APPENDIX D

LAND USE AND WATERSHED MANAGEMENT

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APPENDIX D LAND USE AND WATERSHED MANAGEMENT

CHAPTER I EXISTING LAND USE

1.1 Geology

The Study Area comprises mainly sedimentary rocks of the Cretaceous form, synclines and anticlines oriented NE-SW. The oldest rocks crop out in the eastern part of the Study Area, around Cucunuba. The Study Area has following geological formations:

(1) Simiti Formation (Kis): This comprises black lutites and limonites with sandstones intercalated with thin layers of luties. This formation promotes the formation of acid soils with broken relief.

(2) Chiquinquira Formation (Kichi): This has layers of fine grain sandstones and black lutites. This formation is associated with acid soils of low fertility and textures that range from fine to medium. Soils are superficial, well drained and have slow permeability. In general, soils are prone to erosion.

(3) Simijaca Formation (Kss): This comprises lutites and limonites with thin layers of sandstones. This generates a morphology of gentle slopes with poor retention of humidity, and slightly acid. Soils tend to be more fertile than those generated in the Chiquinquira Formation.

(4) La Frontera Formation (Ksf): It is characterized by gray or black limonites, with layers of chert, Iodolitas and black arcillolite. It forms gentle slopes and well-drained soils of medium fertility, poor retention of humidity and slow permeability.

(5) Conejo Formation (Kscn): This formation includes black or gray lodolites with intercalations of micaceous limonites and sandstones. Soils are superficial, well drained, and slightly acid and have poor retention of humidity. Fertility is medium.

(6) Hard Gritty Formation (Ksgd): This consists of quartzoce, of fine grain gritty with claystone intercalations. This generates some of the most prominent features of landscape in the western most part of the Study Area, like the Peña de Moiba in the Simijaca valley.

(7) Plaeners Formation (Ksgpl): This formation includes gray siliceous limonites intercalated with layers of clay. Landscape formed by the formation tends to be gentle.

(8) La Regadera Formation (Tr): It consists of quartzoce, from fine grain to middle, conglomeratic commonly with crossed stratification.

(9) Bogota Formation (Teb): This comprises mottled mudstone and silty claystone with gritty lens, generally friable, motley, from fine to middle grain silty claystone, with rarely sandy conglomerate lens and thin layers of low quality coal.

(10) Guaduas Formation (Ktg): This comprises motley claystones and clays, with gritty intercalations. In the lower to middle part there are frequent coal stratums.

(11) Upper Guadalupe Formation (Ksgs): Its upper part has quartzoce, hard to friable from middle to gross grain. Middle part has quartzoce mudstone with siliceous in thin

layers and lower part has quartzoce generally solid of middle grain light gray gritty.

(12) Chipaque Formation (Ksc): It comprises of light gray to dark gray claystones with thin layers of fine grain gritty.

(13) Guadalupe Lower Formation (Ksgi): Its upper part has light gray to dark gray silty claystone and clay mudstone, middle part has siliceous, kaolinitic, light gray, in thin layers mudstone and lower part has light gray quartzoce gritty.

(14) El Cacho Gritty (Tpc): It consists quartzoce, of gross to conglomerated grain, with reddish claystone intercalations.

(15) Soft Gritty Member (Ksgt): It has quartzoce, white solid gritty with gray lutite intercalation.

(6) Labor and Los Pinos Gritty Member (Ksgp): It comprises black lutites and mudstones with intercalation of few centimeters of thickness gritty.

(17) Talita Formation (Qtt): This comprises gritty and fine to coarse grain sand, whitish to reddish sand, solid comglomerate, conglomerated gritty and gravel.

(18) Alluviam and Colluvium (Qal): It comprises silt, lacustrine and fluvial clay, glacier deposits and no consolidated material terrace.

The coverage of various geologic formations is given below.

