PART 3

MONITORING AND EARLY WARNING

PLANNING FOR SELECTED AREA IN SOACHA

CHAPTER 8 Landslides in Soacha Municipality

8.1 Outline of Landslides

8.1.1 Outline

The study areas are parts of commune 4 named Altos de Cazuca area and El Divino Niño area in commune 6. Altos de Cazuca area located near at the boundary of the southern urban area of Bogota city is divided into 32 districts named Barrios. El Divino Niño area is one of the “barrios” in commune 6.

Landslides, mostly classified into rock fall and surface collapses, in the study areas are found at abandoned quarries in Altos de Cazuca area where houses gathered in the upper and lower area close to steep slopes and landslide hazard areas, also, houses gathered in landslide hazard area formed by a quarry in El Divino Niño area.

Term “landslide”: the perceptible downward sliding or falling of a mass of earth, rock, or mixture of the two. The term landslide includes a wide range of ground movement, such as rock falls, deep failure of slopes, and debris flows.

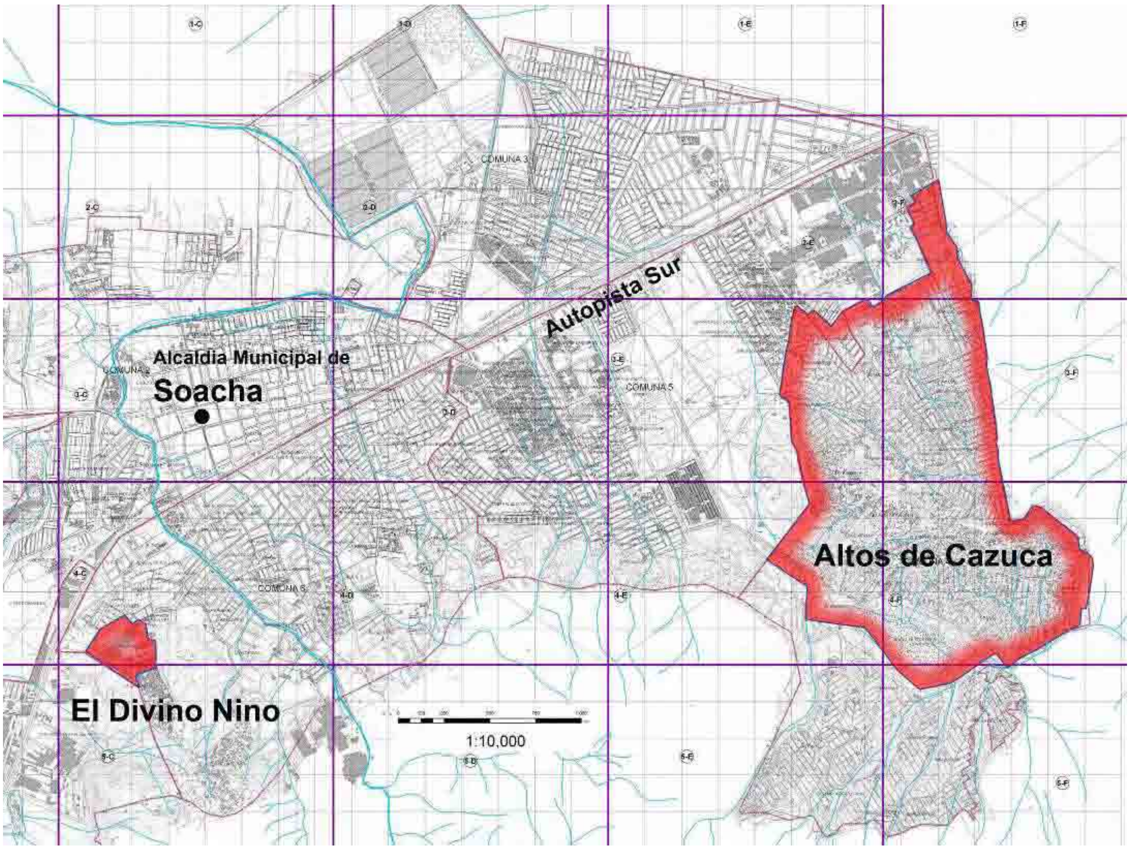

Figure 8-1 Guide Map of the Landslide Study Areas in Soacha Municipality

The area is underlain by Guaduas Formation (KTg) and Guadalupe Group (Ksglt). Both Guaduas Formtion (KTg) and Guadalupe Group (Ksglt) covered with Quaternary (Qta) in areas of low topographic relieves consist of sandstone layers with mudstone layers and some coal layers. These layers are classified into soft rocks. Ktg and Ksglt are partially covered with high terrace deposit (Qta).

8.2 Existing Studies

8.2.1 Existing Studies

In the study by INGEOMINAS (1996 study in La Capilla area), topography survey was made and topography map of 1/500 scale with 1-meter interval contour was made. By interpretation of aerial photos with 1/5,000 scale and field works to identification and mapping of geological and geomorphologic unit, a geological map of 1/500 scale was made. For subsoil exploration studies, five lines of geophysical exploration, two trenches, and three borings with depth between from 8 m to 22 m and laboratory tests were made. The study made four assumed models of rotational landslide hazard areas and made stability analysis using modified Bishop's limit equilibrium method. Based on the results of analysis, it proposed mitigation works for different part of the slope.

INGEOMINAS (2000) study in Villa Esperanza area was made on an emergency visit. The study undertook a preliminary zoning map of 1/10,000 scale for the short term purpose. The zoning map was made using hazard zoning map of 1/25,000 by INGEOMINAS in 1988 and a topographic map of 1/10,000 scale in 1989, in which Villa Esperanza is not yet figured.

A study made by National University (2004) basically from the viewpoint of urban planning, it includes location of infrastructures such as water pipelines

The Study by INGEOMINAS (2006-2007) financed by Soacha Municipality covers the entire municipality urban area, and is based on geology and geomorphology to identify high risk areas. The Study was completed as initial stage in 2007.

There are a few more potentially useful but unconfirmed information at the time of preparation of this document. Hearing from a resident in Villa Esperanza in Altos de Cazuca area mentions a study as mitigation works by corps of military engineer was made in seven years ago, but the document was not found. Another one is a study by Medicos Sin Frontera that was mentioned elsewhere, but is not yet found so far. Any study regarding El Divino Niño area was not found elsewhere. Any significant landslide monitoring has not been implemented by Soacha Municipality.

8.2.2 Past Disasters

Some statistical data have been prepared even though records of individual disasters have not been prepared properly. There are some descriptions about landslides in the area as follows;

According to a study by the Chamber of Commerce cited in the report of Soacha Municipality in 1992, 16,500 people lived in Altos de Cazuca area and 228 people in Villa Esperanza at that time. It was also reported that 163 people or 37 families needed urgent evacuation.

In Villa Esperanza, the study by INGEOMINAS in 1988 already mentioned the area as high risk area. Due to the rainy season at the end of 1999, landslide occurred in January 6, 2000. Emergency visit and study was made in February 29, 2000 by INGEOMINAS.

In 2001, historical landslide records in recent years in Soacha were compiled by Ingeniería y Geotecnia Ltda. (IGL) in JICA study. The purpose was to develop a slope disaster database in Bogota and eight municipalities in Cundinamarca department using uniform format.

In El Divino Niño area, there was a fall of a rock larger than one meter in size in 2004, with no human injury.

According to the record of fire fighter response to landslide disasters in the municipality in last 5 years, nine times of dispatches to La Capilla area in Altos de Cazuca area were most, and five times of dispatches to El Divino Niño area were second.

All of above-mentioned descriptions about the landslide in the Soacha Municipality do not show the spots of affaires.

The Soacha Municipality implements a special survey program after the landslide event of May 11, 2006, in order to estimate the number of inhabitants (families) and houses affected. Social Development Secretariat was designed as leader for all municipality staffs in order to compile the social information to provide, initially basic household as sprung mattress, blankets, etc and then, a monetary subsidy to the families who accepted to be evacuated. At first moment, the municipality surveyed 1200 families for basic household help and then, almost 700 families were surveyed again for monetary subsidy. This second survey was directed in Altos de Cazuca area and El Divino Niño area. The Survey Data Base was done applying a special format, which includes property of land, inhabitants of houses, structural features, observation results, and priority to intervene. The actual spots of houses surveyed were specified on the map as shown in Figure S5-2-4 of Supporting Report, based on names of house owners and address on the format of survey. Most of houses are not only affected by landslides but also water and mud flows. Generally, lack of slope protection after exploitation and improper treatment of sewage water due to shortage of sewer system can be major inducing factors. The average annual rainfall for several years at nearby Casablanca station by EAAB is 575 mm (INGEOMINAS, 1996). The rainfall has not been a major inducing factor in general. However, the rainfall in May 2006 was so heavy that this could be main inducing factor.

8.2.3 Critical Areas in the Study Area

According to the statistic record mentioned above, the number of residential houses that suffered from landslides especially in La Capilla area of Altos de Cazuca area and El Divino Niño area is highest in Soacha Municipality. Prompt measures should be taken to protect people in these areas.

8.3 Landslide Maps

8.3.1 Inventory Survey

Rock fall, collapse, mass movement and mudflow are seen in the study area, Altos de Cazuca area and El Divino Niño area.

(1) Existing slope disasters

A disaster inventory survey in Altos de Cazuca area and El Divino Niño area was carried out by aerophoto analysis and site reconnaissance. The results of the disaster inventory survey are shown in Disaster Inventory Map which is compiled in the attached figures of Supporting Report S5. The map shows existing steep slopes, mass movement, traces of collapses and traces of mud flows. Steep slopes were formed in abandoned quarry and with 30 degree inclination do not constitute disasters, however, rock falls and surface collapses occur frequently on the steep slopes.

8.3.2 Steep Slopes in Abandoned Quarries

Steep slopes in the abandoned quarries represent the most critical conditions among many disasters in Altos de Cazuca area. In this project, only steep slopes in the abandoned quarries are the object of the studies, since INGEOMINAS is studying landslide disasters in the areas based on an agreement between Soacha Municipality and INGEOMINAS, and steep slopes in the abandoned quarries are most critical areas with respect to mass movements and others.

(1) Phenomenon on Steep Slopes

The features of the steep slopes in abandoned quarries are as follows;

a) Quarries which were exploited in the 50’s and 60’s to obtain sand and clay from geological layers, therefore slopes in abandoned quarries are very steep and they are mostly gentle above and below the slopes.

b) Because above and below the slopes are gentle, it is easier to build houses there. There are many residential houses close to the steep slopes. Most of these residential houses are illegal, and most of residents in the houses are not well-off economically.

c) Small rock falls and collapses occur frequently on the slopes.

d) The areas are underlain by alternation of sandstone and mudstone as base rocks in the areas. The base rocks exposed on the steep slopes are soft rocks (geotechnical term; compression strength (qu) < $40N/mm^2$) with cracks. It easy for soft rocks to be weathered, and sometimes gully erosion can be seen on the slopes.

e) Therefore rock falls or small collapses could occur in future and larger collapse or mass movement may occur on steep slopes. This is hazardous for residents living close to the slopes.

8.3.3 Critical Zones in El Divino Niño area and La Capilla area

In the study area, Critical Zones has been set to verify the critical area in the barrios, El Divino Niño area and La Capilla area in Altos de Cazuca area where houses are dense, slopes are high and landslides occur frequently.

(1) Setting of Critical Zones

The Critical Zones are set above and below the steep slopes. Steep slopes are defined in the Study as steep slopes of over 5 m in height with an incline of over 30 degrees formed through quarrying. Critical Zone is defined as the area within the distance of twice of the slope height (2h) from toe of the slope and the area within the same distance as the slope height from top of the slope as shown in Figure 8-2.

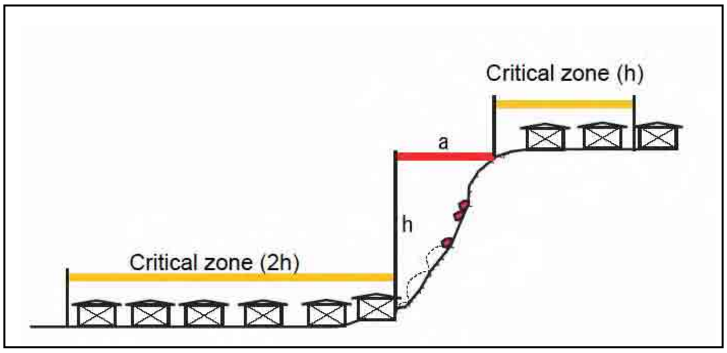

Figure 8-2 Definition of Critical Zone of Steep Slope

(2) Critical Zones in El Divino Niño area and La Capilla area

Critical Zone in El Divino Niño area is shown in the Figure below. Maxim height of the steep slope is about 40 m, and Critical Zone is extended to a maxim of 80 m from the slope. Many houses are involved in Critical Zone.

Critical Zone in La Capilla area is shown in Figure 8-4. Maxim height of the steep slope is about 40 m, and Critical Zone is extended to a maxim of 80 m from the slope. Many houses are involved in Critical Zone.

