part of curriculum for hydrology, and part-time professors made lectures in both universities. In Andes University, a program on hydrogeology has been prepared in the hydrological course of master level. Only one student takes the program this year. According to the professors, many of the graduate got jobs not related to groundwater.

Establishment of an association of hydrogeologists is under preparation. Members of the association will be comprised of staff of consulting firms specialized for hydrogeology, professors of the universities, staff of CAR, DAMA, EAAB, IDEAM, INGEOMINAS, as well as drilling companies.

### (4) Problems in Groundwater Management

Series of discussion meetings were held with counterparts from CAR, DAMA, Ministry of Environment, IDEAM, EAAB, INGEOMINAS, ASOCOLFLORES, Fundación Al Verde Vivo (environmental NGO) to identify problems in groundwater management after confirmation of responsibility assignments, self-evaluation of performances and procedure for granting rights to use groundwater. Various problems were raised at first. Then, problems were grouped into several clusters. The major problems and the structure; cause-result relations, can summarized as follows.



**Figure 2.4 Major Problems in Groundwater management and their Cause-Result Relations**