S.N.	Formation Code	Area (km^2)	%
1	Simiti Formation (Kis)	15.07	0.9
2	Chiquinquira Formation (Kichi)	357.84	20.4
3	Simijaca Formation (Kss)	87.51	5.0
4	La Frontera Formation (Ksf)	13.82	0.8
5	Conejo Formation (Kscn)	151.75	8.7
6	Hard Gritty Formation (Ksgd)	19.81	1.1
7	Planers Formation (Ksgpl)	75.05	4.3
8	La Regadera Formation (Tr)	19.13	1.1
9	Bogota Formation (Tb)	42.13	2.4
10	Guaduas Formation (Ktg)	140.80	8.0
11	Upper Guadalupe Formation (Ksgs)	135.69	7.7
12	Chipaque Formation (Ksc)	98.01	5.6
13	Guadalupe Lower Formation (Ksgi)	24.49	1.4
14	El Cacho Gritty (Tpc)	24.88	1.4
15	Soft Gritty Member (Ksgt)	7.00	0.4
16	Labor and Los Pinos Gritty Member (Ksgp)	5.51	0.3
17	Tilata Formation (Qtt)	5.62	0.3
18	Alluvium and Colluvium (Qal)	504.07	28.8
19	Lake	23.82	1.4
	Total	1752.00	100.0

Alluvium and Colluvium (Qal) has the highest coverage, 28.8% in the Study Area followed by Chiquinquira Formation (Kichi) with 20.4% coverage. The locational distribution of the geologic formations is presented in Fig. D.1.1.

1.2 Land Use

1.2.1 Methodology

Two (2) land use maps are available for the Study Area, one of the land use and the other is of classification of erosion grades. The first is the land use map with scale of 1:250,000 covering the entire CAR administration and published in 1985. The land use of this map is classified into the following seven (7) categories.

(1) Primary/Secondary Forest: This is the land with natural and/or artificial vegetation in more than 90% of the area.

(2) Shrub Land: This is land with herbaceous and/or bushy natural vegetation.

(3) Pasture in Flat Land: This is the pasture land relatively located in flat land. Presence of water channel, as source of water supply to grasses, is main distinguishing factor from pasture land in sloppy land.

(4) Pasture in Sloppy Land: This type of pasture land is located relatively in sloppy land. Irrigation facility is generally absent in this category.

(5) Agricultural Land: The land that has major area used for crop production.

(6) Agricultural and Grass Land: Land that has both activities, crop production and grass land, together.

(7) Urban Area: This comprises the densely inhabited permanent settlements.

The second is the erosion classification grades map prepared under the Chequa Project in 1990 and 1993. This map covers the central part of the Study Area (equivalent to approximately 60% of the Study Area) and is classified in details (12 categories), considering the soil erosion conditions as shown below.

(1) Zone of primary woodland

(2) Zone of weeds with vegetation (mostly grass) coverage.

(3) Zone of agricultural rotation (grassland and transitory crops) with scarce vegetable coverage in 10%.

(4) Zone of out of agricultural rotation with grasses between 30-70%.

(5) Zone of agricultural rotation mixed with 70% grassland.

(6) Zone of grassland mixed with 70% agricultural rotation.

(7) Zone out of use of agricultural rotation intersected in 70% critical zones (concave, furrow and deep ditch).

(8) Zone lack of stubble vegetation but having 30% of vegetation hedge (woodland vegetation other than planted one).

(9) Zone of agricultural rotation intersected in 70% with critic zones (concave, furrow

and deep ditch).

(10) Zone of critical area (concave, furrow and deep ditch) intersected in 70% of zone of agricultural rotation.

(11) Critical zone (concave, furrows and deep ditch).

(12) Zone of flat land (mostly pasture land).

The second map is comparatively new and no significant differences were identified between the map and current condition of the land. It is considered that this map shows the actual condition of the erosion grades.