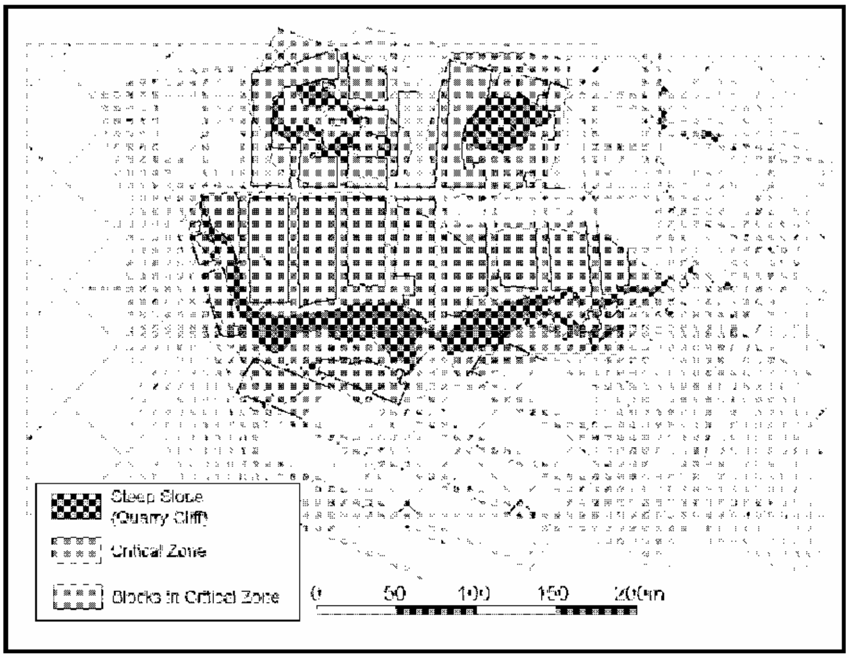

Figure 8-3 Critical Zones in El Divino Niño area

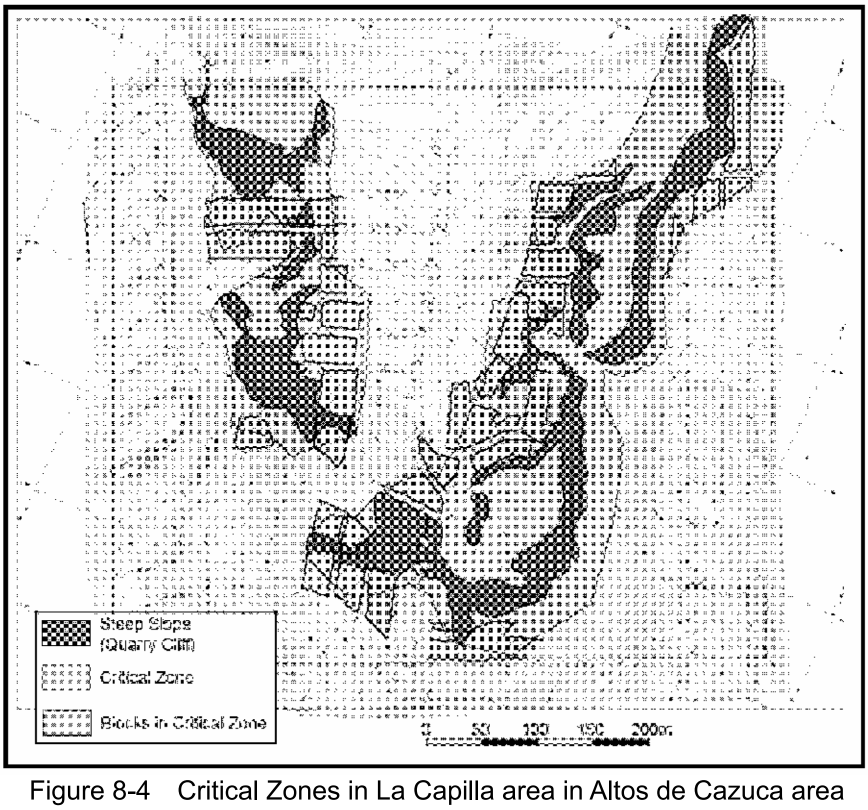

Figure 8-4 Critical Zones in La Capilla area in Altos de Cazuca area

(3) Setting of Emergency Zone

Soacha Municipality introduced a scheme for relocation of houses from high risk areas in a disaster prevention program. The Critical Zone maps could provide useful information for Soacha Municipality's relocation scheme. It is obvious, however, that the early relocation of houses in the Critical Zones in El Divino Niño area and La Capilla area is difficult, since many houses are settled in the Critical Zones. For the information of the relocation scheme of Soacha Municipality, the Emergency Zone is set in the Critical Zones in El Divino Niño area where is found the most critical area in Soacha city. It is imperative that the houses in Emergency Zone be relocated urgently. The criterion of Emergency Zone should be within the limits of 10 m or 2 houses from toe of the slope as shown in Figure below; however, a final decision of Emergency Zone in El Divino Niño area was done by the Study Team with site survey. The Emergency Zone in El Divino Niño area is shown in Figure 8-6.

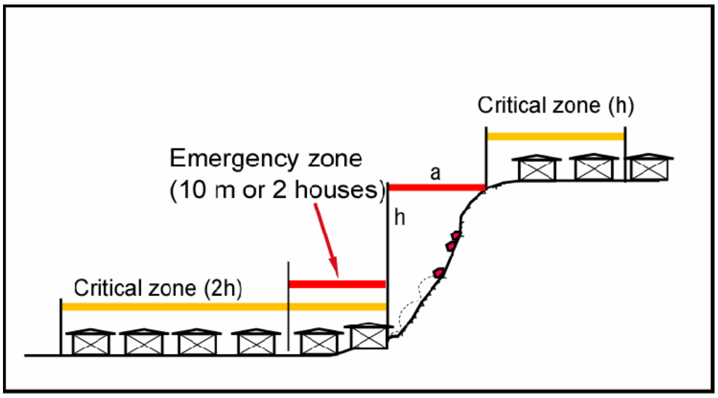

Figure 8-5 Definition of Emergency Zone of Steep Slope

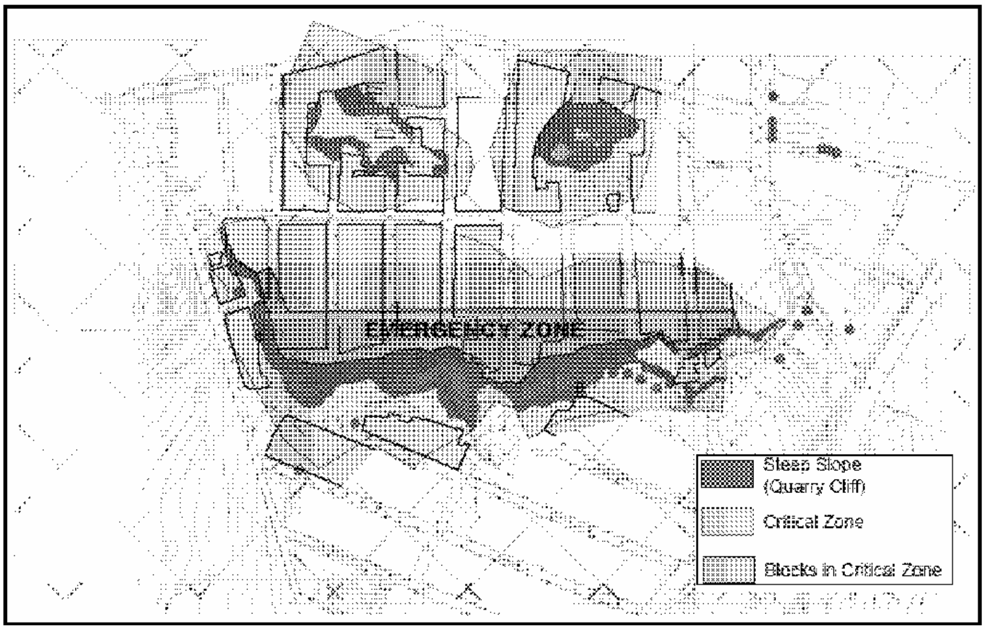

Figure 8-6 Emergency Zone in El Divino Niño area

8.3.4 Community Hazard Map

For the relocation program in El Divino Niño area, the relocation of all people from Critical Zones and even from the Emergency Zones may take a long time. Therefore, it is important to protect the peoples who stay in the Emergency and Critical Zones until they are relocated. To do end, the people should know whether they are settled in the zones or not using the Critical Zone Maps. The public in the zones should be well informed by referring to Community Hazard Map attached.

a) People in Emergency Zones and Critical Zones are always exposed to danger.
b) People should always watch any unusual things on the slopes.
c) People should take care of the slopes in case of rain.
d) If people find any unusual occurrence on the slopes during rain or even in case of fine weather, they should inform Soacha Municipality and seek refugee according to their own judgments.

8.4 Measures for Critical Zones

8.4.1 Consideration of Structural Countermeasures

Many houses were built and many people lives near the toe and upper part of steep slopes formed through mining in Soacha municipality. Rock falls and slope collapses frequently occur in this area even in case of fine weather as well as in rainy weather. These areas have suffered from not only rock falls and slope collapses but from also large mass movements. It is known that quarries, which were exploited until about 50 years ago, triggered the mass movement in Altos de la Estancia in the capital district of Bogota. In Villa Esperanza in Soacha municipality, in order to prevent the mass movement occurred at the abandoned quarry, earth-filling works were implemented by the army. It is quite difficult to stop the movement of landslide once it is generated by human activities because the imbalance of landslide body is substantially larger than in any natural circumstances. For example in El Divino Niño area, the steep slopes are covered with clayey material created during the weathering of sandstone and mudstone. Cuboid blocks and boulders through the development of cracks on outcrops can be observed on the slope. These blocks and boulders can fall in situation of rock fall or slope collapses. In addition, open cracks observed on the slopes indicate that the entire body of the slopes have been continuously moving from the past. Therefore, it is necessary to pay attention to the phenomena of transition to mass movement.

It is well known that small-scale slope cut and excavation can trigger mass movements in which slopes have similar topographical and geological conditions to Altos de la Estancia. In reality in Altos de La Estancia, slope cutting and excavation through human activities promoted transition phenomena, and finally triggered the mass movement. Consequently, further cutting on steep slopes in abandoned quarries should not be carried out because the slope is deemed an unstable condition caused by the former quarry activities. For the emergency protection works against rock fall and slope collapse, it is effective to form gentle slopes in order to limit the scale of the rock falls and slope collapses phenomena.

However, forming gentle slopes corresponds to the removal of toe of the slope and this activity increase the risk of mass movement. In that case it is impractical from the viewpoint of prevention of landslide. It is difficult to stop the mass movement after the effect of human activities as for the mass movement which is relatively small as observed in Villa Esperanza. It is theoretically possible to form gentle steep slope with the landslide prevention works such as piling works and anchors, but these stabilization works are quite expensive. As a basic rule, these expensive works should be done after the completion of counter-weight filling works at the toe of landslide. These works would be of large-scale on flatland where many houses are presently settled and it would be similar to recovery works to the original land shape. Therefore the “emergency protection works” on steep slopes in abandoned quarries in El Divino Niño area and Altos de Cazuca area are impracticable to implement from the technical viewpoints.

8.4.2 Recommendation to Mitigate Landslide Damages

As a measure against slope disasters on steep slopes in abandoned quarries, it is recommended to relocate people from the Critical Zones. The houses found close to the steep slopes should be relocated to safe areas, outside the Critical Zones. The relocation programs should be realized in the following order, because it could take a long time to relocate from many Critical Zones in which there are many houses.

a) People in the Critical Zones should be relocated. A priority of relocation should be given to the people settled in the most hazardous area of the Critical Zones.
b) Until all the people in the Critical Zones are relocated, Soacha municipality should take care of safety of people remaining in the Critical Zones.
c) People remaining in the Critical Zones should be informed that they are found in the Critical

Zones and they may be affected by danger even in case of fine weather.

d) In case of heavy rain, Soacha municipality should stay on the alert for people found in the Critical Zones

e) To obtain the basic information about the alert level of rainfall, Soacha municipality should collect rain fall data.

However, further investigation for possibility of measure works on each steep slope is recommendable after completion of all relocation program from Emergency Zones before commence of the relocation program from Critical Zones.

8.4.3 Process for Relocation

The relocation from all Critical Zones in Soacha municipality is necessary to protect the people's lives and properties. It could take a long time to complete the plan, and the relocation from more hazardous areas is necessary observing the following measures.

a) Complete the relocation program from Emergency Zone in El Divino Niño area

b) Set up Emergency Zones in La Capilla area. (Critical Zones in La Capilla area have been set up in the study. Figure 8-4).

c) Proceed with the relocation program from Emergency Zones in La Capilla area in accordance with the process in El Divino Niño area.

d) Set up Critical and Emergency Zones in El Arroyo area (Villa Esperanza area) where they are surrounded by steep slopes formed by mining activities too.

e) Proceed with the relocation program from Emergency Zones in El Arroyo area (Villa Esperanza area) in accordance with the process in El Divino Niño area.

f) Set up Critical and Emergency Zones in other areas where steep slopes in abandoned quarries are found (refer figure attached below), and proceed with the relocation program from the Emergency Zones.

g) After the completion the relocation program from the Emergency Zones, proceed with the relocation program from the Critical Zones in El Divino Niño area, and continue with the same orders as relocation program from the Emergency Zones.

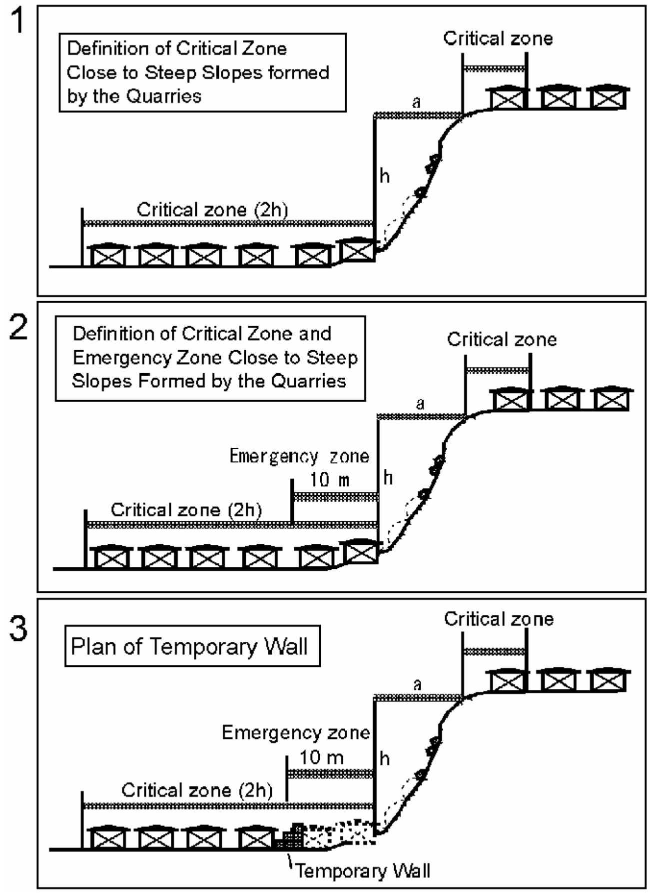

Figure 8-7 Process of Relocation from Emergency Zones

8.4.4 Measures until Completion of Relocation Program

In the process of the relocation program in El Divino Niño area, we found that relocation of people could take a long time. Therefore, it is important to protect the peoples who stay in the Emergency and Critical Zones using the Community Hazard Map as mentioned in Section 8.3.4.

