# APPENDIX H

# MONITORING SYSTEM

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# CHAPTER I METEOROLOGICAL AND HYDROLOGICAL MONITORLING SYSTEMS

## 1.1 General

In the Study Area, meteorological and hydrological characteristics are monitored by CAR and IDEAM. Judging from the present status of meteorological/hydrological observation and water resource management of CAR, there seems necessary to improve present monitoring systems in harmony with future conditions. These subjects are studied in this Chapter.

## 1.2 Existing Meteorological and Hydrological Monitoring Systems

### 1.2.1 Meteorological Monitoring System

Table B.1.3 and Fig.B.1.3 show the inventory and locations of the existing climate and rainfall stations. At almost these stations, observations have been conducted for over twenty years, but some data are defective.

Rainfall stations in the Study Area are evenly distributed except for the upper basin of the Ubate River, which has a higher station density to operate and manage Hato Dam. In the Cucunuba Lake basin, IDEAM has two (2) rainfall stations but CAR has no rainfall station.

The climate stations in the Study Area are also evenly distributed. Only IDEAM observes climate in the area near Fuquene Lake.

### 1.2.2 Hydrological Monitoring System

Table B.2.2 and Fig. B.2.1 show inventory and locations of the existing water level and discharge gauging stations. At least one (1) automatic gauging station has been installed along each major river. Almost all stations are installed at places where observation conditions are preferable in terms of stableness in hydraulics and easy access to station, etc.

## 1.3 Improvement of Monitoring Systems

### 1.3.1 Meteorological Monitoring System

Based on the results of field survey and climatic and rainfall analyses, the improvements of the meteorological monitoring system are proposed, as follows:

(1) Collection of Climate and Rainfall Data from IDEAM

It is recommended for CAR to collect climate and rainfall data from IDEAM from the areas where CAR has no monitoring stations. These areas are middle area near Fuquene Lake for climate data, and the Cucunuba Lake basin for rainfall data.

(2) Surrounding Circumstances of Stations

Novilleros climate station is surrounded by trees, which affect its monitoring data. It is recommended, therefore, to improve its surrounding circumstances. This kind of

consideration is necessary for other stations.

(3) Inspection of Observation Stations

Defects of data at the stations in the Lenguazaque River basin are noticeable in comparison with other stations. Reasons of the defects are ill-function of recording equipment including running out of roll paper. Periodical inspection of observation equipment and consumable materials are necessary for these stations.

### 1.3.2 Hydrological Monitoring System

The optimum operation of Hato Dam will be monitored/adjusted based on the river flow data of the Ubate and Suta Rivers. At present, there already exist gauging stations along these rivers, Code No. 2401715 and No. 2401716 at the Ubate and Suta Rivers, respectively.

On the other hand, the optimum operation of Fuquene Lake will be monitored/adjusted based on the inflow and outflow data of the Lake. In relation with this aspect, the following improvements are proposed:

(a) Ubate River

There exists one (1) automatic gauging station along the lower reach of the Ubate River, around 8 km upstream from Fuquene Lake. This station is Code No. 2401729, Pte. Colorado. However, the data of this station were only water levels since 1989 (refer to Table B.2.2). Therefore, the discharge measurements and establishment of rating curve of this station are proposed.

(b) Suarez River

At present, no gauging station exists near the outlet of Fuquene Lake. Therefore, installation of a new gauging station is proposed at the mentioned place. The discharge measurements and establishment of rating curve of this station will be conducted for the rainy season in principle.

## 1.4 Cost Estimate

Improvement cost is estimated for hydrological monitoring system. Cost for improvement of meteorological monitoring system is not estimated because it is methodological one.

### 1.4.1 Installation Cost

Installation cost for one (1) new gauging station at the Suarez River is estimated, as follows:

| Item | Unit | Unit Price (Col$) | Quantity | Total (1,000 Col$) |
|---|---|---|---|---|
| Equipment | nos. | 3,500,000 | 1 | 3,500 |
| Labor Cost | L. S. | | 1 | 100 |
| Total | | | | 3,600 |
| Total (1,000 US $) | | | | (1.9) |

Exchange rate: 1 US$ = 106 ¥ = 1,920 Col$

### 1.4.2 Operation and Maintenance Cost

Annual operation and maintenance cost accrues from the said two (2) gauging stations is estimated, as follows:

| Item | Unit | Unit Price (Col$) | Quantity | Total (1,000 Col$) |
|---|---|---|---|---|
| Observation and Maintenance | man/day | 20,000 | 20/year | 400 |
| Consumable Materials | L. S. | | 1 | 40 |
| Total | | | | 440 |
| Total (1,000 US$) | | | | (0.23) |

Exchange rate: 1 US$ = 106 ¥ = 1,920 Col$

# CHAPTER II WATER QUALITY MONITORING SYSTEM

## 2.1 General

CAR stipulated the standards of surface water and wastewater quality for the Study Area through the Agreement 58 in 1987, based on the national standards. Further, they categorized the target water quality of the rivers/lakes in the Study Area in accordance with the water use level.

On the other hand, the existing water quality monitoring system in the Study Area is in a low level due to shortage of analysis equipment, man-power and finance. CAR has conducted the water quality monitoring on ad hoc basis only when a strong requirement arose.

The river/lake water quality must periodically be observed to manage the river/lake water to meet the above standards. For this purpose, the existing laboratory must be improved as well. In this Chapter, the improvement plan of the existing monitoring system is proposed.

## 2.2 Existing Water Quality Monitoring

### 2.2.1 River/Lake and Wastewater Quality

The water quality of the river/lake and wastewater quality are monitored by CAR on ad hoc basis. The existing river/lake water quality data are shown in Table E 1.1.

### 2.2.2 Existing Equipment of Water Quality Analysis

The existing equipment for water quality analysis are listed in Table H 2.1, and the existing spaces in the CAR laboratory are listed in Table H 2.2. The existing analysis equipment are not enough for the periodical observation of water quality.

## 2.3 Improvement of Water Quality Monitoring System

### 2.3.1 Execution of Water Quality Monitoring

(1) CAR

CAR has to monitor the surface water quality of river/lake and sewerage effluent into river/lake. The purpose of monitoring on the sewerage inflow into river/lake is to cross-check the water quality data with the data of each municipality.

(2) Municipality

Each municipality has to monitor the wastewater quality of sewerage inflow/outflow and factory outflow into sewerage.

### 2.3.2 Improvement of Periodical Observation

(1) Surface Water

The water quality of the Study Area will be monitored every three (3) months at the proposed 17 monitoring points which include four (4) points on the lake and 13 points on the river. These recommended water quality observation points and frequency are shown in Table H 2.3.

(2) Wastewater

In the improvement plan, wastewater quality of sewerage treatment system will be monitored with a frequency of twice a year at 15 sewerage and three (3) major industry effluent points, as shown in Table H 2.4.

(3) Parameter

Parameters for the periodical water quality analysis have been selected, as shown in Table H 2.5. Each parameter is considered to adapt National/CAR standards.

### 2.3.3 Improvement of Laboratory

To periodically monitor water quality, laboratory equipment must be improved, as shown in Table H 2.6.

## 2.4 Cost for Improvement of Monitoring System

### 2.4.1 Procurement and Construction Cost

The procurement and construction costs related to the improvement of monitoring system consist of procurement cost for laboratory equipment, vehicles and furniture as well as the building construction cost, and these costs were estimated based on the market prices prevailing in October 1999.

The procurement cost for the laboratory equipment, vehicles and furniture is estimated to be 544.4 million Col$ (0.28 million US$) with the break-down as shown in Table H 2.6.

The construction cost of the laboratory is estimated as follows.

| Item | Area($m^2$) | Unit Price ( Col$ ) | Total (million Col$ ) |
|---|---|---|---|
| 1 story Building | 278 | 2,500,000 | 695 |
| Garage and Warehouse | 120 | 1,500,000 | 180 |
| Total | 398 | | 875 |
| Total (million US$) | | | (0.46) |

Exchange rate: 1 US$ = 106 ¥ = 1,920 Col$

The total procurement and construction costs related to the laboratory are summarized below.

| Item | Cost (million Col$ ) |
|---|---|
| Procurement Cost | 544.4 |
| Construction Cost | 875.0 |
| Total | 1,419.4 |
| Total (million US$) | (0.74) |

Exchange rate: 1 US$ = 106 ¥ = 1,920 Col$

### 2.4.2 O&M Cost

The O&M cost related to the laboratory is composed of manpower cost and consumable material cost. The number of personnel for the monitoring in the CAR is listed below.

| Department | Existing | Plan |
|---|---|---|
| Laboratory | 5 | 10 |
| Driver | 0 | 2 |

The annual O&M cost is estimated as below.

| Item | Cost (1,000 Col$ / year) | Remarks |
|---|---|---|
| Manpower Cost | 141,400 | |
| Consumable Material Cost | 1,360 | 0.25% of procurement cost |
| Total | 142,760 | |
| Total (1,000 US$) | (74) | |

Exchange rate: 1 US$ = 106 ¥ = 1,920 Col$

# CHAPTER III MONITORING FOR AQUATIC PLANTS CONTROL OF THE LAKE

## 3.1 General

To control the excessive aquatic plants of the Lake Fuquene, the following three (3) kinds of projects are proposed in this Study.