However, the first map is old and some land uses are different from the existing conditions. Then, this map was updated by using the latest aerial photos and satellite print, and through a field reconnaissance for the upper (southern) and lower (northern) part of the Study Area which are not covered by the second map. The used aerial photos are ranged from 1993 to 1997 and scale from 1:28,000 to 1:44,000. The satellite print is from Landsat5 TM (acquired on 14th February 1995) with the combination of 5,4,3 (R, G, B).

Finally, an integrated exiting land use map for the Study Area was prepared by combining the updated first map and the second map.

1.2.2 Land Use Coverage

The updated existing land use coverage by its category in the Study Area is shown below. This clears that forest area covers only 5.6 % of the whole study area while 53.0 % of the land is under agricultural rotation.

Land Use Type	Area (km^2)	(%)
Primary/Secondary Forest	96.82	5.6
Shrub Land	72.66	4.1
Pasture in Flat Land	300.71	17.2
Pasture in Sloppy Land	313.77	17.9
Agricultural Rotation Land	929.14	53.0
Lake	29.81	1.7
Urban Area	9.09	0.5
Total	1752.00	100.0

1.2.3 Land Use and River Basins

The comparison of existing land use types in various river basins is presented in Table D.1.1. This has uncovered the pity condition of forest cover in all river basins. Simijaca has the highest percentage of forest cover compared to all other basins, which is merely 12.1%. On the other hand, the coverage of agricultural rotation is as high as 80.8%, which is in Chiquinquira river basin.

The locational distribution of updated existing land use along with river basin boundary for the Study Area is presented in Fig. D.1.2.

1.3 Reserved Area

In Colombia, land or its renewable natural resources are reserved so as to organize/facilitate the public service supply and to make progress of restoration programs or protection of natural resources and environment. The “reserved area” is classified into two (2) categories, namely, (1) Forest Reserve and (2) Integrated Management District.

(1) Forest Reserve

The forest reserve is private or public zone to maintain or recuperate native protective vegetation. The forest reserve is further classified into (a) Protective Forest Zone and (b) Protective – Productive Forest Zone.

(a) Protective Forest Zone

This zone aims to protect soil, water, fauna, flora, biological diversity, genetic resources or other renewable resources. In the zone, agricultural use, livestock farm, industrial use, urbanization, mining and activities such as tree cutting, tree burning, hunting and fishing are prohibited.

(b) Protective – Productive Forest Zone

This zone aims to protect soil and other natural resources, but the zone is used for production in consideration of forest conservation and stabilization. The land use and activities mentioned in (a) are also prohibited in this zone.

(2) Integrated Management District

The district is reserve/protection area for sustainable development, in which its use, renewable natural resources management and existing economic activities are planed, ordered and/or regulated. In this district, mechanized agricultural and livestock use, large scale recreation, division for farm housing, mining and extraction of construction materials are prohibited.

In the Study Area, there are four (4) reserved areas and one (1) area under processing for the reserved area as listed below and shown in Fig. D.1.3.

Name	Basin	Municipality	Area (ha.)	Category	Remarks
El Robledal	Lake Fuquene	Guacheta and Raquira	400	Protective Forest Zone	
Paramo de Rabanal	Lake Fuquene	Guacheta – Raquira and Lenguazaque	2,681	Protective Forest Zone	
Juaitoque	Lake Cucunuba	Cucunuba	400	Integrated Management Disctrict	
Paramo de Telecom and Merchan	R. Suarez	Saboya	1,857	Protective Forest Zone	
Paramo de Guerrero, Guargua and Laguna Verde	R. Bogota and Lake Fuquene	Tausa, Carmen de Carupa, Cogua and Zipaquira	23,573		Under processing

CHAPTER II SOIL EROSION AND SEDIMENT RUNOFF

2.1 Erosion Problems in the Study Area and Neighboring Areas

The CAR analyzed the potential severe erosion areas in its jurisdiction in early 1980's, classifying the erosion mechanism into 7 categories as mentioned below (Fig. D.2.1).