8.4.5 Time Schedule of Measure Works and Monitoring

The recommendable time schedule until 2020 is shown in Figure 8-8.

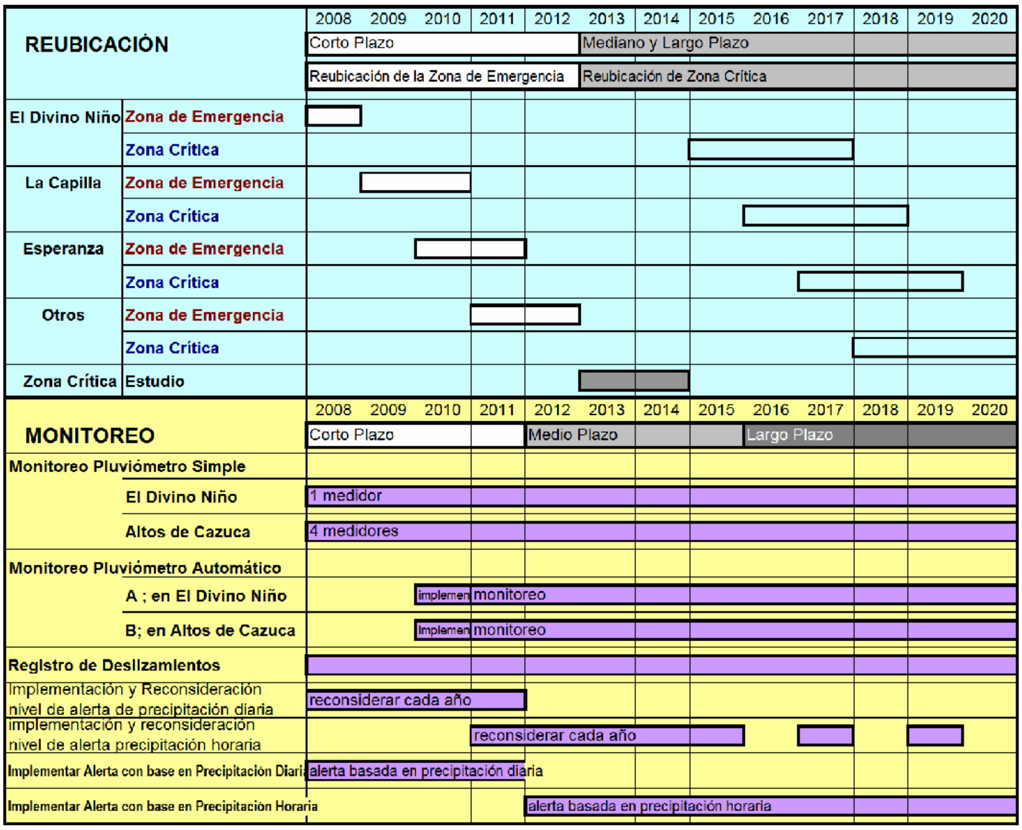

Figure 8-8 Time Schedule of Measure Works and Monitoring

8.5 Pilot Project

8.5.1 Necessity of Precipitation Monitoring and Disaster Records

(1) Background

Many landslide disasters occurred during or after heavy rain in Altos de Cazuca area and El Divino Niño area in Soacha Municipality. In May, 2006, many houses were affected by the slope collapses and rock falls due to heavy rain. Meanwhile, some landslide disasters occur even in dry season. It may be true that the rainfall causes many landslides in Soacha Municipality, but this is not certain without any support data. The information collection of precipitation and disasters are critical for prevention against the landslide disasters. The following questions should be verified for a future plan of disaster measures, such as early warning systems serving the people remaining in the Critical Zones.

- Is it true that landslides occur more frequently with heavy rain fall?
- How much rainfall triggers off landslides?
- What type of landslides occurs in case of rainfall?
- Do the relations between rainfall and landslides differ in area by area, or barrio by barrio?
- How many landslides and what type of landslides occur in dry surroundings (without rain)?
- Does occurrence of landslides change by the way of rain fall (less and long / heavy and short)?
- Do intensities of rainfall differ from one small area (barrio) to another?

The relation between rainfall and occurrence of landslides should be studied while collecting information about precipitation and occurrence of landslides. If we can solve above questions, we might be able to build early warning system with rainfall monitoring.

(2) Purpose

Precipitation monitoring and record of landslides are carried out in order to collect and accumulate the basic information for analysis of the relation between rainfall and occurrence of landslide and to study landslide disaster prevention measures especially early warning systems in future. In order to install the rain gauges as many as possible for the purpose, the simple gauges which are low cost and easy to be read were installed in the pilot project area. To monitor many rain gauges constantly, the monitoring works were left to the community in where the rain gauges are installed. It is expected also that community's awareness of disaster prevention becomes higher with the monitoring works. The record of landslide is being carried out by Soacha Municipality, since recording of landslides requests more expertise.

8.5.2 Method of Precipitation Monitoring

(1) Locations of Installation of Rain Gauges

Precipitation monitoring was carried out in the pilot project area where is Altos de Cazuca area and El Divino Niño area in Soacha Municipality. Five rain gauges were installed in five schools in the pilot project area as shown in Table 8-1.

Table 8-1 Locations of Rain Gauges

area	gauge no.	school	barrio
Altos de Cazuca area	RG1	Institution Educativa Cazuca area	La Capilla area
	RG2	Gimnasio Moderno Colombiano	El Mirador De Corinto
	RG3	Institution Educativa Luis Carlos Galan	Luis Carlos Galan
	RG4	Institution Educativa Antonio Narino	Sede El Arroyo
El Divino Niño area	RG5	Institution Education Las Villas	Escuela La Panamericana

For the following reason, the schools are selected for the location of rain gauges installation.

- There are more than one school in Altos de Cazuca area.
- Monitoring can be executed in night time by a security guard as security guards stay in the schools for 24 hours a day.
- The rain gauges can be protected from burglaries as securities of schools are adequate.
- The rain gauges may be able to be useful for a part of education for school children, and the children's awareness of disaster prevention become higher.

(2) Rain Gauge Monitoring

The rain gauge consists of funnel and Cylinders and sub cylinder for reading minutely is attached. It is very simple rain gauge without any mechanical parts and electric power.

<u>Person who monitor</u>
Basically, monitoring works are carried out by the person in each school who is assigned by the principal of each school. During the school holiday, the person in charge in each school assigns and instructs a security person who stays in the school in holiday to monitor the rain gauge.

<u>When</u>
The rain gauges are read three times a day at 6:30, 14:00, and 18:00. The water in the rain gauge is emptied every time immediately after the rain gauge is read.

<u>Record Format</u>
The record format of rain gauge monitoring is shown on Figure 8-9.

MONITOREO DE PLUVIOMETRO

PLUVIOMETRO NO. ____________ AÑO 2007

INSTITUTO ____________ MES ____________

DIA	HORA propuesto	HORA real	PRECIPITACION (mm)	PRECIPITACION DIARIA (mm)
1	6:30			
	14:00			
	18:00			
2	6:30			
	14:00			
	18:00			
3	6:30			
	14:00			
	18:00			
4	6:30			
	14:00			
	18:00			
5	6:30			
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28	6:30			
	14:00			
	18:00			
29	6:30			
	14:00			
	18:00			
30	6:30			
	14:00			
	18:00			
31	6:30			
	14:00			
	18:00			

In case total precipitation in 24 hours is beyond 20 mm, please inform the fire fighter station of it.
the fire fighter station : xxx-xxx-xxxx

Figure 8-9 Rain Gauge Monitoring Record Format

(3) Report

The record should be submitted once a week to Ing. Sandra Vásques of the Soacha municipality. In the case the accumulate rainfall is more than 20mm/24h, the person who read the rain gauge should call the firefighter station in Soacha Municipality with following steps.

Excess 20 mm in 24 hours * - Call to Firefighter Station
"Excess 20 mm in 24 hours"
"xx mm in 24 hours from xx:xx hour"

After 20 mm in 24 hours until the rain is over
- Call to Firefighter Station
"Accumulated precipitation is xx mm from xx:xx hour"
(20 mm in 24 hours : normally accumulation of three readings)

8.5.3 Landslide Record

(1) Objective Area

All of landslides in Soacha Municipality should be recorded immediately after the occurrence of the landslide. Especially, the pilot project areas, Altos de Cazuca area and El Divino Niño area, are emphasized.

(2) Landslides Recorded

Only the landslides which caused damages to persons, houses, facilities and others are recorded.

(3) Record Format

The format is shown in Figure 8-10. Figure 8-11 shows the type of landslides which is to be filled in the format.

(4) Persons

The format are filled by the engineer immediately after he visited the landslide site, and the following two persons should be responsible for the record and the custody.

Dr. Iván Demóstenes Calderón*-1 : manager of the landslide record
Ing. Sandra Vásquez*-2 : civil engineer in charge of landslide record

(*-1 Technical Director, Justice Support Direction, CLOPAD's Coordinator)
(*-2 University Professional, Planning Secretariat, CLOPAD)

(5) Report

The report of monitoring contains an analysis of the relation between the rain fall and the landslide disasters.

(6) Filing

Record format which has been recorded should be filed in Ing. Sandra Vásques's office.

LANDSLIDE (SLOPE DISASTER) RECORD	
Date Recorded	___ / ___ /20___ RECORD BY
Barrio Name	
Address	
Date / Time Occurrence	Date: ___ / ___ / 20___ , Time: am/pm ___
Type of Slope	Quarry / Cut (not quarry) / Natural / Embankment
Type of Landslide	Landslide / Collapse / Rockfall / Toppling / Debrisflow / others
Dimension of Landslide	Width : ___ m, Height : ___ m
Volume of Fallen Debris or Rocks	(Approximately) ___ m^3
Victims and Damage	Death or Injury : ___ Number of Affected Houses : ___
Scope of Damage	
Emergency Operation	
Remarks	
Rough Sketch of Landslide	
Rain Fall (before the disaster)	24 Hours Rainfall of the Day: ___ mm (Date: ___ / ___ /20___)
	Total for 3 days : ___ mm (Date from ___ / ___ to ___ / ___)
	Maximum Hourly Rainfall: ___ mm(Date ___ / ___ /20___)am/pm ___)
	Data Source : station name ___
Checked by	Date : ___ / ___ / 20___

LANDSLIDE (SLOPE DISASTER) RECORD	
Date Recorded	___ / ___ /20___ RECORD BY
Barrio Name	
Address	
Date / Time Occurrence	Date: ___ / ___ / 20___ , Time: am/pm ___
Photos	
Checked by	Date : ___ / ___ / 20___

Figure 8-10 Landslide Record Format, page 1 (left) and page 2 (right)

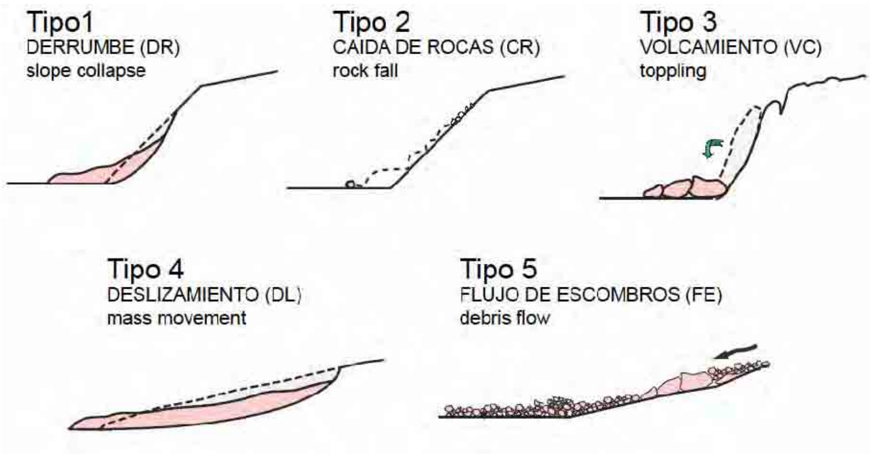

Figure 8-11 Type of Landslides (Tipo=Type)

8.5.4 Results

(1) Excursion of Precipitation Monitoring

Reading of rain gauge has been done by the school teachers and security guards. In the first stage of the monitoring, some mistake such as in case of failure of the unit may be found in record sheets. A reliable monitoring can be achieved after workshop to be held following one month monitoring.

(2) Results of Precipitation Monitoring

Though the precipitation monitoring has been carried out for five months, the precipitation data must be accumulated for longer periods in order to have information on rainfall. At the moment, the following situation is observed in the monitoring.

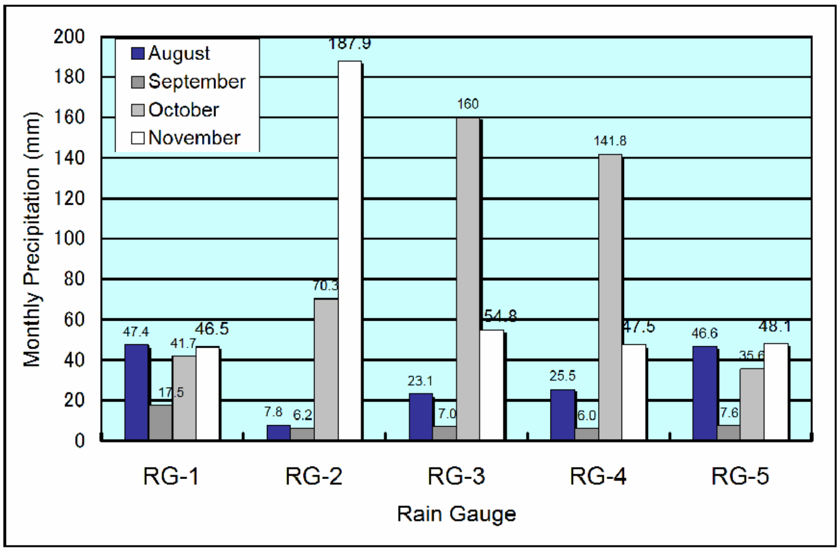

Figure 8-12 Monthly Precipitation in September and October

a) Monthly precipitations in August occur more frequently than in September. This shows different trends from the average normal year.
b) Monthly precipitations are different in each point in August, and are not different in each point in September.
c) Maximum monthly precipitations were observed with RG-4 by 141.8 mm in October 2007.

d) Maximum daily precipitations were observed with RG-4 by 58.2 mm on 13th October. 2007
e) With a lower altitude, rainfall will fall more frequently especially in August.