(1) Dredging of the lake bed in front of Bulrush to control its expansion.

(2) Mechanical Harvesting/Removal of Elodea and Water hyacinth

(3) Control of Elodea by grass carp

The following changes should periodically be monitored to know the effects or impacts of the projects on the environments of the Lake.

(1) Change of aquatic plant area

(2) Change of the species of fauna and flora

(3) Change of Bulrush frontline and bed elevation in the dredged lake zone

(4) Growth and consumption rates of grass carp

## 3.2 Monitoring Methodology

### 3.2.1 Survey of Aquatic Plant Area

The aquatic plant area will change according to the progress of the projects. Then, the following surveys will be done.

(1) The floating and emergent aquatic plant areas of the Lake can be measured by aerial photograph on a macro-scale. The aerial photograph covering the lake area has been taken 12 times irregularly since 1940 by the Geographic Institute and one (1) time by JICA in 1999 as described in Appendix G Chapter II. It will regularly be taken once every three (3) years in the future to know the change of the aquatic plant area with accuracy. The photograph will be analyzed by GIS of CAR to prepare aquatic plant maps.

(2) The submerged plant area will be surveyed with eye on the field with supporting of the aerial photograph once every three (3) years.

### 3.2.2 Survey of Species of Fauna and Flora

(1) Species of the aquatic plants in the Lake have been surveyed on ad hoc basis by CAR and other organizations. However, the species may possibly change according to the progress of the projects. Then, the species of the aquatic plants in the Lake will be confirmed regularly once every three (3) years.

(2) Species of the aquatic animals including fish, bird and others in the Lake have also been surveyed on ad hoc basis by CAR and other organizations. The species may

possibly change according to the progress of the projects. Then, the species of the aquatic plants in the Lake will be confirmed regularly once every three (3) years.

### 3.2.3 Survey of Bulrush Frontline and Bed Level in the Dredged Lake Zone

The proposed lake bed dredging is expected to stop the forward movement of Bulrush frontline. Then, the location of the Bulrush frontline will be surveyed once every three (3) years to confirm the effects of the project.

The lake bed of the dredged zone may possibly be buried by sediment deposition or topographic deformation in the future. Then, the lake bed level of the dredged zone will be surveyed once every three (3) years.

### 3.2.4 Measurement of Growth and Consumption Rates of Grass Carp

The grass carp will grow in ages at a high rate. The grass consumption rate will also increase in proportion to the growth of grass carp. Stocking of too many grass carps may over-consume the aquatic plants in the Lake, causing damages on the other aquatic lives. On the other hand, too few grass carp stocking may not attain a satisfactory control of the excessive aquatic plants. Then, the stocking number of grass carp must properly be controlled. For this purpose, the following monitoring will be made.

(1) Sampling measurement of the size and weight of grass carp once every year

(2) Sampling measurement of Elodea density to estimate the remaining biomass once every year

## 3.3 Monitoring Cost

The required cost of the above monitoring is estimated as follows.

| Monitoring Item | Cost (1,000 Col$) | Remarks |
|---|---|---|
| 1. Survey of Aquatic Plant Area | 11,100 | |
| Aerial Photograph Taking | 10,000 | Once every 3 years |
| Field Survey | 1,100 | Once every 3 years |
| 2. Survey of Fauna and Flora | 4,000 | Once every 3 years |
| 3. Survey of Bulrush Frontline and Dredged Bed Level | 2,200 | Once every 3 years |
| 4. Measurement of Grass Carp and Biomass | 7,300 | |
| Grass Carp Measurement | 6,000 | Once every year |
| Biomass Measurement | 1,300 | Once every year |
| Total (Equivalent Annual Cost: 1,000 Col$/year) | 13,100 | |
| Total (Equivalent Annual Cost: 1,000 US$/year) | (6.81) | |

Exchange rate: 1 US$ = 106 ¥ = 1,920 Col$

# CHAPTER IV GEOGRAPHIC INFORMATION SYSTEM (GIS)

## 4.1 Review of Existing GIS

### 4.1.1 Organizational Structure and Jurisdiction of CAR

(1) CAR Nature

CAR of Cundinamarca is a public corporate entity and autonomous administratively and financially having the functions by law the administration of the environment and the natural resources with sustainable development in the area under its jurisdiction.

(2) Institutional Structure

CAR's institute is composed by the followings: Corporate Assembly, the Directive Council, the General Directorate, the 7 Sub-directorates and the 7 Regional Directorates (See Fig. H.4.1).

(3) CAR's Jurisdiction

CAR is managing the territories covering the all basin of Bogota River, including the Municipality of Girardot and the basin of Ubate and Suarez Rivers located in Cundinamarca and Boyaca prefectures. Altogether, its jurisdiction includes 104 municipalities of Cundinamarca and Boyaca.

### 4.1.2 GIS Related Activities

Out of seven (7) Sub-directorates of CAR, more or less, following four (4) are dealing with the spatial type of data:

(1) Sub-directorate of Planning and Development

(2) Sub-directorate Scientific

(3) Sub-directorate of Environmental Quality Control

(4) Sub-directorate of Operations

Furthermore, the use of computer based GIS is limited to the Division of Information under Sub-directorate of Planning and Development, and Division of Technique Evaluation under Sub-directorate Scientific. At present, their GIS activities are mainly for presentation purpose and not significantly for analysis purpose.

### 4.1.3 Hardware and Software at CAR

For GIS related activities, available hardware and software are given below.

(1) Division of Information (Sub-directorate of Planning and Development)

Hardware:

- PC computer two
- Unix work-station one
- Digitizer one
- Plotter HP250C one

Software:

- Genasys version 7.2 two
- CAD map one
- ER Mapper version 5.6 one
- Oracle one

(2) Division of Technique Evaluation (Sub-directorate Scientific)

Hardware:

- PC computer two
- Unix work-station one
- Digitizer Sun-Graphics one
- Plotter HP250C one
- Plotter HP750c one

Software:

- Genasys version 7.2 two
- Micro Station one

### 4.1.4 Technical Personnel Involved in GIS Activity

Each, Division of Information and Division of Technique Evaluation, has three (3) personnel involved in GIS related activities. Besides this, in Division of Information, one staff is working as system technician.

### 4.1.5 Data Availability

(1) Digital Data at CAR

The available digital data at CAR has been enlisted in Table H.4.1 which includes spatial data covering the whole CAR likes river net-work, reserve areas, meteorological stations, region wise like regional risks, and municipality wise such as soil use and topography. Besides this, it has also data of some particular basin likes Fuquene, Apulo, Subachoque, and related to some specific projects likes Chequa, Hidrotec, Cardan. These data may have due importance in managing the environmental problems.

(2) Paper Map at CAR

For the Fuquene basin area, the inventory of paper maps, so available at CAR, is presented in Table H.4.2. Roughly, these include maps of hydrology, topography, cadastre, bathymetry of lakes, isolines, irrigation, etc. Some cover the whole basin while some are specific ones such as map of Palacio Lake Gate. The importance of information included in those maps becomes clearer at the time of requirement.

(3) Collected/Used by JICA Study Team

Besides the attribute data, following are the spatial data used by the JICA Study team.

| S.N. | Title |
|---|---|
| 1 | Land Use |
| 2 | Historical Propagation of Aquatic Plants |
| 3 | Geology |
| 4 | River Basin |
| 5 | Municipality |
| 6 | Bathymetric of Fuquene Lake |
| 7 | Reserve Area |
| 8 | Irrigation Blocks |
| 9 | Isohyetal Map |
| 10 | River Net-work |
| 11 | Road |
| 12 | Location of Meteorological Stations |
| 13 | Location of Gauging Stations |
| 14 | Location of Ground Water Stations |
| 15 | Location of Water Sampling Points |
| 16 | Location of Supplementary Water Points |
| 17 | Soil Erosion Map |

Out of these updated existing land use and historical propagation of aquatic plants were delineated under this study using aerial photographs and other data.