(1) No erosion

(2) Erosion by rain drop

(3) Erosion by sub-surface flow

(4) Erosion by surface flow (gully erosion)

(5) Erosion by mass movement (landslide)

(6) Erosion by chemical dissolution

(7) Rocky appearance under different erosive process

Further, each erosion category is classified from the view points of erosion rate and sediment yield based on conditions of soils, topography, climate, vegetation.

In general, out of these categories, (4) erosion by surface flow and (5) erosion by mass movement have possibility of massive sediment production and transportation to downstream areas. In the study area, there were areas with high possibility of serious erosion due to surface flow. These areas were located along upstream of the Ubate River, Q. Bautista, upstream of the Lenguazaque River, Q.Mina/Q. Honda, all of which flow into the Fuquene Lake and other rivers which enter the Cucunuba Lake. In addition to the above, areas of serious erosion by surface flow are located along the Susa, which flows in the downstream of the Fuquene Lake.

In the neighboring areas, which is located along the upstream of the Checua River, the left tributary of the Bogota River, there were areas of high possibility with surface erosion.

2.2 Soil Erosion Control of Ongoing Project

2.2.1 Checua Project I

In 1982, a project named Checua (Checua Project I) started by the CAR aiming to control the soil erosion in the upstream of the Checua River (the Nomocon valley), which had affected irrigation canals of the Bogota River and water source for the Santa Fe de Bogota taken from the Bogota River. The erosion in this area was accelerated by the human factors such as inadequate farming and mining in addition to the natural condition of the area.

At the end of 1984, it was agreed that the GTZ and the KfW would provide technical and financial assistance for the CAR to implement the Checua Project. The works of the project were concentrated on stabilization of the project area of 17,000 ha., by means of diminishing of the water velocity, increase of the retention capacity of water and establishment of more protective and permanent vegetation. In order to attain those, ditches, sumps, check dams were constructed and then trees were planted with the farmers' participation. In addition to the above, farming and social integral assistance were also given to the farmers.

Due to successive result of the Checua Project (Stage I), the Project was extended to the basins of the Suta River (11,200 ha.), the Ubate River (22,800 ha.) and the Cucunuba Lake (9,200 ha.) covering a total area of 43,200 ha in 1989 (Stage II). The Checua Project I has been completed successfully in 1995. The following table summarizes project works both for stage I and stage II (Refer to Fig. D.2.2)

Stage	Structural Works				Vegetation	
	Ditch (km)	Sump (thousand m^3)	Brick Check Dam (m^3)	Sand Bag Check Dam (m^3)	Seeds (thousand holes)	Tree (thousand)
Stage I	2,620	1,605	5,416	36,479	4,134	5,212
Stage II	8,129	584	46	0	1,020	201
Total	10,749	2,189	5,462	36,479	5,154	5,413

2.2.2 Checua Project II

Further development in the activities resulted in extension of project as Checua project II in 1995 and planned to be completed in 2004. Presently, this project covers an area of about 125,000 ha. Roughly, it includes municipalities of Simijaca, Susa, Fuquene, Guacheta, Raquira, Ubate, San Miguel de Sema, Lenguazaque, and Carmen de Carupa.

Under this project, current land classification map of the area was prepared first with due emphasis to delineate critical areas to soil erosion as mentioned in Section 1.2 Land Use. Then identifying the cause of such pity condition at a particular location, both economical and technical assistance have been extended to control soil erosion in two ways, i.e. Curative and Preventive. This project is considered as of much success in this regard. The following table tabulates project works done or planned up to the year 1999.