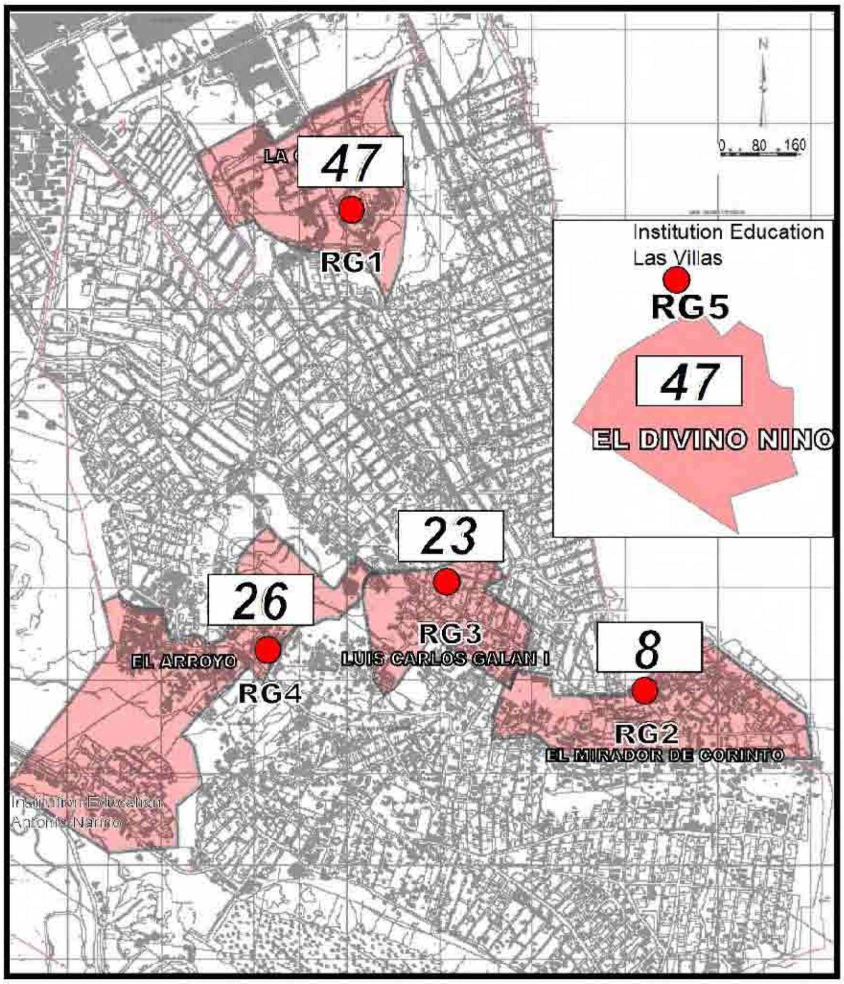

Figure 8-13 Monthly Precipitation of September at Each Monitoring Points

(3) Relation between Precipitation and Landslide Disasters

Three landslide disasters occurred in the period from 13th October 2007 to 15th October 2007 in Los Robbles, Terranova and La Capilla area in Altos de Cazuca area. Rain continued falling intermittently from 6th October to 14th October in Altos de Cazuca area. The nearest rain gauge points to Los Robbles is RG-4, to Terranova is RG-3 and to La Capilla area is RG-1. According to Figure 8-14, an excess of 20 mm of accumulate precipitation may be appropriate for Alert Level 1 and an excess of 50 mm of accumulate precipitation may be appropriate for Alert Level 2.

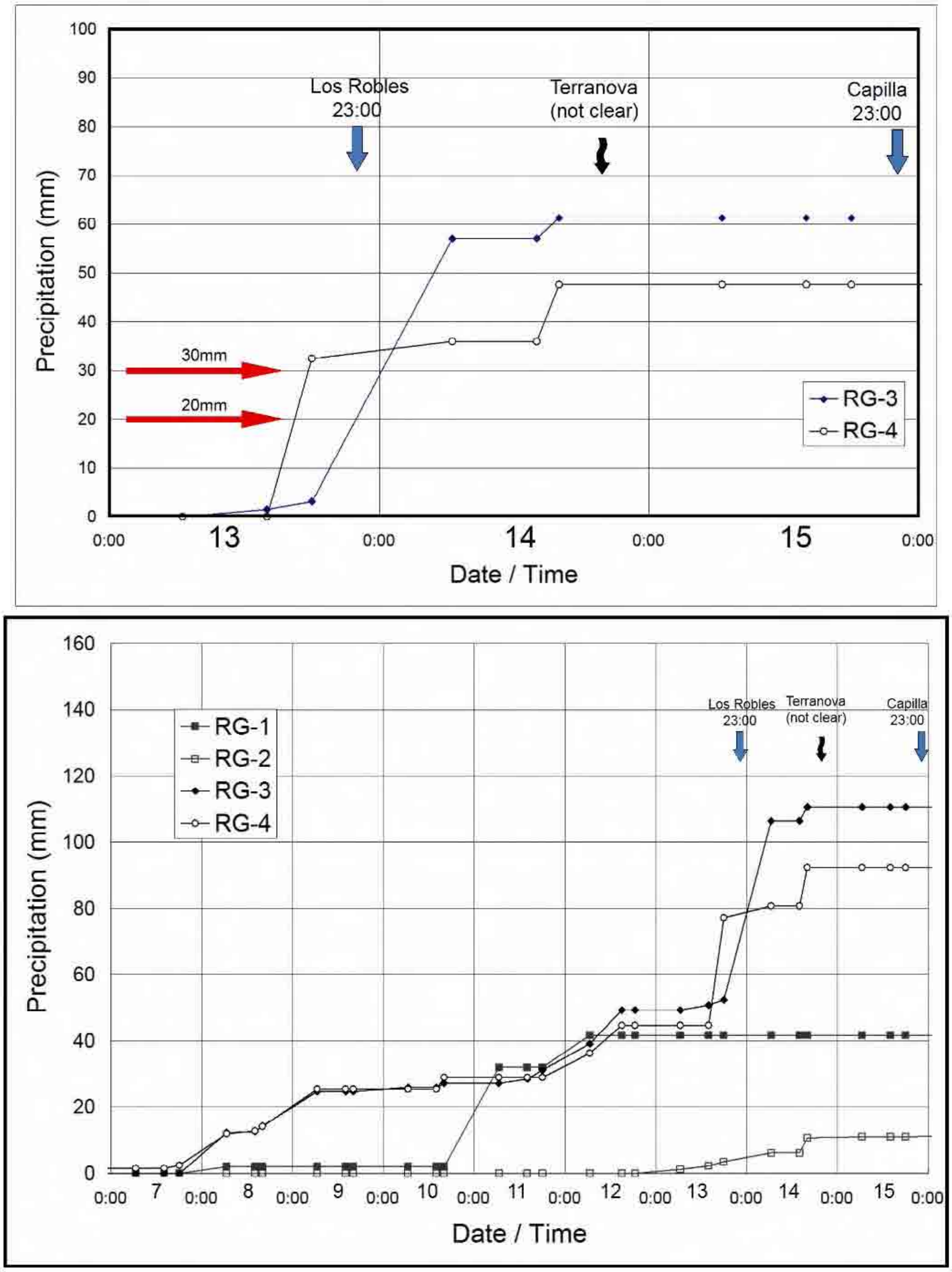

Figure 8-14 Precipitation before Landside Disasters in October 2007

CHAPTER 9 FLOOD

9.1 Rivers in Study Area

The Study Area in Soacha Municipality covers the Soacha River and the Tibanica River. The catchment area of the Soacha river and the Tibanica river is 44.3 km^2 and 19.2 km^2, respectively.

The Soacha River is a tributary of the Bogota River, which is joining at Las Huertas upstream. The length of the Soacha river is 24 km, originating from San Jorge whose elevation is about 3,300 m above sea level. Figure 9-1 shows the longitudinal profile of the Soacha River. At 11.5 km from the Bogota river, there is a step which is corresponding to the end of glacial gorge. From 10.0 km, the river is running down in the alluvial area.

Annual rainfall in San Jorge (IDEAM) which is located in the upper part of the Soacha river is 691 mm as an average value between 1960 and 2002.

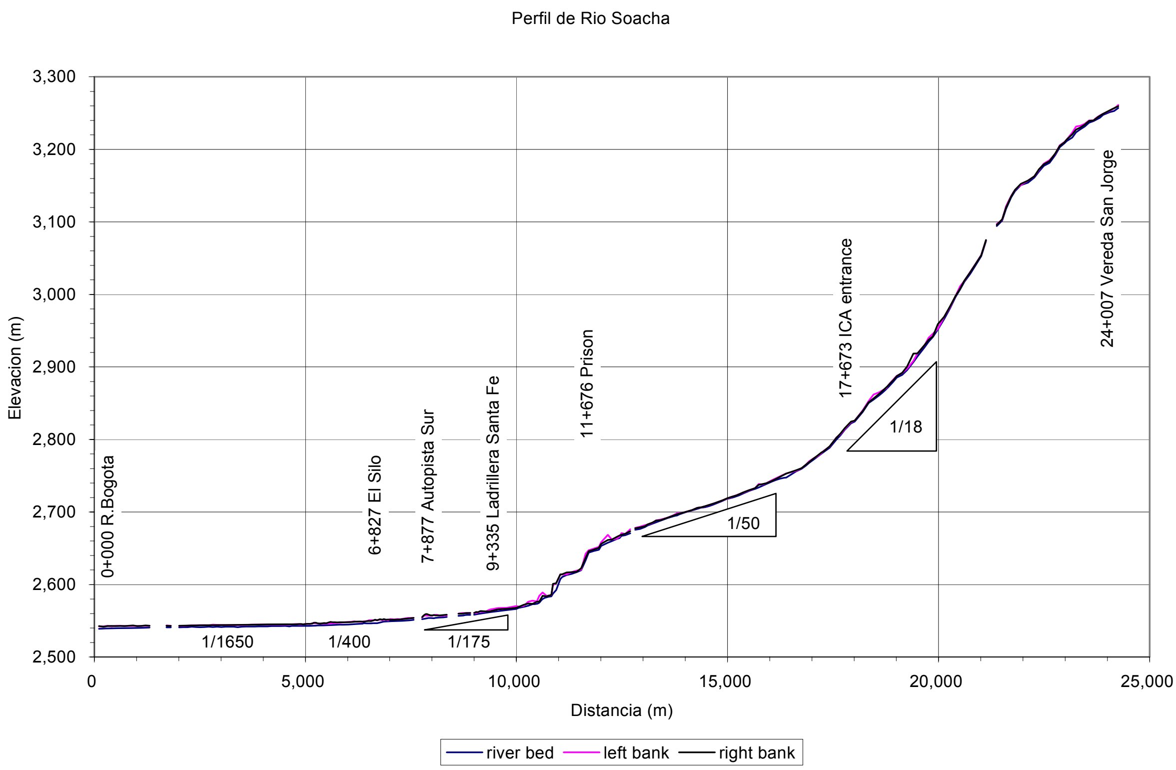

Figure 9-1 Profile of Soacha River

The reach between Ladrillera Santa Fe (a brick company) and Autopista Sur used to be wetland according to the aerial photo in 1941. In this reach at present the Soacha river is straight along the right edge of the previous wetland.

The area downstream of El Silo (6+827) can be regarded as within the floodplain of the Bogota River and low-lying area. The present river course of the Soacha river is running as such it is avoiding the low area. In this low area there are some residential areas such as El Silo. Figure 9-2 shows the most downstream reach of the Soacha river. The ground elevation is lower than the river bed elevation in some sections. It is regarded that the present river course was made selecting the higher location in order to make the drainage of the Soacha river itself easily, however, it means that the surrounding area is always lower than the Soacha river waterlevel resulting into the frequent inland flood when it is raining.

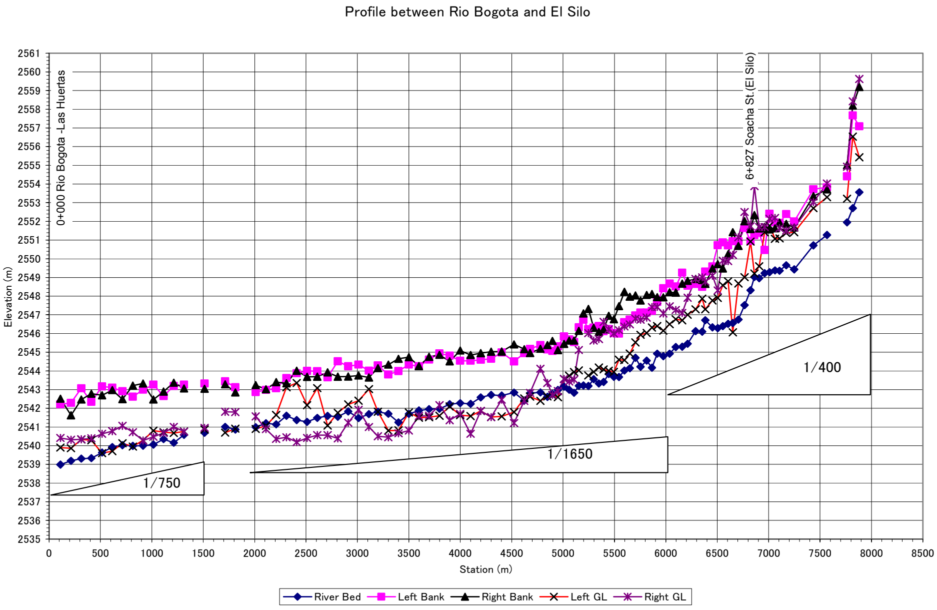

Figure 9-2 Profile of Downstream of Soacha River

The Tibanica River (it is called Claro River in the downstream reach of Autopista Sur) is a tributary of the Tunjuelo River, which is joining at Punete La Isla. In the upstream there is Tererros Dam, which was constructed in 1950's for irrigation purpose. The length of the Tibanica river is 6.6 km, starting from the spillway of the Terreros Dam whose elevation is about 2,614 m above sea level (IGAC datum). The surface area is about 17.5 ha and the storage volume is 1,200,000 m^3. However at present the dam is filled up until spillway crest.