(4) Other Agencies with related GIS Data

CAR has connection with a number of governmental and non-governmental agencies from where it can get the concerned spatial data. Some of such agencies are mentioned below.

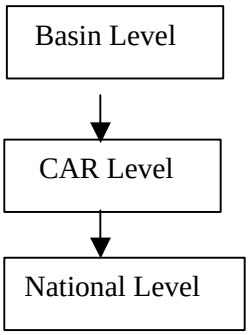
- IGAC (Geographic Institute)
- URPA (Regional Unit of Agriculture and Cattle Planification)
- DANE (National Administrative Statistical Department)
- DAMA (Environmental Administrative Department of Bogota)
- Ingeominas
- Javeriana University

## 4.2 Recommendations for Proposed GIS

### 4.2.1 GIS Implementation Strategy for Environmental Management System

GIS is a powerful tool in analyzing the spatial data and linked such data with attribute ones to derive the information needed for decision support system for environmental management. On the other hand, considering the fact that at present, the use of GIS in CAR is mainly limited to presentation purpose, it would be better to start its applicability with small command area, say at Basin level, for instance, Fuquene basin. And, after getting assimilated at this level, it can be later on broadened to whole CAR Jurisdiction and then to whole nation as shown in flow chart below.

The phase I being the backbone of successive two, due care shall be required regarding the narrowing the type data required for concerned environmental monitoring. Also, it should be noted that command area being smaller one, the scale of analysis would be relatively larger whose result would be directly affected by the scale and standard of the input data.




Phase I

Phase II

Phase III

After getting satisfactory result from the Phase I, it would be worth to proceed to phase II by applying this system in other basin and gradually covering the whole CAR jurisdiction. At this phase, it would be worth to note that the need of environmental monitoring within one basin may differ from another and so are the types of required GIS data. After getting full flag GIS system for a whole CAR area, it may be proceeded for national level as phase III.

### 4.2.2 Main Considerable Points

(1) GIS Groups

For smooth GIS implementation, it is recommended to combine both the existing GIS groups to one. This will have not only the advantage of sharing the available hardware, software and database but also the involved personnel will have a greater opportunity to exchange their knowledge and experience. Thus, this will provide the involved personnel some sort of in-house training.

(2) Training to the Involved Personnel

As complementary to the in-house training as mentioned above, the involved personnel shall require to provide training from time to time about the GIS for environmental management and related software from the concerned institutes. This will help them to increase their ability keep up with the updated technology.

(3) Data Compatibility

Creating all the data set being not feasible, during the course of GIS implementation, the CAR would repeatedly need to use the data created by other related agencies. While doing so, it would be worth to consider the points like how much the available data set would meet the required purpose or whether the GIS system available in related Institute would be compatible for data use or not.

(4) Geodetic Aspects

To get more reliable result from the implemented GIS system, it would be worth to give emphasis to produce more accurate thematic maps with clear information such as

scale, projection system, input materials (methodology) used to produce the map, and so on

(5) Coordination within the CAR

This would have vital role in yielding the GIS system more successful.

### 4.3 GIS Data Input and Its Application

In order to uncover the capability of GIS for environmental monitoring, some examples of GIS applications were first discussed with the concerned counterpart and then were performed using the Genasys software, so available in CAR giving due emphasis to methodology. For this the necessary data were input to Genasys software. The used data include land use, river/channel network, meteorological data, aquatic plants, topographic features, reserve area, cadastral map, ground water data, bathymetric features, water use, etc. A brief description of the performed exercises are mentioned below:

#### 4.3.1 Display of Spatial Data and Link with Attribute Tables

Along with displaying the spatial data under GIS environment, the methodology was shown how to link it with the attribute table containing the data related to environment. After the linkage, querying with just one mouse click was found enough to display the characteristics of particular feature or location. Thus, this can have great importance in preparing database for environmental management.

#### 4.3.2 Analysis of Spatial Data

GIS is a easy tool in overlaying two spatial data to perform the comparative analysis. For example, the comparison of land use with reserve area data, it makes easier to monitor the possible encroachment of cultivation inside the reserve area (See Fig. H.4.2).

Also, the overlay of same kind of maps prepared at two different times yields the change over that period. For instance, two land use maps, of 1985 and present, were overlaid. This gave opportunity to know the extent to which land use has been changed from 1985 to present (See Fig. H.4.3).

#### 4.3.3 Prediction of Irrigation Water Requirement

This exercise was done for a part of irrigated area using land use map, cadastral map, meteorological data like precipitation and evapotranspiration, and attribute data like crop coefficient. In brief, the effective precipitation (Pe) was calculated from the available period of annual precipitation setting the criteria as 65%.Similarly, the average value of evapotranspiration (Ev) was obtained for the same period. These both were then converted to polygon form. On the other hand, the present land use was overlaid with existing cadastral map to get the exact land use in each parcel. The crop coefficient (K) value was input to the resulted parcel wise land use data from which consumptive use (Uc) was known by overlaying it with evapotranspiration data. At last, the consumptive use data was overlaid with effective precipitation (Pe) polygon data to calculate the net irrigation requirement using the formula as shown in Fig. H.4.4.

### 4.3.4 Slope Stability

Using the contour data, the Digital Elevation Model (DEM) was created. This DEM was further used to derive the slope which was compared with the existing land use to predict about the slope stability. The DEM was also used to create aspect and hill shading (See Fig. H.4.5).

### 4.3.5 Extracting Fuquene Lake Information from Aerial Photo

In this exercise, the aerial photos were first scanned to get its digital data which were georeferenced using control points from existing maps. Then, the information related to lake likes shore line and distribution of aquatic plants, etc were extracted by on screen digitizing (see Fig. H.4.6). Performing this operation for other time aerial photo, the results could be overlaid to observe the change in shore line and locational distribution of aquatic plants.

Besides, the above exercises, extensive discussion was done about the possible methodology and points to be considered for estimating the soil erosion using USLE under Fuquene condition.

## Table H 2.1 Existing Water Quality Analysis Equipment in CAR Laboratory

| Analysis Equipment | Type/Model | Number | Remarks |
|---|---|---|---|
| Gas chromatograph | Philips Model PU 4410 | 1 | |
| (Detector ECD,FID) | Philips Model PU 3120 | 1 | |
| Incubator (one for BOD, one for microbiological analysis) | Precision | 1 | |
| COD,Grease,Oil analysis equipments | National | 4 | |
| Direct reading balance | Precisa Model AOSM 200A | 1 | |
| Atomic absorption spectrometer | Perkin Elmer Model Landa 3B | 1 | |
| Autoclave | All American Model 25 | 3 | |
| Vacuum pump | Gast | 4 | |
| Titration devise | Digital | 2 | |
| Stirrer | Lab-line L.E.D | 2 | |
| | Lab-line L.E.D | 1 | With Temperature Regulator |
| pH meter | Orion Reseach Model 301 | 1 | |
| | Fisher Scientific | 1 | |
| | Mettler Ref M 320 | 1 | |
| | Mettler Ref M 340 | 1 | |
| Electroconductibity meter | Digital | 1 | |
| Water bath for serological test | Precision | 1 | |
| Water bath | Precision | 2 | |
| Distillation apparatus | Labconco | 1 | For Nitrogen and Phenol Analysis |
| Muffle furnace | | 1 | |
| Turbidity Meter | Chemetrix Type 12 | 1 | |
| Dissolved oxygen meter | YSI Model 57 | 1 | |
| Oxygen meter | YSI Model 54 ARC | 2 | |
| Draft chamber | Labconco | 1 | |
| Laminar flow chamber | Labconco | 1 | |
| Gas Chromatography Mass Spectrometer | Hewlett Packard Model Series HP 6890 | 1 | |
| Ultraviolet spectrometer | Perkin Elmer Model Landa 3B | 1 | |
| Centrifugal separator | Fisher Model 225 | 1 | |
| Heater | Corning | 1 | With Stirrer |
| Jar tester | Schott | 3 | |
| Dryer | Precision | 2 | |
| | Lab-line | 1 | |
| Drying oven | Sybron Termolite Model FA1730 | 1 | |
| Rotary evaporator | Buechi Model RE 111 & 461 | 2 | |
| Grass instrument | Frask, Beaker, etc | | |
| Dry sterilizer | Precision | 1 | |
| Sprinkler for emergency | | 1 | |
| Regulator | Soltironic | 1 | |
| Current meter | Propeller tipe | 10 | |
| Water sampler | Kemmerer | 4 | |
| Sludge sampler | Ekman | 1 | |
| Generator | Honda | 1 | |
| Sifter | | unknown | |
| Field Water Quality Analyzer | | 1 | Electroconductivity, pH, Watertemperature |