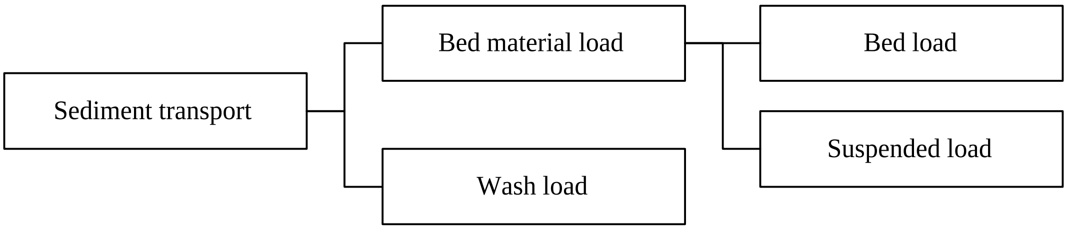
Year	Structural Works			Vegetation	
	Ditch (km)	Sump (m^3)	Reservoir (m^3)	Seeds (holes)	Tree
1996	1,470	24,000	-	2,115,000	125,000
1997	920	20,085	204,250	1,300,000	110,000
1998	328		308,500	-	195,000
1999	190		90,000		

2.3 Sediment Runoff Analysis

2.3.1 Sediment Transport Type

Fluvial sediments in transit are classified as bed material load and wash load according to their origin. Further, bed load material is also classified as bed load and suspended load according to its transport mechanisms. As a result, whole sediments in transit by flood water are categorized into three components, namely bed load, suspended bed material load (hereinafter called "suspended load") and wash load.

The sediment deposited in the Fuquene Lake is transported in three types. The sediment volume of the above three (3) components can be estimated as described below.



(1) Bed Load

The bed load is transported downwards by rolling or sliding on the surface of riverbed. It is always in contact with the riverbed and is not suspended by all means. The actual mode of movement varies depending on the transport rate determined by the balance of the shear stress of flood flow and critical shear force of grain itself.

So far many bed load equations have been proposed on the basis of dimension analytical examinations and experimental data. Among them, Sato, Kikkawa & Ashida's equation is employed in this study since this equation is applicable for a wide range of riverbed slope from a steep bed of alluvial fan to a gentle bed of flood plain. The equation is given below.

$$q_{Bi}=f(di)U_*^3/(\sigma/\rho-1)g \cdot \phi \cdot F(\tau_0/\tau_{ci})$$

Where q_{Bi} is sediment runoff per unit river width per unit time for sediment particle size di, σ is sediment particle density, ρ is water density, g is gravitational acceleration, di is sediment particle diameter, τ_0 is critical shear stress for mean sediment size of gravel mixture, τ_{ci} is critical shear stress for sediment particle size di , U_* is shear velocity and f(di) is ratio of sediment particle size di in gravel mixture and $F(\tau_0/\tau_{ci})$ is function of τ_0/τ_{ci}.

Regarding critical shear velocity for mean size sediment particle , Iwagaki's equation is employed. The equation is given for a uniform bed with a mean diameter (d) of gravel mixture as follows.

$d \geq 0.303$ cm	: $U_{*c}^2 = 80.9\ d$
$0.118 \leq d < 0.303$ cm	: $U_{*c}^2 = 134.6\ d^{31/22}$
$0.0565 \leq d < 0.118$ cm	: $U_{*c}^2 = 55.0\ d$
$0.0065 \leq d < 0.0565$ cm	: $U_{*c}^2 = 8.41\ d^{11/32}$
$d < 0.0065$ cm	: $U_{*c}^2 = 226\ d$

On the gravel mixture bed, big size particles easily move because they are exposed to water flow on the bed surface, while small particles do not easily move because they are shaded by big particles. Therefore, modified Egiazaroff's equation is used to estimate critical shear stress of individual particles on the gravel mixture bed after estimation of critical shear velocity U_{*cm}^2 for the mean diameter by using Iwagaki's equation. The equation is given below.

$d_i/d_m \geq 0.4$: $\tau_{*ci} = \tau_{*cm} \{\log_{10}19/\log_{10}(19\times d_i/d_m)\}^2(d_i/d_m)$

$d_i/d_m < 0.4$: $\tau_{*ci} = 0.85\ \tau_{*cm}$

Where d_i is diameter of individual particle of gravel mixture, d_m is mean diameter of gravel mixture, τ_{*ci} is non-dimensional critical shear stress to the particle with a diameter (d_i), τ_{*cm} is non-dimensional critical shear stress to the particle with a mean diameter (d_m) [$\tau_{*cm} = U_{*cm}^2/\{(\sigma/\rho-1)gd\}$].