Figure 9-3 shows the longitudinal profile of the Tibanica River. From the dam to Autopista Sur, the bed slope is 1/50 to 1/140. From the Autopista Sur to the Tunjuelo River confluence the riverbed is quite mild, 1/1,000 to 1/2,800.

In the downstream of Autopista Sur, the present Tibanica river is canalized (excavated and straightened) in the urban area, however, due to the flat topography and sedimentation, small scale inundation can easily happen by local rainfall.

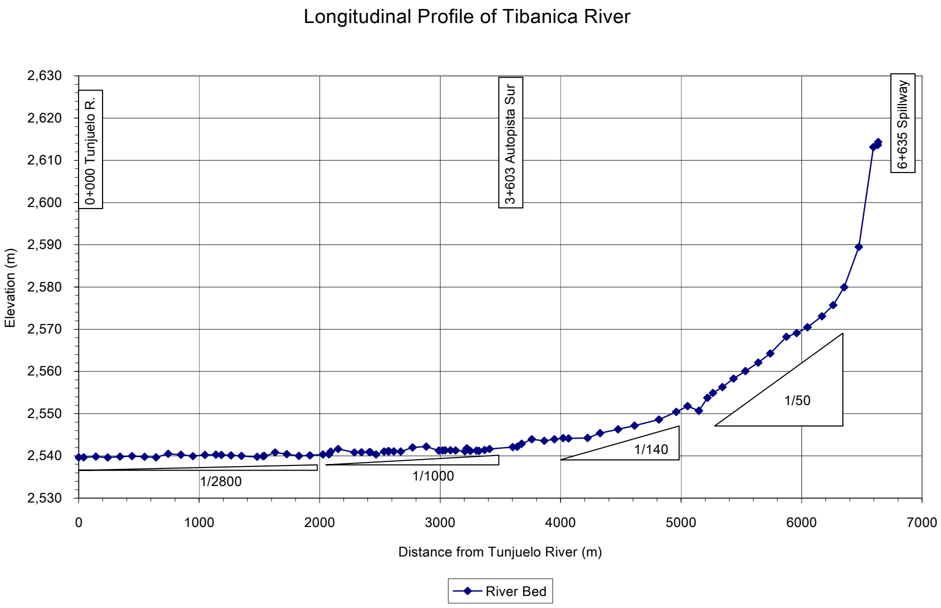

Figure 9-3 Profile of Tibanica River

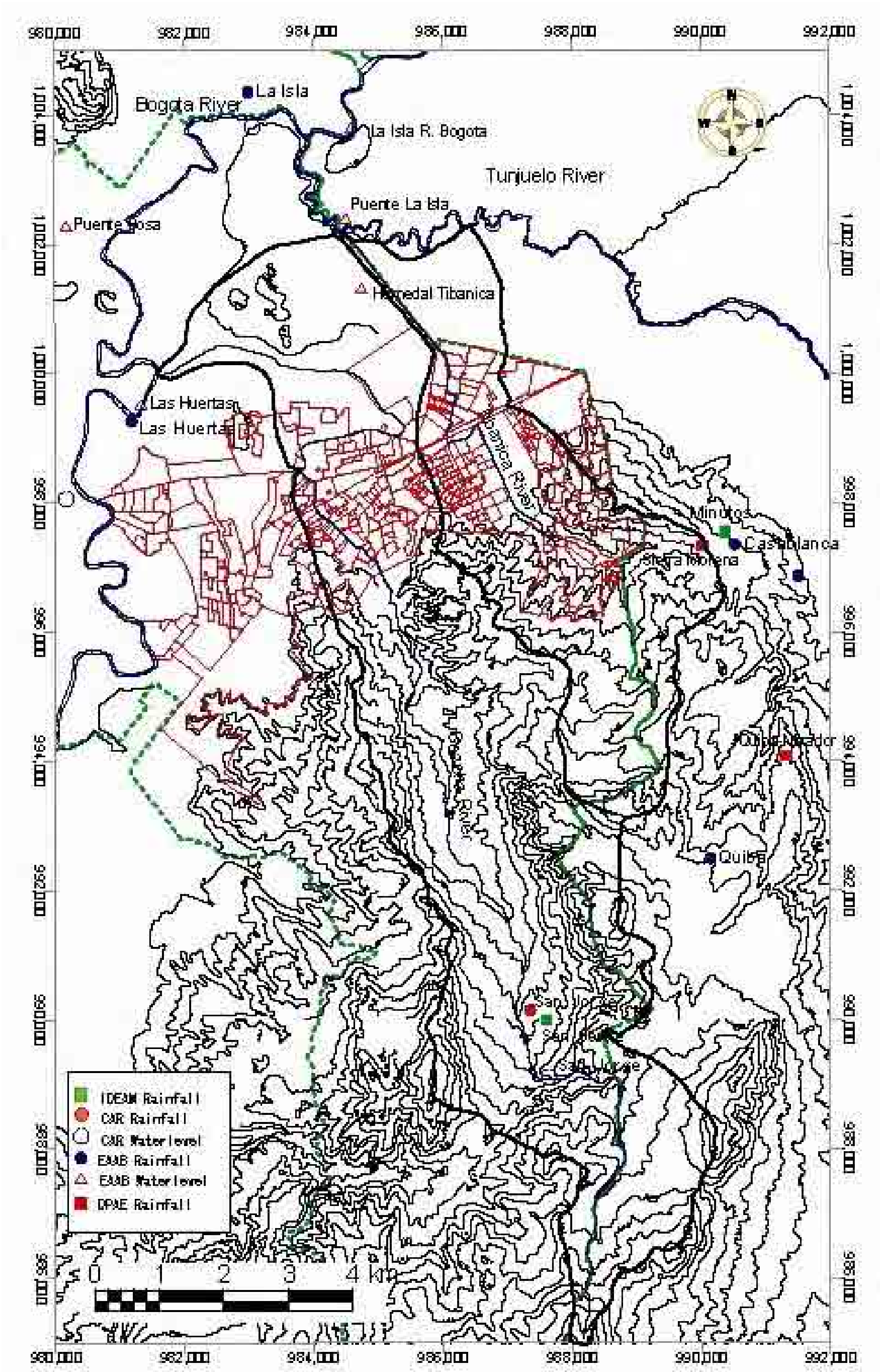

Figure 9-4 Catchment of Soacha River and Tibanica River

9.2 Past Floods

9.2.1 Investigation of Past Floods

(1) Newspaper “El Tiempo” Article

The Study Team collected the recent newspaper articles of “El Tiempo”, which is one of the major newspapers in Colombia, regarding the inundation, stream names in the study area and landslide. The total number of the articles is one hundred two (102) since 1992.

It was found that in Soacha there were flood disasters in December 1992 and May in 2006.

According to the article dated on December 13, 1992, one dead person, more than 12 districts of Bosa and one part of its industrial sector was affected, the same as one Soacha neighborhood. The strong Wet Season that is affecting the capital of the country caused one person’s death and left 20 families damaged, and affected twelve neighborhoods most of them Soacha districts and one Soacha settlement.

In Soacha Municipality, they suffered from serious flood on May 2006, which was the most serious flood in recent 20 years. It is regarded as the maximum flood in Soacha on people’s memory. In order to confirm the frequency and magnitude of the past floods, the interview for affected people and collection of local newspaper articles were considered in this Study.

(2) Interview Survey

The Study Team undertook an interview survey for past flooding in Soacha on September 2006. In Soacha, they suffered from serious flood on May 2006, which was the most serious flood in recent 20 years. The Study Team assumed that people in Soacha remembered the latest flood very well, so prepared the questionnaire focusing on the May 2006 flood as shown in Figure 9-5.

The Study Team organized two (2) teams for the interview survey, one team composed of two (2) researchers and one (1) car with driver. The Study Team received information on the past affected areas such as barrio name from the Soacha City in advance. Based on that information, the Study Team made schedule for the interview survey. The survey was conducted by visiting of houses in the affected area, however for selecting houses to be interviewed, the Study Team asked JAC leader for their advice.

The total number of houses which the Study Team visited in this Study is about two hundred (200). The interview results table for the Soacha city is attached in Supporting Report S6.

The total number of barrios which the Study Team made interview is seventy one (71). Among them, twenty three interviews were done in El Cardal and Llano Grande where the inundation depth was over 1 m in May 11, 2006.

Table 9-1 List of Barrios which the Interview was made by the Study Team

BARRIO NAME	No.	BARRIO NAME	No.	BARRIO NAME	No.
BARBADOS II	2	JULIO RINCON I	1	MIRADOR DE SAN IGNACIO V	1
CASALINDA XII	1	LA ARBOLEDA	1	MIRADOR DE SAN IGNACIO VI	1
CENTRO COMERCIAL UNISUR	2	LA CAPILLA	4	NUEVA PORTALEGRE	1
CIEN FAMILIAS	3	LA DESPENSA	7	NUEVO COLON	8
CIUDAD DE QUITO	1	LA FLORIDA I	6	PABLO VI	1
CIUDAD LATINA I	1	LA FLORIDA II	5	PARQUE DE LAS FLORES	1
CIUDAD LATINA II	2	LA FONTANA I	1	PARQUES DE SAN MATEO I	2
CIUDAD SATELITE	2	LA FRAGUA	1	PARQUES DE SAN MATEO II	1
COHABITAR	2	LA MARIA	1	PASEO REAL	1
COLMENA II	1	LA PRADERA I	2	QUINTANAR DE LOS OCALES	1
COMPARTIR	1	LA PRADERA II	6	QUINTAS DE SANTA ANA I	2
EL CARDAL	12	LAS ACASIAS I	1	SANTA MARIA DEL RINCON	7
EL CEDRO I	1	LAS ACASIAS II	1	SIMON BOLIVAR	1
EL CIPRES	1	LEON XIII	5	TERRAGRANDE	4
EL DANUBIO	4	LEON XIII SEGUNDO SECTOR	5	TIERRA BLANCA	1
EL PARAISO	3	LEON XIII TERCER SECTOR	5	UBATE	1
EL PRADO DE LAS VEGAS	5	LLANO GRANDE	11	VALLES DE SANTA ANA	2
EL RINCON DE SANTAFE	4	LLANOS DE SOACHA	1	VILLA ITALIA	1
EL ROSAL	1	LOS CEREZOS	1	VILLA SOFIA II	4
EL SILO	4	LOS DUCALES II	1	VILLAS DE SANTA ROSA	1
EL TABACAL	1	LOS OCALES	1	ZONA INDUSTRIAL DE CAZUCA	6
EL TREBOL	4	LOS OLIVARES	11		
EUGENIO DIAZ CASTRO	1	LOS OLIVOS I	2		
HOGAR DEL SOL	2	LOS OLIVOS II	1		
JUAN PABLO I	1	LOS OLIVOS III	4		
				TOTAL	195

Date and Time	
Interviewer	
Name of Barrio / address	
Name of Interviewee	
1. General	
How many years have you lived in the house?	
How many times have you suffered from inundation in the house?	
Which were the year and month in which you suffered from those inundations?	Year Month Year Month
When was the maximum (most serious) flood in your house ?	
2. May 2006 flood	
Do you remember the day and time of the highest waterlevel ?	May XX, AM/PM
If you have some marks of the waterlevel, please show me ?	ZZ cm above the floor YY cm above the ground.
How many hours did the high waterlevel last ?	hours
Did the flood water include sediment? If it did, what kind of sediment it was ?	
Did you evacuate to other places ? If so, where ?	
What kind of damage did you suffer from ? If you can estimate the damage, how much was it ?	
3. Other flood	
Do you remember the day and time of the highest waterlevel ?	May XX, AM/PM
If you have some marks of the waterlevel, please show me ?	ZZ cm above the floor.
How many hours did the high waterlevel last ?	hours
Did the flood water include sediment? If it did, what kind of sediment it was ?	

Figure 9-5 Interview Sheet for Soacha

Figure 9-6 shows the inundated area in the May 2006 flood according to the interview results. The Soacha River was affected more heavily than the Tibanica river. At San Jorge Station (IDEAM, self-recording gauge) the daily rainfall 20 mm was recorded on May 11, 2006. The hourly rainfall was 7.5 mm from 8:40AM, May 11, 2006. The most seriously affected area in the Soacha river was Llano Grande, which is located in the left bank of the upper stream of the Autopista Sur. The maximum inundation depth was slightly higher than 1 m. A child was rescued by boat supplied by the Soacha firefighter. The area around Llano Grande is lowland area compared with the Soacha River. The Soacha River is affected by the sediment runoff from the upstream area, especially from the brick factories. So, that the river bed has been getting higher due to the sedimentation, which causes a flood easily. According to the interview results, the inundation was caused by the backwater of sewerage pipe from the river.

The most downstream reach of the Soacha River near the confluence to the Bogota River was also inundated; however, this area is rural area such as livestock farming area.