## Table H 2.2 Existing Space of CAR Laboratory

| Infrastructure | Area (m2) | Remarks |
|---|---|---|
| Analysis Laboratory | 278 | |
| Administrative | 12 | |
| Preparation Room | 87 | |
| Storage for Sample with Refrigerator | 3 | |
| Storage for Sample without Refrigerator | 3 | |
| Storage for Reagent with Ventilation | 31 | |
| Pretreatment Room | 10 | |
| Extraction of Gases | 4 | |
| Instrument Room (Volume) | 63 | |
| Instrument Room (Balance) | 31 | |
| Instrument Room (Atomic absorption spectrometer etc) | 34 | |
| Total | 556 | |

**Table H 2.3 List of River/Lake Water Quality Monitoring Point**

| River/Lake | Code | Point Name | River/Lake Name | Observation Frequency (times/year) |
|---|---|---|---|---|
| Lake | QL-1 | Near Ubate Mouth | Fuquene Lake | 4 |
| | QL-2 | Near Port | Fuquene Lake | 4 |
| | QL-3 | Center | Fuquene Lake | 4 |
| | QL-4 | Near Suarez Outlet | Fuquene Lake | 4 |
| River | QR-1 | Dam outlet | Hato Dam | 4 |
| | QR-2 | Downstream of Ubate City | Ubate | 4 |
| | QR-3 | Verda Punta Gande | Lenguazaque | 4 |
| | QR-4 | Before Confluence of Ubate River | Suta | 4 |
| | QR-5 | After Confluence Suta River | Ubate | 4 |
| | QR-6 | After Confluence Lenguazaque River | Ubate | 4 |
| | QR-7 | Colorado | Ubate | 4 |
| | QR-8 | Balsa Bridge | Suarez | 4 |
| | QR-9 | Upstream of Chiquinquira City | Chiquinquira | 4 |
| | QR-10 | Before Tolon Gate | Suarez | 4 |
| | QR-11 | Downstream of Chiquinquira City | Suarez | 4 |
| | QR-12 | Pte Reralonso | Susa | 4 |
| | QR-13 | Pte GUZMAN | Simijaca | 4 |

## Table H 2.4 Water Quality Monitoring Plan for Point Pollution Source

| Point Pollution Source | Municipality | Observation Point | Receiving Body | Observation Frequency (times/year) |
|---|---|---|---|---|
| Sewerage | Ubate | After treatment | Suta River | 2 |
| Sewerage | Cucunuba | After treatment | Q.Buida | 2 |
| Sewerage | Lenguazaque | After treatment | Lenguazaque River | 2 |
| Sewerage | San Miguel de Sema | After treatment | Q.Santa Ana | 2 |
| Sewerage | Saboya | After treatment | Suarez River | 2 |
| Sewerage (After Construction ) | Carmen de Carupa | After treatment | Q. La Playa | 2 |
| Sewerage (After Construction ) | Tausa | After treatment | Suta River | 2 |
| Sewerage (After Construction ) | Sutatausa | After treatment | Suta River | 2 |
| Sewerage (After Construction ) | Guacheta | After treatment | Q.Gualacacia | 2 |
| Sewerage (After Construction ) | Fuquene (Urban) | After treatment | Q.Ochoque | 2 |
| Sewerage (After Construction ) | Fuquene (Capellania) | After treatment | Q.Bautista | 2 |
| Sewerage (After Construction ) | Susa | After treatment | Susa River | 2 |
| Sewerage (After Construction ) | Simijaca | After treatment | Simjaca River | 2 |
| Sewerage (After Construction ) | Caldas | After treatment | Chiquinquira River | 2 |
| Sewerage (After Construction ) | Chiquinquira | After treatment | Suarez River | 2 |
| Slaughterhouse | Simijaca | Effluent to River | Q.El Capitodio | 2 |
| Slaughterhouse | Chiquinquira | Effluent to River | Chiquinquira River | 2 |
| Milk Factory | Simijaca | Effluent to River | Q.El Capitodio | 2 |

## Table H.2.5 Parameters to be Observed for Surface Water and Wastewater

| No. | Item (Quality Parameter) | Unit | National/CAR Standard | | Monitoring Plan | | |
|---|---|---|---|---|---|---|---|
| | | | Surface Water | Wastewater | River | Lake | Wastewater |
| 1 | Watertemperature | ℃ | | x | ◎ | ◎ | ○ |
| 2 | pH | (-) | x | x | ◎ | ◎ | ○ |
| 3 | DO | $O_2$ mg/l | x | | ◎ | ◎ | ○ |
| 4 | $BOD_5$ ($OBO_5$) | $O_2$ mg/l | x | x | ◎ | | ○ |
| 5 | COD (OQO) | $O_2$ mg/l | | | ◎ | ◎ | ○ |
| 6 | Suspended Solid | SS mg/l | | x | ◎ | ◎ | ○ |
| 7 | Lead | Pb mg/l | x | | △ | △ | △ |
| 8 | Zinc | Zn mg/l | x | | △ | △ | △ |
| 9 | Copper | Cu mg/l | x | | △ | △ | △ |
| 10 | Chromium | Cr6+ mg/l | x | | △ | △ | △ |
| 11 | Nickel | Ni mg/l | x | | △ | △ | △ |
| 12 | Cobalt | Co mg/l | x | | △ | △ | △ |
| 13 | Mercury | Hg mg/l | x | | △ | △ | △ |
| 14 | Arsenic | As mg/l | x | | △ | △ | △ |
| 15 | Barium | Ba mg/l | x | | △ | △ | △ |
| 16 | Cadmium | Cd mg/l | x | | △ | △ | △ |
| 17 | Cyanide | CN mg/l | x | | △ | △ | △ |
| 18 | Polychlorobiphenyl | PCB mg/l | x | | △ | △ | △ |
| 19 | Molybdenum | Mo mg/l | x | | △ | △ | △ |
| 20 | Silver | Ag mg/l | x | | △ | △ | △ |
| 21 | Selenium | Se mg/l | x | | △ | △ | △ |
| 22 | Vanadium | V mg/l | x | | △ | △ | △ |
| 23 | Boron | B mg/l | x | | △ | △ | △ |
| 24 | Fluorine | F mg/l | x | | △ | △ | △ |
| 25 | Phenol | $C_6H_5OH$ mg/l | | | | | |
| 26 | Organicmercury Compounds | Hg mg/l | x | | △ | △ | |
| 27 | Trichloroethylene | $C_2H_3Cl_3$ mg/l | | | | | |
| 28 | Chloroform | $CHCl_3$ mg/l | | | | | |
| 29 | Tetrachlorocarbon | $CCl_4$ mg/l | | | | | |
| 30 | Dichloroethylene | $C_2H_4Cl_2$ mg/l | | | | | |
| 31 | Carbon disulfide | $CS_2$ mg/l | | | | | |
| 32 | Other organochloric compounds | mg/l | | | △ | △ | |
| 33 | Other organophosphoric compounds | mg/l | | | △ | △ | |
| 34 | Carbamate | mg/l | | | △ | △ | |
| 35 | Iron | Fe mg/l | x | | ◎ | ◎ | ○ |
| 36 | Manganese | Mn mg/l | x | | ◎ | ◎ | ○ |
| 37 | Lithium | Li mg/l | x | | △ | △ | △ |
| 38 | Berylium | Be mg/l | x | | △ | △ | △ |
| 39 | Total Nitrogen | N mg/l | | | ◎ | ◎ | ○ |
| 40 | Aluminium | Al mg/l | x | | △ | △ | △ |
| 41 | Ammonium | $NH_4$-N mg/l | x | | ◎ | ◎ | ○ |
| 42 | Nitrate | $NO_3$-N mg/l | x | | ◎ | ◎ | ○ |
| 43 | Nitrite | $NO_2$-N mg/l | x | | ◎ | ◎ | ○ |
| 44 | Nitrate + Nitrite | N mg/l | x | | | | |
| 45 | Total Phosphorus | P mg/l | | | ◎ | ○ | ○ |
| 46 | Orthophosphoric acid | $PO_4$-P mg/l | | | ◎ | ○ | ○ |
| 47 | Salt | Weight mg/l | x | | △ | △ | △ |
| 48 | Floating Material | mg/l | | x | | | ○ |
| 49 | SVI | ml/l | | | | | |
| 50 | N-hexane extract substance | mg/l | | | | | △ |
| 51 | Oil/Grease | mg/l | | x | | | ○ |
| 52 | Chloride | Cl mg/l | x | | △ | △ | |
| 53 | Color | Real Color | x | | △ | △ | |
| 54 | Sulfate | $SO_4^{2-}$ mg/l | x | | △ | △ | |
| 55 | Ethylene blue active substance | mg/l | x | | △ | △ | |
| 56 | Turbidity | JUT | x | | ◎ | ◎ | ○ |
| 57 | Total cloakroom | MAN | x | | ◎ | ◎ | ○ |
| 58 | Fecal cloakroom | MAN | x | | ◎ | ◎ | ○ |
| 59 | Acids,Inflammable Substance | - | | x | | | ○ |

x : Regulated in Standards

◎ To be analyzed every four months

○:To be analyzed twice a year.