(2) Suspended Load

The suspended load is transported downwards, floating in the river water. It does not contact with the riverbed all the time. Its settling force is smaller than the upward component of turbulence force of the river water. The size of suspended load is in a wider range than that of wash load. It includes coarse sand.

Ashida & Michiue's equation is adopted from the same reason as mentioned above. The equation is given below.

$$Q_s = f(d_i)\ C_B\ [\{1+U_*/(\kappa U_0)\}\ \Lambda_1+\Lambda_2\ U_*/(\kappa U_0)]\ Q$$

Here, $\Lambda_1=\{a/(h-a)\}^z\int_{a/h}^{1}\{(1/\eta)-1\}^z d\eta$

$\Lambda_2=\{a/(h-a)\}^z\int_{a/h}^{1}\ln\eta\ \{(1/\eta)-1\}^z d\eta$

$\eta=Z/h$

$Z=w_0/(1.2\ \kappa\ U_*)$

Where Q_s is sediment discharge per time, C_B is sediment concentration at a height of [a] above bed surface and function, κ is Karman constant, Λ_1 and Λ_2 are parameters of concentration distribution, h is flow depth, and w_0 is terminal settling velocity of sediment particle.

(3) Wash Load

The wash load is finer in size compared with the suspended load. In Fuquene Lake Basin, the wash load is eroded at hilly areas not covered by vegetation and deposits in the Fuquene Lake after transportation without deposit on riverbed of rivers.

In view of the transportation mechanism, wash load cannot be estimated from bed material, but in general wash load can be expressed as follows.

$$Q_w = \alpha\ Q^\beta$$

Where, Q_w is wash load per time and both of α and β are constants which should be determined from the field observation.

2.3.2 Estimation of Annual Sediment Deposition in the Fuquene Lake

(1) Grain Size Distribution

Bed material survey including sampling and laboratory tests was carried out at two (2) points in the Ubate River (QR-1, QR-3), one (1) point in the Lenguazaque River (QR-2) and four (4) points in the Fuquene Lake (QL-1, QL-2, QL-3 and QL-4) as shown in Fig. D.2.3.

The grain size Accumulation curve of these points is shown in Fig.D.2.4 and followings can be concluded.

- At the two (2) points of the Ubate River, sand occupies almost 83 % and remains of the bed materials are composed of silt. In the Lenguazaque River, the grain size is finer than that of the Ubate River and the sand component occupies 75 %. From the grain size distribution in the Ubate River, size of wash load may be defined to be finer than 0.04 mm, which is less than 10 % in the river bed.

- In the Fuquene Lake, at the two (2) points near to the Ubate River, wash load component is less than 30 % and sand component occupies more than some 70 %. At the outlet of the Fuquene Lake and east of the Santuario Island, the grain size is finer and the wash load component occupies 40 % and 60 %, respectively. Judging from the grain size of the lake bed materials, the sediment transported by the suspended/bed load is important component of the deposits in the Lake as well as the wash load component.

(2) Sediment Observation and Wash Load Equation

Continuous sediment observation (SS concentration and its grain size) was made by the Study Team on May 12 and 13, 1999 at the QR-3 point (El Colorado). The result of the observation is tabulated below. Based on this result, the following equation for wash load is established assuming that constant β is 2.0 and particle density as 2.6 g/cm^3.