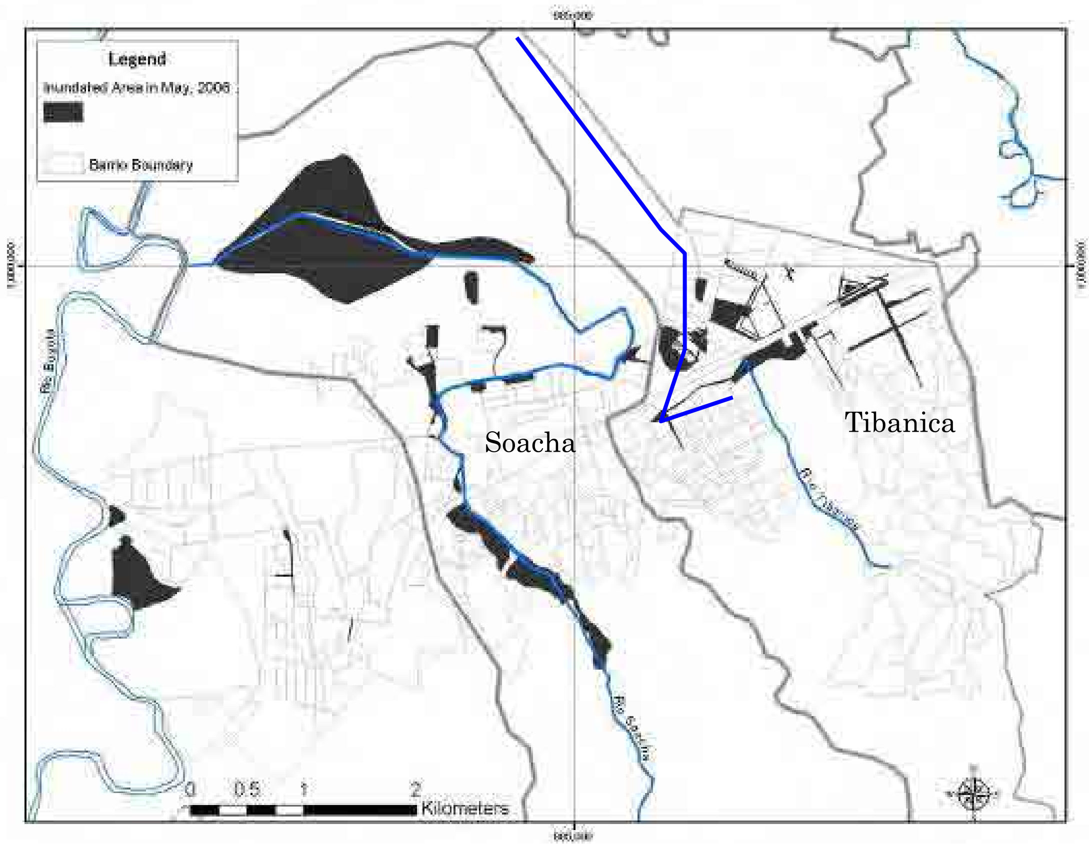

Figure 9-6 Inundation Area by Flood in May 11-12, 2006 in Soacha

In the Tibanica basin, the upstream and the downstream of the Autopista Sur were affected locally. According to a Soacha City official, because of the lack of capacity of culvert passing the Autopista Sur, the same areas have suffered from inundation very frequently. In the Tibanica basin, there is the Terreros Dam in the middle part, which has flood water storage function. It is regarded that at May 2006 flood the Terreros Dam was effective, however, local improper drainage system caused inundations.

9.2.2 Characteristics of Floods

(1) Soacha River

There are three (3) main flood-prone areas in the Soacha river. One is El Cardal to Autopista Sur, Another is the area around El Silo. And the rural area neat the confluence of the Bogota river is also flood-prone area.

The area between El Cardal and Autopista Sur used to be wetland of the Soacha river, according to the aerial photo in 1941. The present residential area is low-lying area along the Soacha river. The inundation usually starts inland flood, sewage water returning from the river side because of the low-elevation. The May 2006 flood was very serious inundation because the inundation was caused by the overflow of the Soacha river. The flooded water remained in the low-lying area for several hours. The more frequent flood can be said the inland flood such as backwater of sewage system and water accumulation in the low area.

The area around El Silo is located at very low elevation compared with the Soacha river channel. El Silo is a residential complex area. According to the digital elevation map near this area, it was found that El Silo and El Danubio, El Prado de las Vegas are located at lower than the Soacha river. Therefore once the Soacha river overflows, the flood water are going toward these barrios.

The rural area neat the confluence of the Bogota river is also low-lying area. The river bed of the Soacha river is higher than the ground, so when the river water is high, the surrounding area suffers from inland flood easily. Also this rural area is affected by the Bogota river high water.

(2) Tibanica River

The Tererros Dam is regulating the rainfall runoff from the upper part of the Tibanica river. According to the EAAB's Soacha Master Plan, the outflow from the Dam for 100 years return period is only 2.7 m^3/s. In this sense, the inundation in the area downstream of the Dam is caused by the local rainfall itself.

The flood-prone area is concentrating in the area around the Autopista Sur. Since the channel slope is milder than 1/1,000 in that area and the channel crossing structure such as bridge culvert are affected by sedimentation and accumulated garbage. Therefore the riverine area is easily affected by local rainfall stagnation. In present condition, the rainfall runoff from the Cazuca area is accumulating in the canal along the Autopista Sur, however, due to the small drainage capacity of the crossing structure under the Autopista Sur, the inundation is quite outstanding.

9.3 Existing Monitoring System

9.3.1 Existing Operated Stations

In and around the Study Area for Soacha, there are several rainfall stations and waterlevel stations. Figure 9-7 shows the location of monitoring stations in and around the Study Area. They are the stations of DPAE, IDEAM, CAR and EAAB. The Soacha city does not have its own monitoring station, even conventional type. Table 9-2 is the list of currently operating stations, of which the Study Team could collect some data.

Table 9-2 List of Monitoring Stations in and around the Study Area

Area	Rain/WL	Name	Features
Upstream area of Soacha River	Rainfall	San Jorge(IDEAM)	Conventional gauge with recording chart. Once a month the data is sent to IDEAM by postal mail.
	Rainfall	San Jorge(CAR)	Conventional gauge with recording chart. It is maintained by CAR.
	WL	San Jorge(CAR)	Staff gauge in mountainous creek.
Bogota River	Rainfall	Las Huertas(EAAB)	Conventional gauge with recording chart.
	WL	Las Huertas(EAAB)	Automatic gauge with telemeter system
	WL	La Isla(EAAB)	Automatic gauge with telemeter system
Tunjuelo River	WL	Puente La Isla (EAAB)	Staff gauge
Upstream area of Tibanica River	Rainfall	Sierra Morena(DPAE)	Automatic gauge with telemeter system
	Rainfall	Minutos(IDEAM)	Automatic gauge with telemeter system
	Rainfall	Casablanca((EAAB)	Conventional gauge with recording chart.

The flooding area in May 11, 2006 flood is mainly downstream area of the Soacha river and the Tibanica river.

In the Soacha river upstream there are San Jorge (IDEAM Climatology), San Jorge (CAR rain) and San Jorge (CAR waterlevel). Among them the IDEAM San Jorge station has been operated and maintained well by IDEAM.

In the Tibanica river upstream there are three (3) rainfall stations closely each other, which are Sierra Morena, Minutos and Casablanca operated by DPAE, IDEAM and EAAB, respectively. They are located in Bogota city, just on the catchment boundary of the Tibanica river. The Sierra Morena (DPAE) station is the closest one to the Tibanica river catchment and one of DPAE monitoring stations with telemeter system.

Along the Bogota river, there are two (2) important waterlevel stations. One is Las Huertas (EAAB) and another is La isla (EAAB). The Las Huertas station is located downstream of the confluence of the Soacha river to the Bogota river. The La Isla station is located just upstream of the confluence of Tunjuelo river to the Bogota river. They are EAAB telemeter stations and the real time data can be seen in the EAAB web-site.

9.3.2 Soacha City's Accessibility to Monitored Data

Soacha city does not have any official, routine line to DPAE, IDEAM, CAR and EAAB regarding the monitored data exchange.

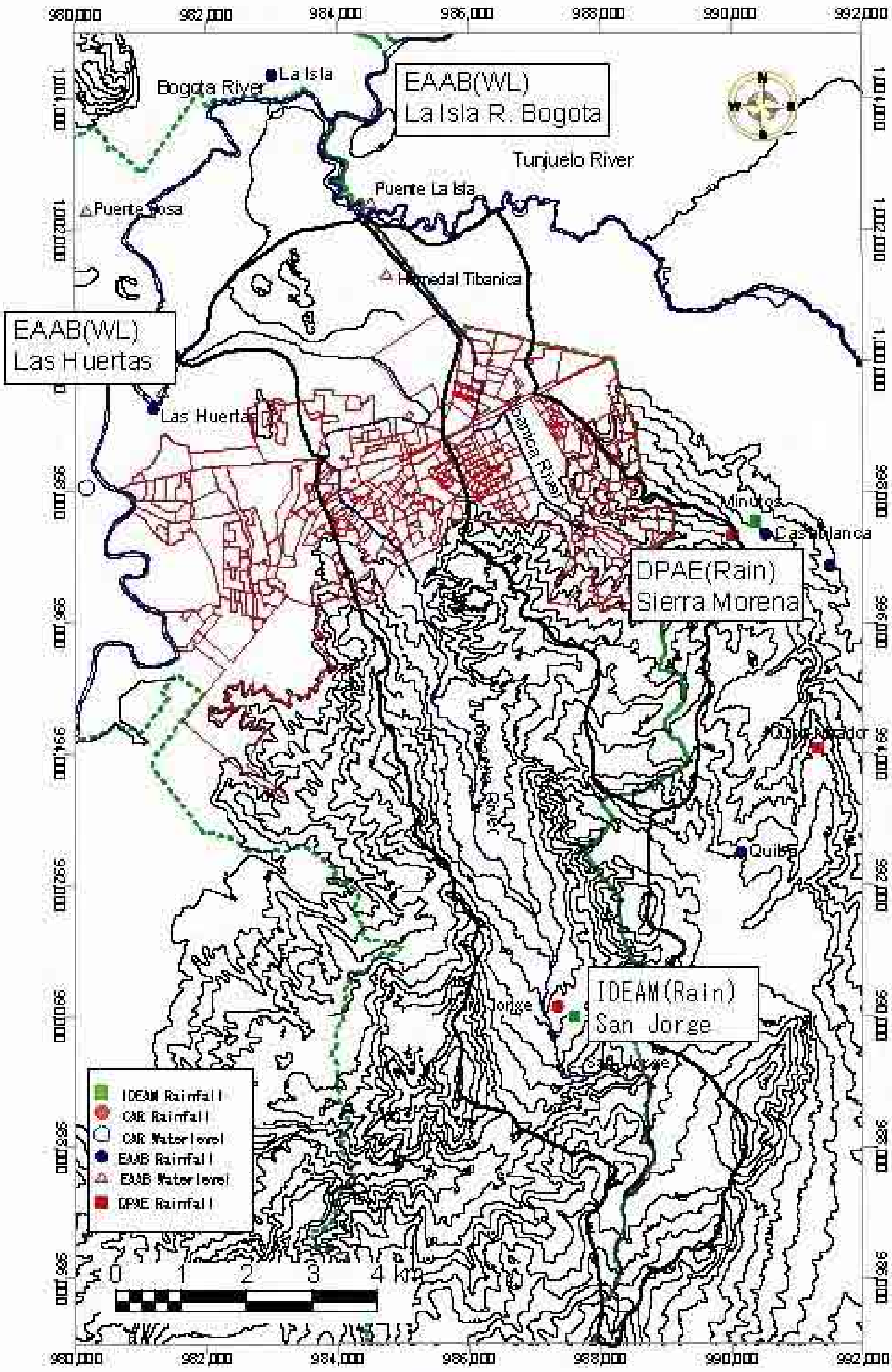

Figure 9-7 Main Monitoring Stations in and around the Study Area

9.4 Flood Analysis and Mapping

9.4.1 Conditions of May 11, 2006 Flood

(1) Rainfall Condition in San Jorge (IDEAM)

In the Soacha river basin, IDEAM's San Jorge Station recorded rainfall during the May 11 flood. San Jorge station is located in the upstream area of the basin.

The daily rainfall of May 11, 2006 at San Jorge was 20 mm according to IDEAM interpretation of the self-recording paper.

Figure 9-8 shows the daily rainfall at IDEAM San Jorge since March 2006. In March 8 and March 18, the rainfalls over than 35 mm per day are registered. The Study Team collected the original self-recording paper of those days and checked the rainfall amount, however, the ink was not drawn on the paper clearly and it might be that actual rainfall amount were 10 mm less than the registered amount.

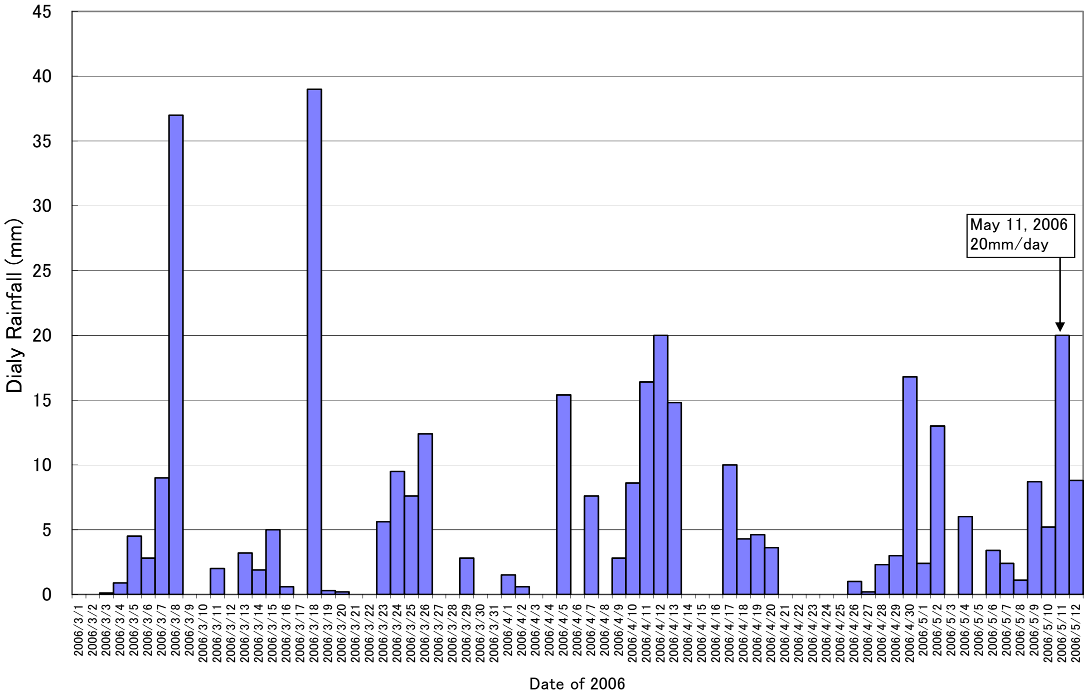

Figure 9-8 Daily Rainfall in San Jorge (IDEAM) in 2006

The Study Team checked the original recording paper on May 2006. The maximum hourly rainfall in May 11, 2006 was 7.5 mm from 8:40AM to 9:40AM according to the self-recording paper.