△:To be analyzed once a year in dry season.

## Table H 2.6 Procurement of Additional Equipment for Water Quality Analysis

| Analysis Equipment | Analysis Parameter | Type/Model | Number | Unit cost ($10^4$*Col$) | Cost ($10^4$*Col$) | Remarks |
|---|---|---|---|---|---|---|
| Gas chromatograph (Detector ECD,FID) | Polychrolobiphenyl, etc | 3800 Varian | 1 | 4,284 | 4,284 | |
| Incubator for BOD | BOD | ITD 150 Type | 1 | 2,592 | 2,592 | |
| Direct reading balance | | Voyager YMI Co | 1 | 396 | 396 | |
| Atomic absorption spectrometer | Pb,Cd,Zn,Cu,As,Fe,Mn | Analyst 300 Perkin Elmer Co | 1 | 5,400 | 5,400 | |
| Spectrometer | $PO_4$-P,$NH_4$-N $NO_2$-N,$NO_3$-N | U-2001 Hitachi Co | 1 | 2,340 | 2,340 | |
| Ultraviolet spectrometer | | V-550 Nihon Bunko Co | 1 | 2754 | 2754 | |
| Autoclave | T-N, T-P | ZX-30 CP Hirasawa Co | 2 | 792 | 1,584 | |
| Water Purification Devise | | HPLC/SC Olgano Co | 1 | 2,160 | 2,160 | |
| Storage for Reagent | | ANX-200 Teraka Co | 1 | 1,116 | 1,116 | |
| Desk for Experiment | | ZS-105 | 2 | 1,314 | 1,314 | |
| Magnetic Stirrer | | | 1 | 248 | 248 | |
| Distillation apparatus | Nitrogen and Phenol Analysis | P 521 Sugiyamagen Co | 1 | 2,063 | 2,063 | |
| Turbidity Meter | Turbidity | 6035 Ogawa seiki Co | 1 | 495 | 495 | |
| Draft chamber | | SA-2FO Kyorichu Co | 1 | 2,992 | 2,992 | |
| Liquid Chromatography | | L-7000 Hitachi Co | 1 | 1,368 | 1,368 | |
| Ultrasonic washing Devise | | SUC2810TBS Toyo rika CO | 2 | 223 | 446 | |
| Dryer | | FV-830-1030 Advantic Co | 1 | 1,800 | 1,800 | |
| Grass Washing Devise | | G7783A Kubota Co | 1 | 2,700 | 2,700 | |
| Refrigerator | | Asahi Life Cycle Co | 1 | 3,366 | 3,366 | |
| Current meter | | UC-2 Tamaya System Co | 2 | 792 | 1584 | |
| Water sampler | | Bandone | 2 | 630 | 1,260 | |
| Sludge sampler | | Ekman | 1 | 513 | 513 | |
| Field Water Quality Analyzer | DO,pH,EC,Temperature | Asahi kagaku Co | 2 | 432 | 864 | |
| Vehicles for Sampling | | | 2 | 5,400 | 10,800 | |
| *Total | | | | 46,170 | 54,439 | |

*Exchange rate: 1 US $ = 106 ¥ = 1,920 Col$ October 1999.

## Table H.4.1 List of Digital Data Inventory at CAR (1/5)

| S. N. | Title | Year |
|---|---|---|
| CAR Whole Area Data: | | |
| 1 | Basin Internal Limit | 1994 |
| 2 | Basins Grid | 1997 |
| 3 | CAR and Cundinamarca Limit | 1993 |
| 4 | CAR General Map Grid | 1996 |
| 5 | CAR Jurisdiction Political Division | 1994 |
| 6 | CAR Jurisdiction Rivers | 1987 |
| 7 | CAR Larger Basins | 1994 |
| 8 | CAR Municipalities Central Areas | 1994 |
| 9 | Capital District Area | 1994 |
| 10 | Cundinamarca Risks and Threats Grade | 1992 |
| 11 | Curves Each 500 Meters | 1994 |
| 12 | D.C. Perimeter | 1993 |
| 13 | Hydro-meteorological Stations Location | 1992 |
| 14 | Ingeominas Base Wells Points | 1991 |
| 15 | Life Zones According to Holdrisge | 1997 |
| 16 | Reserve Area According to Hidrotec | 1996 |
| 17 | Reserve Zones Established by the CAR | 1992 |
| 18 | Risks and Threats in Cundinamarca | 1992 |
| 19 | URPA /87 - General | 1987 |
| 20 | Zoning Limit | 1996 |
| 21 | Colombia Grid | |
| 22 | Old CAR Municipality Limits | 1985 |
| 23 | Old CAR Railway | 1985 |
| 24 | Old CAR District Limit | 1985 |
| 25 | Old CAR Jurisdiction Limit | 1990 |
| 26 | Old CAR Jurisdiction Rivers Map | 1992 |
| CAR Regional Area Data: | | |
| 27 | Funza Regional Grid | 1997 |
| 28 | Funza Regional Limit | 1995 |
| 29 | Funza Regional Risks Map | 1997 |
| 30 | Fusagasuga Regional Grid | 1997 |
| 31 | Fusagasuga Regional Limit | 1995 |
| 32 | Girardot Regional Grid | 1997 |
| 33 | Girardot Regional Limit | 1995 |
| 34 | Girardot Regional Risks Map | 1997 |
| 35 | Ubate Regional Grid | 1997 |
| 36 | Ubate Regional Limit | 1995 |
| 37 | Ubate Regional Risks Map | 1997 |
| 38 | Villeta Regional Limit | 1995 |
| 39 | Villeta Regional Risks Map | 1997 |
| 40 | Zipaquira Regional Risks Map | 1997 |
| 41 | Zipaquira Regional Limit | 1995 |
| Municipality Data: | | |
| 42 | Agua de Dios Municipality Soil Use | 1987 |
| 43 | Agua de Dios Municipality Topography | 1990 |
| 44 | Alban Municipality Soil Use | 1987 |
| 45 | Alban Municipality Topography | 1990 |
| 46 | Anapoima Municipality Soil Use | 1987 |
| 47 | Anapoima Municipality Topography | 1990 |
| 48 | Anolaima Municipality Soil Use | 1987 |
| 49 | Anolaima Municipality Topography | 1990 |
| 50 | Apulo Municipality Soil Use | 1987 |