$Qw = 4.7192 \times 10^{-6} Q^2$

Date	Time	Discharge (m^3/s)	SS Concentration (mg/L)	Percentage of Grain between 0.038 mm and 0.4 mm
05/12/1999	13:10	1.43	20	
	15:20		22	
	18:07	1.58	21	
	19:07		22	100.0
	20:07		24	
	21:07		19	100.0
05/13/1999	05:00		37	15.1
	07:00		37	
	09:00		38	26.3
	11:00	(1.63)*	33	
	13:00		47	
	14:20		14	
	15:46		47	
	16:11		32	

Note : discharge at May 13 12:00

(3) Average Annual Sediment Deposition Volume in the Fuquene Lake

(a) Daily Discharge in Hydrological Average Year

The hydrological average year needs to be selected to calculate the average annual sediment deposition volume in the Fuquene Lake. The hydrological average year is determined from the annual mean discharge. Fig. D.2.5 shows a series of annual mean discharge for 18 years from 1967 to 1988 excluding four (4) years from 1979 to 1982, in which a lot of data are missing.

From the series of the annual mean discharge, the year of 1987, which is mean of the data series, is selected as the hydrological average year.

(b) Annual Sediment Runoff at QR-3

Annual sediment runoff at QR-3 point is firstly obtained from the equations for bed load, suspended load and wash load mentioned above, giving 365 daily discharge in 1987, which is shown in Fig. D.2.5. The average annual sediment runoff at QR-3 totals 11,699 m3, consisting of bed load of 11 m^3, suspended load of 8,048 m^3 load and wash load of 3,640 m^3.

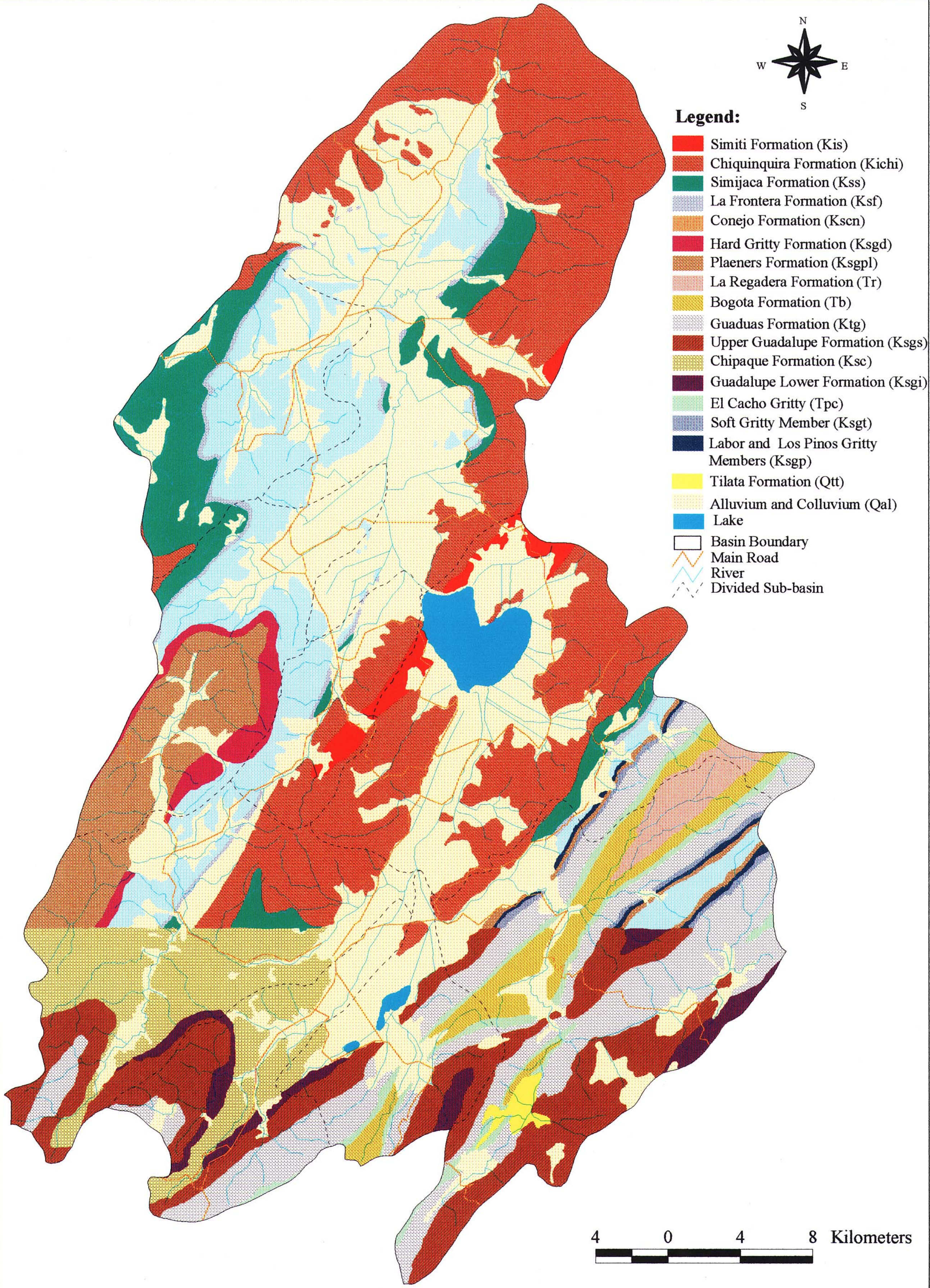
(c) Average Annual Sediment Deposition Volume in the Fuquene Lake