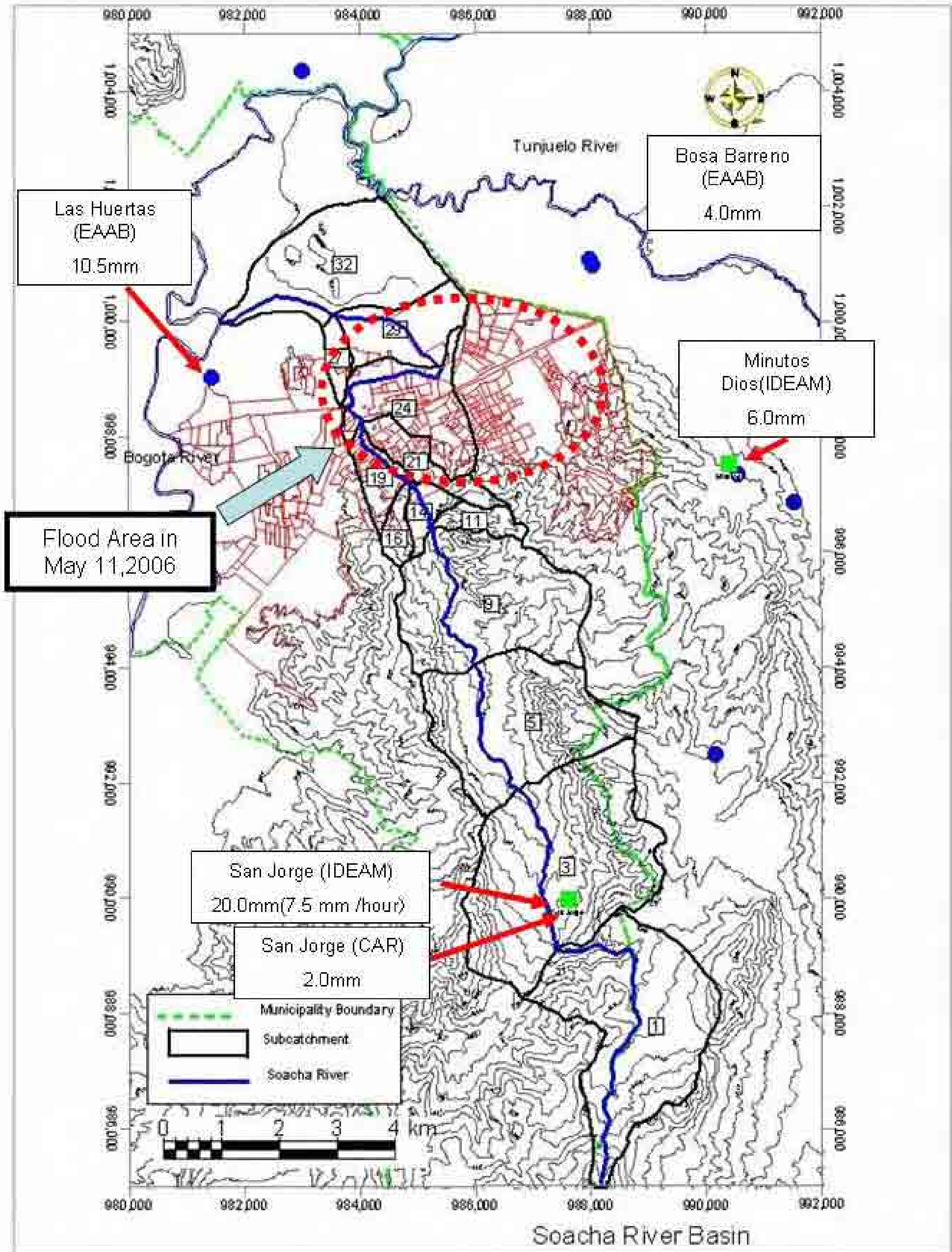

Figure 9-9 Daily Rainfall in San Jorge (IDEAM) in 2006

(2) Flooding Time in Soacha River

The flood level at Fusunga was about 50 cm above the left -bank ground elevation. The peak water level took place at 11:45 AM on May 11, 2006 and lasted about 4 hours according to a resident living at the riverside. In the photo below, the water level was just 1 meter 40 cm on the staff gauge at 8:00AM and the heavy rainfall happened at 10:30 AM on that day.

Photo 9-1 Flood Level of Fusunga Section

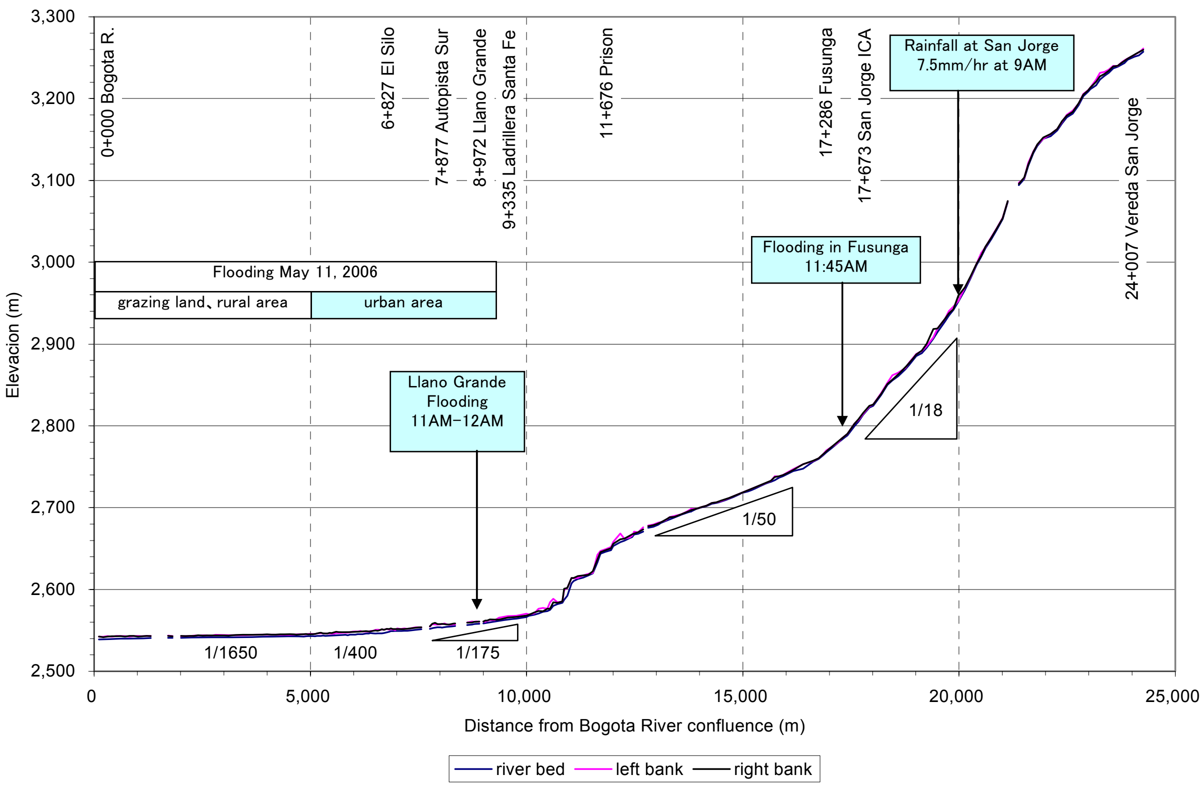

Figure 9-10 Flooding Time in May 11, 2006 in Soacha River

The flooding in Llano Grande (El Cardal to Autopista Sur) took place from 11AM to 12AM. According to the communities in Llano Grande, there was no rain in their area and the river overflow suddenly happened.

9.4.2 Channel Capacity and Flood Discharge

(1) Flood Discharge

The Study Team obtained flood elevation by interviewing to the communities regarding May 11, 2006 flood in the Soacha River. The locations are Fusunga, Prison, Ladrillera Santa Fe and Llano Grande. The area between El Cardal to Autopista Sur has quite a few flood marks.

For Fusunga, Prison, Ladrillera Santa Fe and Llano Grande, the flood peak discharges were assumed by uniform flow calculation.