## Table H.4.1 List of Digital Data Inventory at CAR (2/5)

| S. N. | Title | Year |
|---|---|---|
| 51 | Arbelaez Municipality Topography | 1990 |
| 52 | Beltran Municipality Soil Use | 1987 |
| 53 | Beltran Municipality Topography | 1990 |
| 54 | Bituima Municipality Soil Use | 1987 |
| 55 | Bituima Municipality Topography | 1990 |
| 56 | Bojaca Municipality Soil Use | 1987 |
| 57 | Bojaca Municipality Topography | 1990 |
| 58 | Buenavista Municipality Topography | 1990 |
| 59 | Cabrera Municipality Soil Use | 1987 |
| 60 | Cabrera Municipality Topography | 1990 |
| 61 | Cachipay Municipality Soil Use | 1987 |
| 62 | Cajica Municipality Topography | 1990 |
| 63 | Calera Municipality Soil Use | 1987 |
| 64 | Caparrapi Municipality Polygonal Landfill | 1997 |
| 65 | Caparrapi Municipality Soil Use | 1987 |
| 66 | Carmen de Carupa Municipality Soil Use | 1987 |
| 67 | Carmen de Carupa Municipality Topography | 1990 |
| 68 | Chaguani Municipality Soil Use | 1987 |
| 69 | Chaguani Municipality Topography | 1990 |
| 70 | Chia Municipality Soil Use | 1987 |
| 71 | Chia Municipality Topography | 1990 |
| 72 | Chiquinquira Municipality Topography | 1990 |
| 73 | Choconta Municipality Sewer Stretch | 1996 |
| 74 | Choconta Municipality Soil Use | 1987 |
| 75 | Cota Municipality Soil Use | 1987 |
| 76 | Cota Municipality Topography | 1990 |
| 77 | Cucunuba Municipality Soil Use | 1987 |
| 78 | Cucunuba Municipality Topography | 1990 |
| 79 | El Colegio Municipality Soil Use | 1987 |
| 80 | El Colegio Municipality Topography | 1990 |
| 81 | El Penon Municipality Soil Use | 1987 |
| 82 | El Penon Municipality Topography | 1990 |
| 83 | Facatativa Municipality Soil Use | 1987 |
| 84 | Facatativa Municipality Topography | 1990 |
| 85 | Funza Municipality Soil Use | 1987 |
| 86 | Funza Municipality Topography | 1990 |
| 87 | Funza Municipality Wastewater Treatment Plant | 1996 |
| 88 | Fuquene Municipality Soil Use | 1987 |
| 89 | Fusagasuga Municipality Topography | 1990 |
| 90 | Girardot Municipality Topography | 1990 |
| 91 | Guacheta Municipality Topography | 1990 |
| 92 | Guaduas Municipality Soil Use | 1987 |
| 93 | Guaduas Municipality Topography | 1990 |
| 94 | Guataqui Municipality Soil Use | 1987 |
| 95 | Guataqui Municipality Topography | 1990 |
| 96 | Guatavita Municipality Soil Use | 1987 |
| 97 | Guayabal Municipality Topography | 1990 |
| 98 | La Mesa Municipality Soil Use | 1987 |
| 99 | La Palma Municipality Soil Use | 1987 |
| 100 | La Pena Municipality Soil Use | 1987 |
| 101 | La Ramada Municipality Soil Use | 1994 |
| 102 | La Ramada Municipality Channel | 1996 |
| 103 | La Ramada Municipality Channel - Hydric System | 1996 |

## Table H.4.1 List of Digital Data Inventory at CAR (3/5)

| S. N. | Title | Year |
|---|---|---|
| 104 | La Ramada Municipality Roads and Wetlands | 1996 |
| 105 | La Ramada Municipality Zoning Plan | 1994 |
| 106 | La Vega Municipality Soil Use | 1987 |
| 107 | Lenguazaque Municipality Soil Use | 1987 |
| 108 | Macheta Municipality Reserve Zone | 1997 |
| 109 | Macheta Municipality Reserve Zone Points | 1997 |
| 110 | Macheta Municipality Soil Use | 1987 |
| 111 | Madrid Municipality Soil Use | 1987 |
| 112 | Madrid Municipality Topography | 1990 |
| 113 | Madrid Municipality Wastewater Treatment Plant | 1996 |
| 114 | Manta Municipality Soil Use | 1987 |
| 115 | Mesa Municipality Topography | 1990 |
| 116 | Mosquera Municipality Topography | 1990 |
| 117 | Narino Municipality Topography | 1990 |
| 118 | Nemocon Municipality Soil Use | 1987 |
| 119 | Nilo Municipality Soil Use | 1987 |
| 120 | Nimaima Municipality Soil Use | 1987 |
| 121 | Nimaima Municipality Topography | 1990 |
| 122 | Nocaima Municipality Soil Use | 1987 |
| 123 | Nocaima Municipality Topography | 1990 |
| 124 | Pacho Municipality Soil Use | 1987 |
| 125 | Paime Municipality Soil Use | 1987 |
| 126 | Pandi Municipality Soil Use | 1987 |
| 127 | Pandi Municipality Topography | 1990 |
| 128 | Pasca Municipality Soil Use | 1987 |
| 129 | Pasca Municipality Topography | 1990 |
| 130 | Puerto Salgar Municipality Soil Use | 1987 |
| 131 | Puerto Salgar Municipality Topography | 1990 |
| 132 | Puli Municipality Soil Use | 1987 |
| 133 | Puli Municipality Topography | 1990 |
| 134 | Quebrada Negra Municipality Soil Use | 1987 |
| 135 | Quipile Municipality Soil Use | 1987 |
| 136 | Quipile Municipality Topography | 1990 |
| 137 | Raquira Municipality Topography | 1990 |
| 138 | Ricarte Municipality Topography | 1990 |
| 139 | S. M. de Sema Municipality Soil Use | 1987 |
| 140 | San Antonio de Teq. Municipality Base Map | 1997 |
| 141 | San Antonio de Teq. Municipality Hydrology Work | 1993 |
| 142 | San Antonio de Teq. Municipality Roads | 1990 |
| 143 | San Antonio de Teq. Municipality Topography | 1990 |
| 144 | San Antonio de Teq. Municipality Usages and Affectations | 1997 |
| 145 | San Antonio de Teq. Municipality Zoning Area | 1997 |
| 146 | San Bernardo Municipality Soil Use | 1987 |
| 147 | San Bernardo Municipality Topography | 1990 |
| 148 | San Cayetano Municipality Soil Use | 1987 |
| 149 | San Cayetano Municipality Topography | 1990 |
| 150 | San Francisco Municipality Topography | 1990 |
| 151 | San Juan de Rio Seco Municipality Soil Use | 1987 |
| 152 | San Juan de Rio Seco Municipality Topography | 1990 |
| 153 | Sasaima Municipality Soil Use | 1987 |
| 154 | Sasaima Municipality Topography | 1990 |
| 155 | Sibate Municipality Soil Use | 1987 |
| 156 | Silvania Municipality Soil Use | 1987 |

## Table H.4.1 List of Digital Data Inventory at CAR (4/5)

| S. N. | Title | Year |
|---|---|---|
| 157 | Silvania Municipality Topography | 1990 |
| 158 | Simijaca Municipality Soil Use | 1987 |
| 159 | Simijaca Municipality Topography | 1990 |
| 160 | Soacha Municipality Soil Use | 1987 |
| 161 | Soacha Municipality Topography | 1990 |
| 162 | Somondoco Municipality Topography | 1990 |
| 163 | Sopo Municipality Soil Use | 1987 |
| 164 | Subachoque Municipality Curves Each 100 Meters | |
| 165 | Subachoque Municipality Forest Areas | |
| 166 | Subachoque Municipality Hydrology | |
| 167 | Subachoque Municipality Reserve Zone Map | 1996 |
| 168 | Subachoque Municipality Reserve Zone With Predial | 1993 |
| 169 | Subachoque Municipality Roads | |
| 170 | Subachoque Municipality Sectors | |
| 171 | Subachoque Municipality Soil Use | 1987 |
| 172 | Subachoque Municipality Zoning | 1995 |
| 173 | Subachoque Municipality Zoning and Soils Study | 1993 |
| 174 | Suesca Municipality Soil Use | 1987 |
| 175 | Supata Municipality Soil Use | 1987 |
| 176 | Supata Municipality Topography | 1990 |
| 177 | Susa Municipality Soil Use | 1987 |
| 178 | Susa Municipality Topography | 1990 |
| 179 | Suta Municipality Topography | 1990 |
| 180 | Sutatausa Municipality Grid | 1997 |
| 181 | Tabio Municipality Soil Use | 1987 |
| 182 | Tausa Municipality Soil Use | 1987 |
| 183 | Ubate Municipality Environmental Plan Zones | 1997 |
| 184 | Ubate Municipality Roads | 1990 |
| 185 | Ubate Municipality Soil Use | 1987 |
| 186 | Ubate Municipality Soil Uses Zoning | 1997 |
| 187 | Ubate Municipality Zoning | 1997 |
| 188 | Utica Municipality Grid | 1997 |
| 189 | Utica Municipality Soil Use | 1987 |
| 190 | Venecia Municipality Soil Use | 1987 |
| 191 | Vergara Municipality Soil Use | 1987 |
| 192 | Viani Municipality Soil Use | 1987 |
| 193 | Villa Gomez Municipality Soil Use | 1987 |
| 194 | Villapinzon Municipality Soil Use | 1987 |
| 195 | Villeta Municipality Soil Use | 1987 |
| 196 | Viota Municipality Soil Use | 1987 |
| 197 | Yacopi Municipality Soil Use | 1987 |
| 198 | Zipacon Municipality Soil Use | 1987 |
| 199 | Zipaquira Municipality Soil Use | 1987 |
| River Basin Data: | | |
| 200 | Apulo River Basin | 1995 |
| 201 | Apulo River Basin Soils Use | 1995 |
| 202 | Apulo River Curves Each 25 Meters | |
| 203 | Subachoque River National Reserve Zone (1st Ver.) | 1995 |
| 204 | Subachoque River National Reserve Zone (2nd Ver.) | 1996 |
| 205 | Subachoque River National Reserve Zone (3rd Ver.) | 1997 |
| 206 | Subachoque River National Reserve Zone Points | 1997 |
| 207 | Fuquene Basin Road | |