It can be said that most of the sediment runoff at QR-3 flows into the Lake and deposits in the Lake, judging from the short distance between the QR-3 and the Lake, and small grain size mentioned above. Moreover, sediment is transported from the remaining basin of 269.8 km^2 in addition to the Ubate River Basin (catchment area: 722.4 km^2) and this sediment runoff may be estimated from ratio of catchment area of remaining basin to the Ubate River Basin.

The average annual sediment runoff into the Lake is 16,068 m3, which is 1.37 times at the QR-3, and average annual deposition depth is estimated to be 1.6 mm using deposition area of 3000 ha. and porosity of 0.67, which is calculated from the water content measured at 4 points in the Lake.

Table D.1.1 Land Use Types in Various River Basins

River	Primary/ Secondary Forest		Shrub land		Pasture in Flat land		Pasture in Sloppy land		Agricultural Rotation		Lake		Urban Area		Total	
Basin	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%
Suarez	8.36	2.0	21.99	5.3	111.22	26.9	36.27	8.8	234.67	56.8	0.09	0.0	0.40	0.1	413.00	100.0
Chiquinquira	4.91	3.8	9.53	7.3	3.39	2.6	3.10	2.4	105.06	80.8			4.01	3.1	130.00	100.0
Simijaca	18.49	12.1	0.84	0.5	26.15	17.1	21.40	14.0	85.37	55.8			0.75	0.5	153.00	100.0
Susa	6.29	9.8	2.38	3.7	14.29	22.3	12.25	19.1	28.42	44.4			0.37	0.6	64.00	100.0
Ubate	12.21	5.4	20.45	9.1	11.26	5.0	45.67	20.3	132.74	58.9	0.91	0.4	1.95	0.8	225.19	100.0
Suta	3.78	3.4	8.50	7.6	15.30	13.7	13.13	11.7	71.06	63.4			0.23	0.2	112.00	100.0
Fuquene	17.52	6.5	0.00	0.0	75.21	27.9	67.78	25.1	81.76	30.3	26.70	9.9	0.84	0.3	269.81	100.0
Lenguazaque	20.99	7.2	1.75	0.6	20.10	6.9	95.74	32.7	154.09	52.6			0.33	0.1	293.00	100.0
Cucunuba	4.27	4.6	7.22	7.8	23.79	25.9	18.43	20.0	35.97	39.1	2.11	2.3	0.21	0.2	92.00	100.0
													Grand Total		1752.00	100.0



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

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. D.1.1 Geology Map of the Study Area