## Table H.4.1 List of Digital Data Inventory at CAR (5/5)

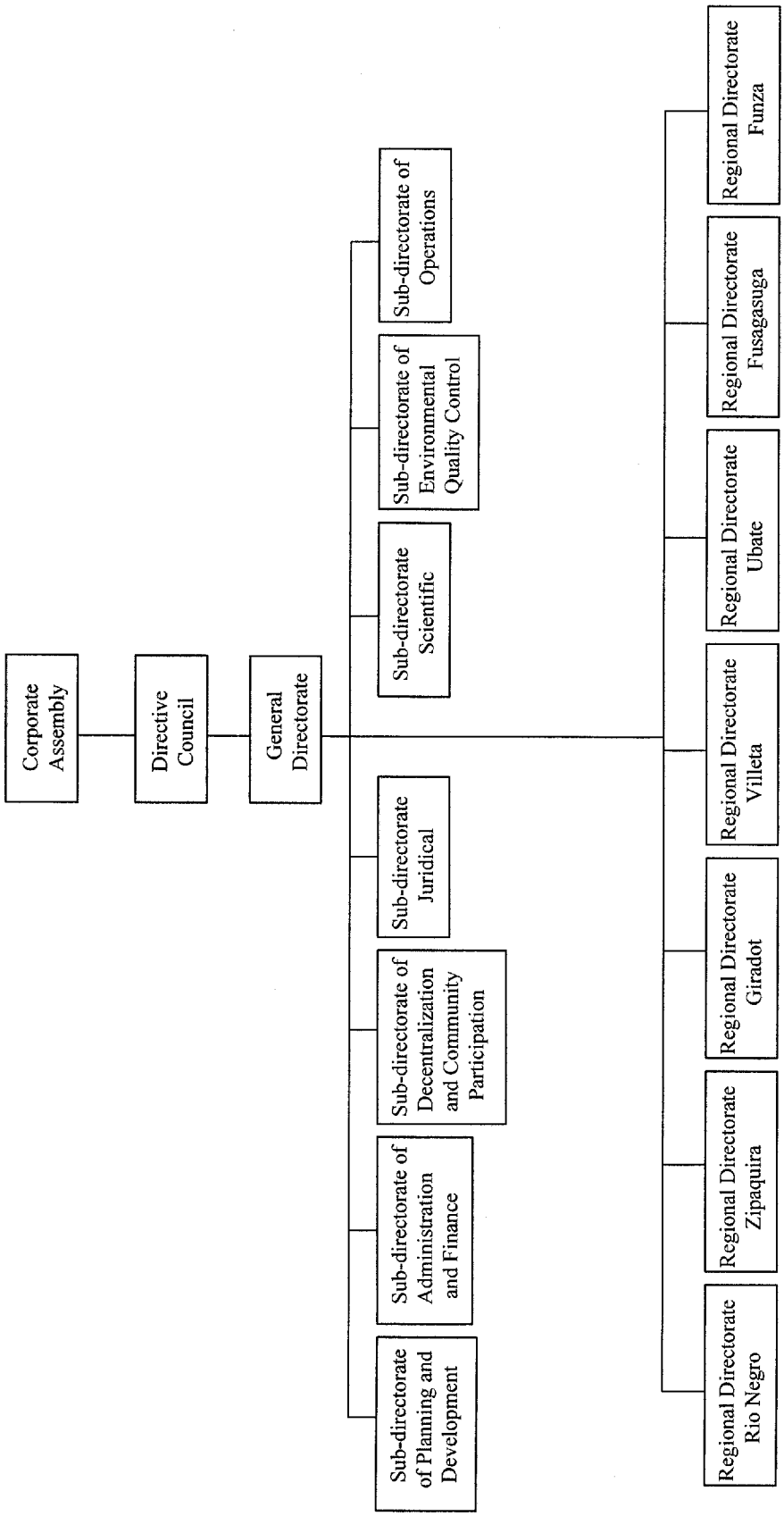
| S. N. | Title | Year |
|---|---|---|
| Miscellaneous: | | |
| 208 | Villeta Park Mapping | 1987 |
| 209 | Hato Dam | 1996 |
| 210 | Chequa Project Land Use Map | 1990-93 |
| 211 | HIDROTEC Project Digitalization | 1996 |
| 212 | Polygonal Neusa | 1996 |
| 213 | Soil Usage Agreement | 1997 |
| 214 | CARDAN Project Plate | |
| 215 | Bathemetric of Fuquene Lake | |
| 216 | Honda Stream Grid | |
| 217 | Bogoa Roads | |

## Table H.4.2 List of Paper Map Inventory at CAR (1/2)

| Reference No. | Title | Year |
|---|---|---|
| Cucunuba 001 | General List of Drawing | 1984 |
| Cucunuba 004 | Cartography of the Basin | 1985 |
| Cucunuba 006 | Hydrologic Adequation of Lenguazaque River, General Localization List of Drawing | 1987 |
| Cucunuba 007 | Hydrologic Adequation of Lenguazaque and Ubate River, K0+000-K8+000 | 1987 |
| Cucunuba 008 | Hydrologic Adequation of Lenguazaque and Ubate River, K8+000-K9+480 | 1987 |
| Cucunuba 009 | Hydrologic Adequation of Lenguazaque River, K5+100-K12+901-53 | 1987 |
| Cucunuba 010 | Hydrologic Adequation of Lenguazaque, K13+000-K19+000 | 1987 |
| Cucunuba 029 | Lenguazaque System General Localization and List of Drawing | 1987 |
| Cucunuba 030 | Lenguazaque System Area Localization of Adequate | 1987 |
| Cucunuba 031 | Lenguazaque Irrigation Units A, B, C Drawing | 1987 |
| Cucunuba 032 | Lenguazaque Irrigation Units D, E, F Drawing | 1987 |
| Cucunuba 033 | Lenguazaque Irrigation Units G, H, I, J, K, L, M Drawing | 1987 |
| Cucunuba 034 | Lenguazaque Irrigation Units N, O, P Drawing | 1987 |
| Cucunuba 052 | Lenguazaque System Structure of Derivation to Irrigation Channel Reference | 1987 |
| Cucunuba 096 | Cucunuba System General Localization and List of Drawing | 1987 |
| Cucunuba 097 | Localization Area of Education | 1987 |
| Cucunuba 098 and 099 | Lenguazaque System and Irrigation Unit of Cucunuba | 1987 |
| Cucunuba 100 | Cucunuba System Irrigation Unit of Paicagoita | 1987 |
| Ubate 044 | Project Localization | 1986 |
| Ubate 048 | Reservoir Area and Road Localization to Salinas | 1986 |
| Ubate 049 | Hydrologic Information | 1986 |
| Ubate 073 | Diversion Tunnel, General Disposition | 1986 |
| Ubate 080 | Diversion Tunnel, Exit Doors and General Disposition of Bottom Discharge | 1986 |
| Ubate 200 | Discharging Channel (Details) | 1985 |
| Ubate 201 | Survey of Channel Zone, Hato River - Tota Lake | 1985 |
| Ubate 202 | Topographic Survey in Ubate | 1992 |
| Ubate 203 | Electric Installtions | 1994 |
| Ubate 204 | Conduction for Irrigation, Ubate Cross | 1995 |
| Ubate 241 and 242 | General Plan | 1995 |
| Ubate Hato 144 | Reservoir Hato Dam (Municipality of Carmen de Carupa) | 1993 |
| Ubate Fuquene 287 to 289 | Project Plan of Developtment, Ubate - Fuquene Sub-region | 1990 |
| Ubate Fuquene 290 | Erosion Zone and Agriculture Use | 1990 |
| Ubate Fuquene 294 | Forseen Projects and Execution | 1990 |
| River Lenguazaque 001 | Localization of Works Basin River Suta and Cucunuba Lake | 1987 |
| River Lenguazaque 002 | Control Project of Erosion and Correcton of Lake Basin of Cucunuba and River Suta | 1987 |
| River Lenguazaque 006 | Sub-basin of Stream Chital and Mosica | 1991 |
| River Suarez 002 and 003 | Cadester Information in Zone of Influence | 1984 |
| River Suarez 004 and 005 | Cadester Information in Zone of Influence (Municipality of S. M. de. Sema) | 1984 |
| River Suarez 006 | Drawing of Palacio Lake Gate | 1984 |
| River Suarez 019 | Bathymetric and Topographic Level Curbs of Cucunuba Lake | 1984 |
| River Suarez 020 | Cucunuba Lake Bathymetric Survey | 1984 |
| River Suarez 021 | Topography of Palacio Lake | 1984 |
| River Suarez 022 to 052 | Transverse Section of Rivers in Fuquene Basin | 1984 |
| River Suarez 058 | Flooding Areas | 1984 |
| River Suarez 067 | Control Structures: Basin, Lakes of Cucunuba Palacio | 1984 |
| River Suarez 068 | Potential Area for Agriculture, Zone of Irrigation | 1984 |
| River Suarez 069 | Dam for Irrigation in the Hato River, Possible Channel: Ubate, Suta, Palacio | |
| River Suarez 070 | Dam for Irrigation in rivers Suta and Lenguazaque | |
| River Suarez 071 | Dam for Irrigation Chiqinquira and Simijaca Rivers | 1984 |
| River Suarez 072 | Perimetral Dike in the Lake of Fuquene | 1984 |
| River Suarez 073 | Modification of Tolon Gate | 1984 |
| River Suarez 074 | General Localization List of Drawings | 1986 |
| River Suarez 076 | Hydrogeology Map | 1986 |
| River Suarez 077 | Zone Good for Agriculture and Livestock | 1986 |
| River Suarez 078 | Conservation Zones of Soil | 1986 |
| River Suarez 079 | Zones of Soil Restoration and Special Management | 1986 |
| River Suarez 080 | Adequation Zone of Soils | 1986 |
| River Suarez 081 | Isolines of Water Necessities for Non-permanent Cultivation | 1986 |

## Table H.4.2 List of Paper Map Inventory at CAR (2/2)

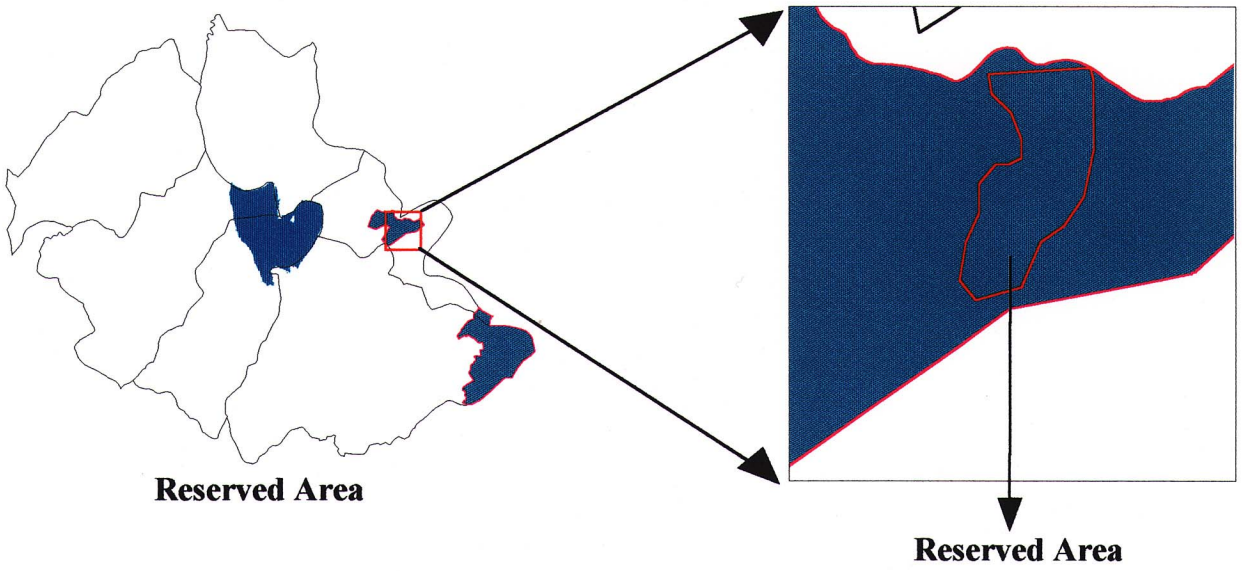
| Reference No. | Title | Year |
|---|---|---|
| River Suarez 082 | Isolines of Water Necessities for Permanent Cultivation | 1986 |
| River Suarez 090 | Isohyetal Curves | 1986 |
| River Suarez 091 | Polygons of Thiessen | 1986 |
| River Suarez 092 | Average Historical Discharge | 1986 |
| River Suarez 094 | General Inventory of Current and Channels in Up-stream of Fuquene Lake Sector | 1986 |
| River Suarez 095 | General Inventory of Current and Channels in Fuquene Lake Sector | 1986 |
| River Suarez 096 and 097 | General Inventory of Current and Channels in Down Stream of Fuquene Lake Sector | 1986 |
| River Suarez 106 | Enlargement Design of Swarez River | 1986 |
| River Suarez 115 | General Localization List of Drawings | 1986 |
| River Suarez 140 | Additional Structure in Tolon Gate | 1986 |
| | CAR Atlas | 1985 |

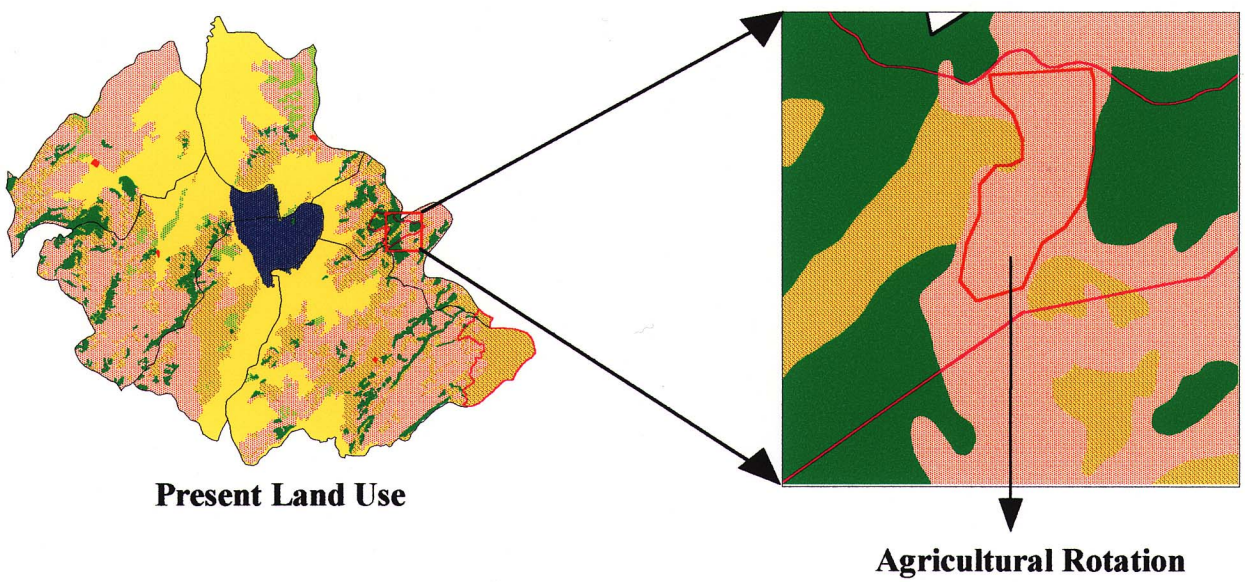



THE STUDY ON
REGIONAL ENVIRONMENTAL IMPROVEMENT PLAN
FOR THE BASIN OF LAKE FUQUENE

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. H.4.1 Organizational Structure of CAR

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| THE STUDY ON<br>REGIONAL ENVIRONMENTAL IMPROVEMENT PLAN<br>FOR THE BASIN OF LAKE FUQUENE | Fig. H.4.2 Example Showing the Agricultural Rotation in Reserved Area |
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