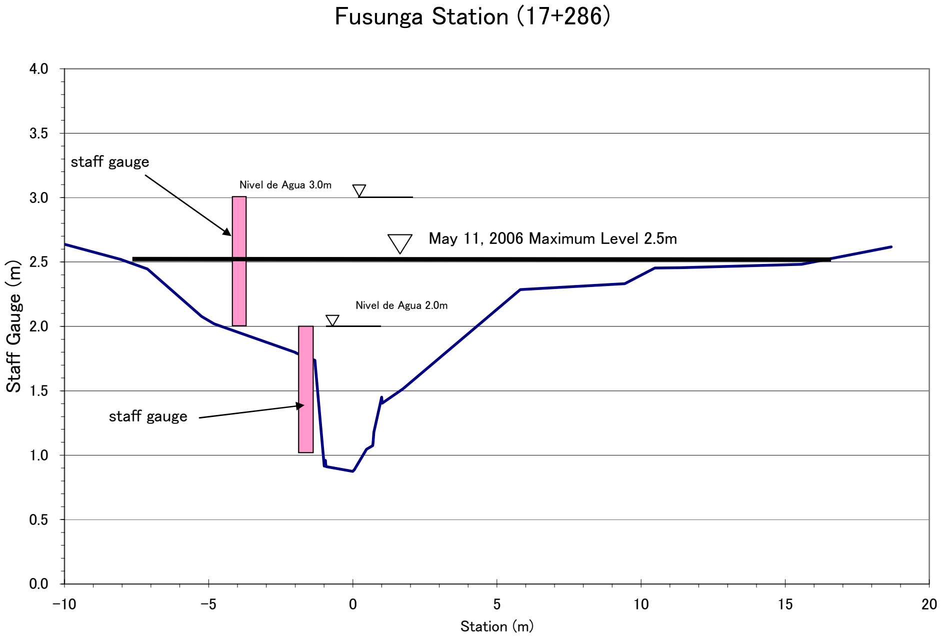

Figure 9-11 Cross Section and Flood Elevation at Fusunga

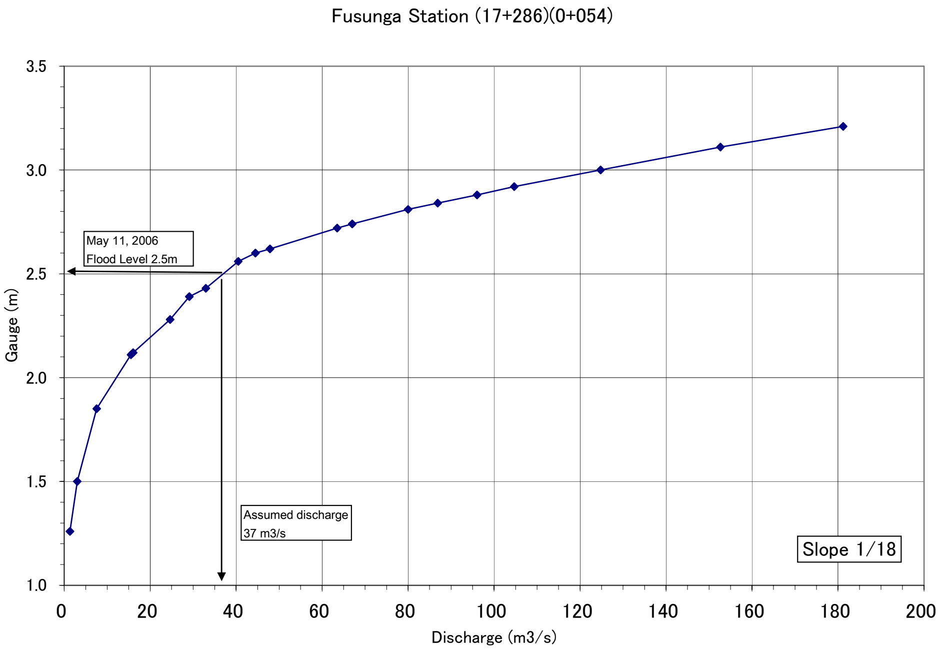

Figure 9-12 Waterlevel and Discharge Curve at Fusunga

Figure 9-13 Cross Section and Flood Elevation at Prison

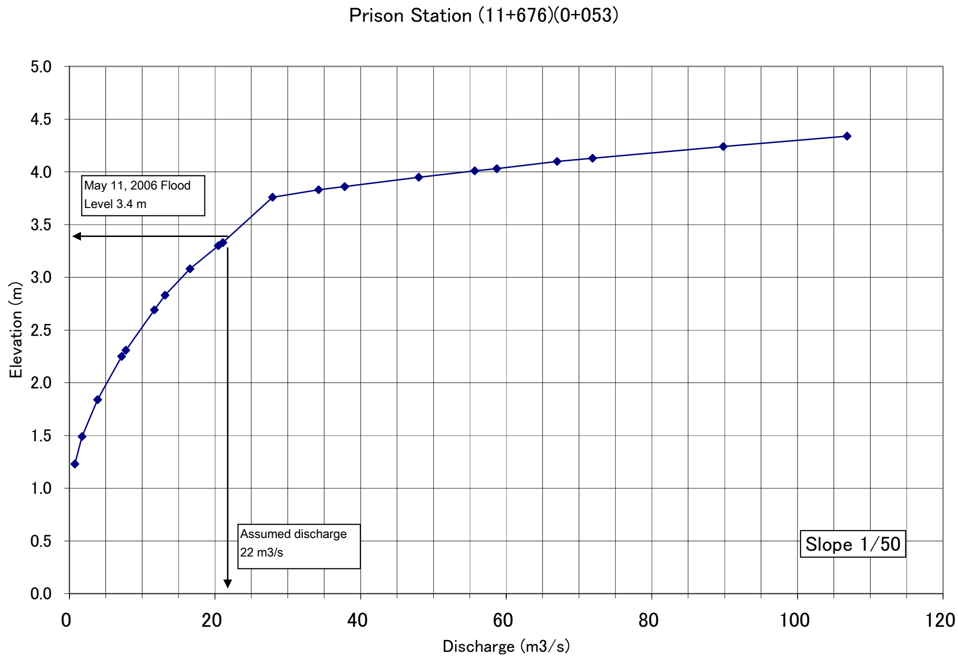

Figure 9-14 Waterlevel and Discharge Curve at Prison

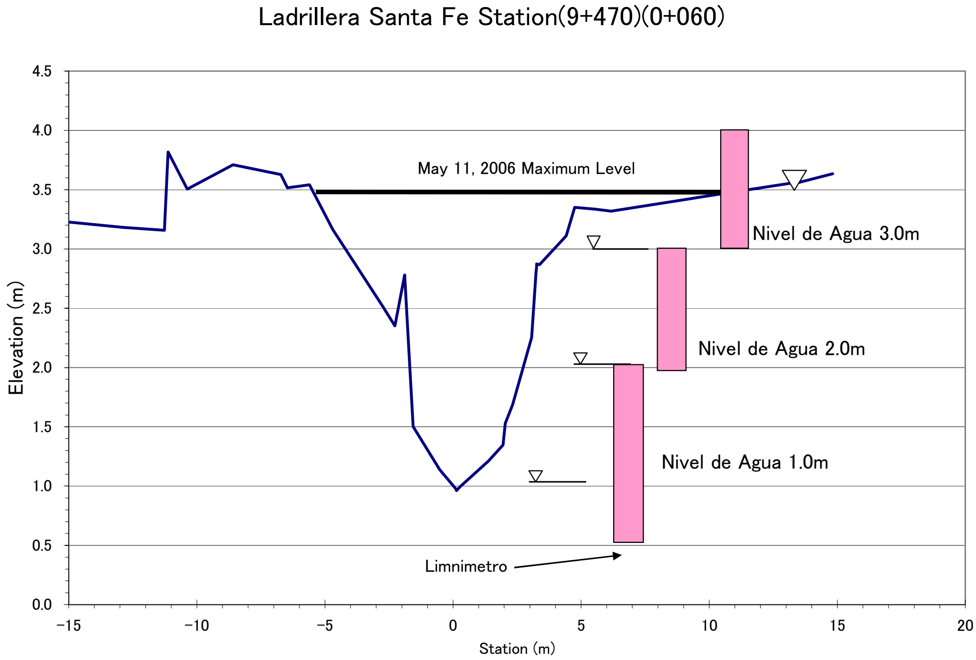

Figure 9-15　Cross Section and Flood Elevation at Ladrillera Santa Fe

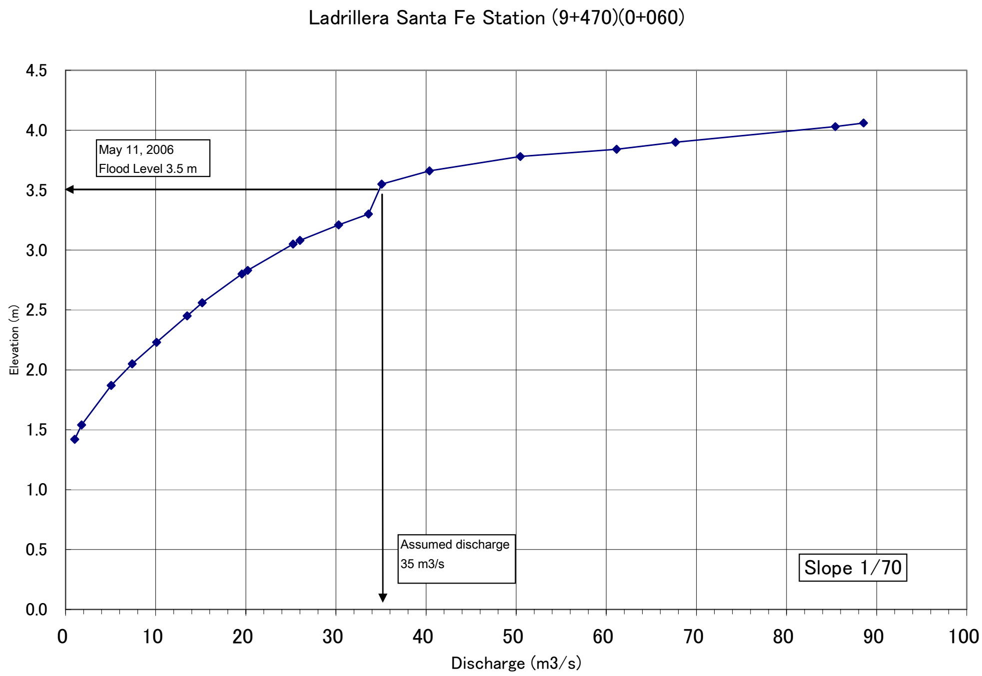

Figure 9-16　Waterlevel and Discharge Curve at Ladrillera Santa Fe

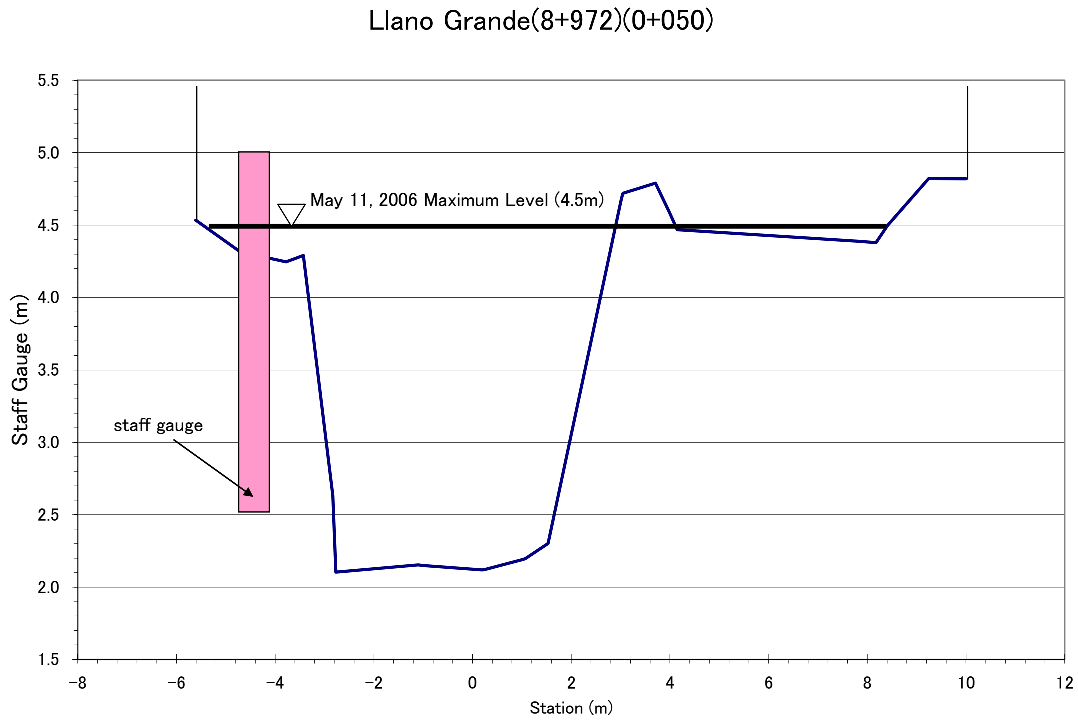

Figure 9-17 Cross Section and Flood Elevation at Llano Grande

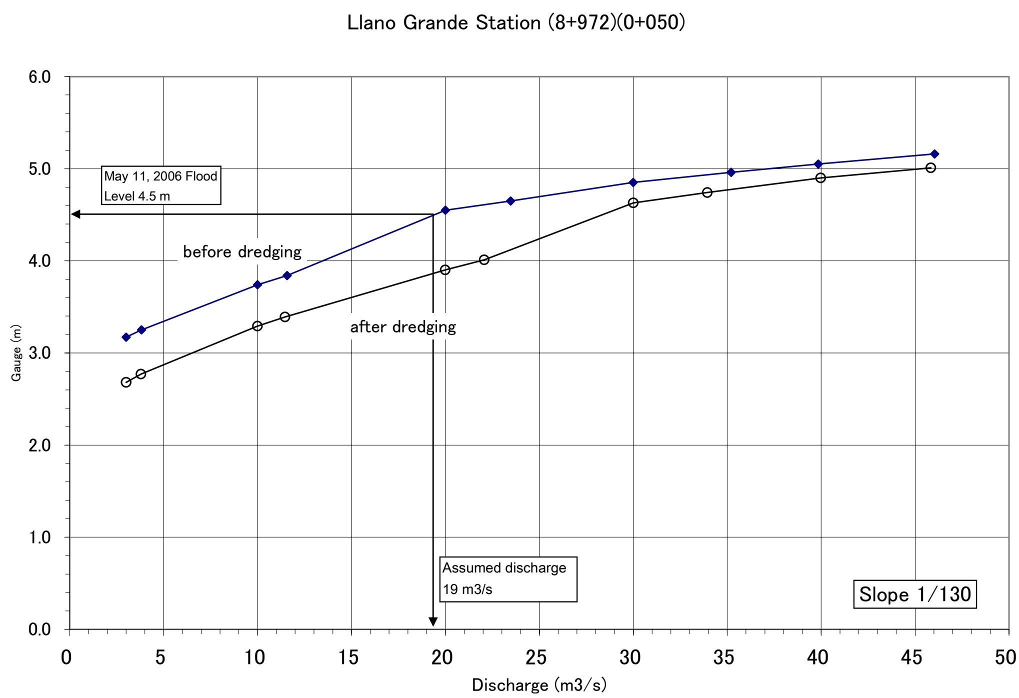

Figure 9-18 Waterlevel and Discharge Curve at Llano Grande

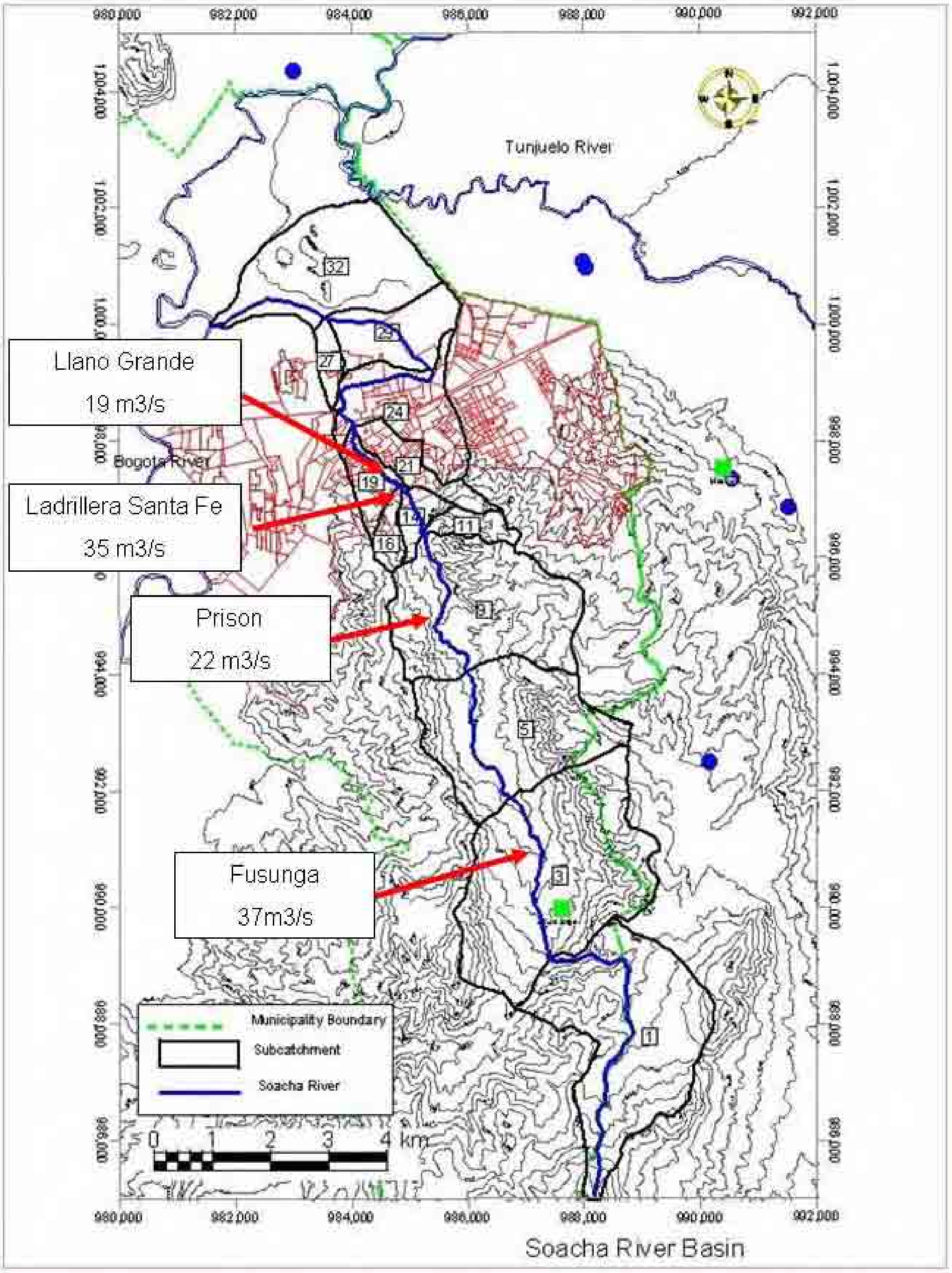

Figure 9- 19 Flood Mark-Assumed Peak Discharge in May 11, 2006 Flood

Figure 9- 19 shows the estimated peak discharge in May 11, 2006 flood based on the flood marks obtained from the community's evidence. The Ladrillera Santa Fe and Llano Grande are 500 m apart. The Ladrillera Santa Fe is so confined section that the peak discharge can be regarded as more reliable. The assumed discharge at Llano Grande is that of discharge after overflow.

Figure 9-20 shows the calculated peak discharge from the measured rainfall. The measured rainfall is the distribution of San Jorge station (IDEAM) in May 11, 2006. The rational method was used considering the concentration time at Fusunga, Prison and Ladrillera Santa Fe. The peak discharge at Prison and Ladrillera Santa Fe seems lower than the assumed discharge from the flood mark. From this result, there is possibility that more rainfall had in the middle part of the catchment. This is one reason for the new rainfall observation point is recommended in the Study.

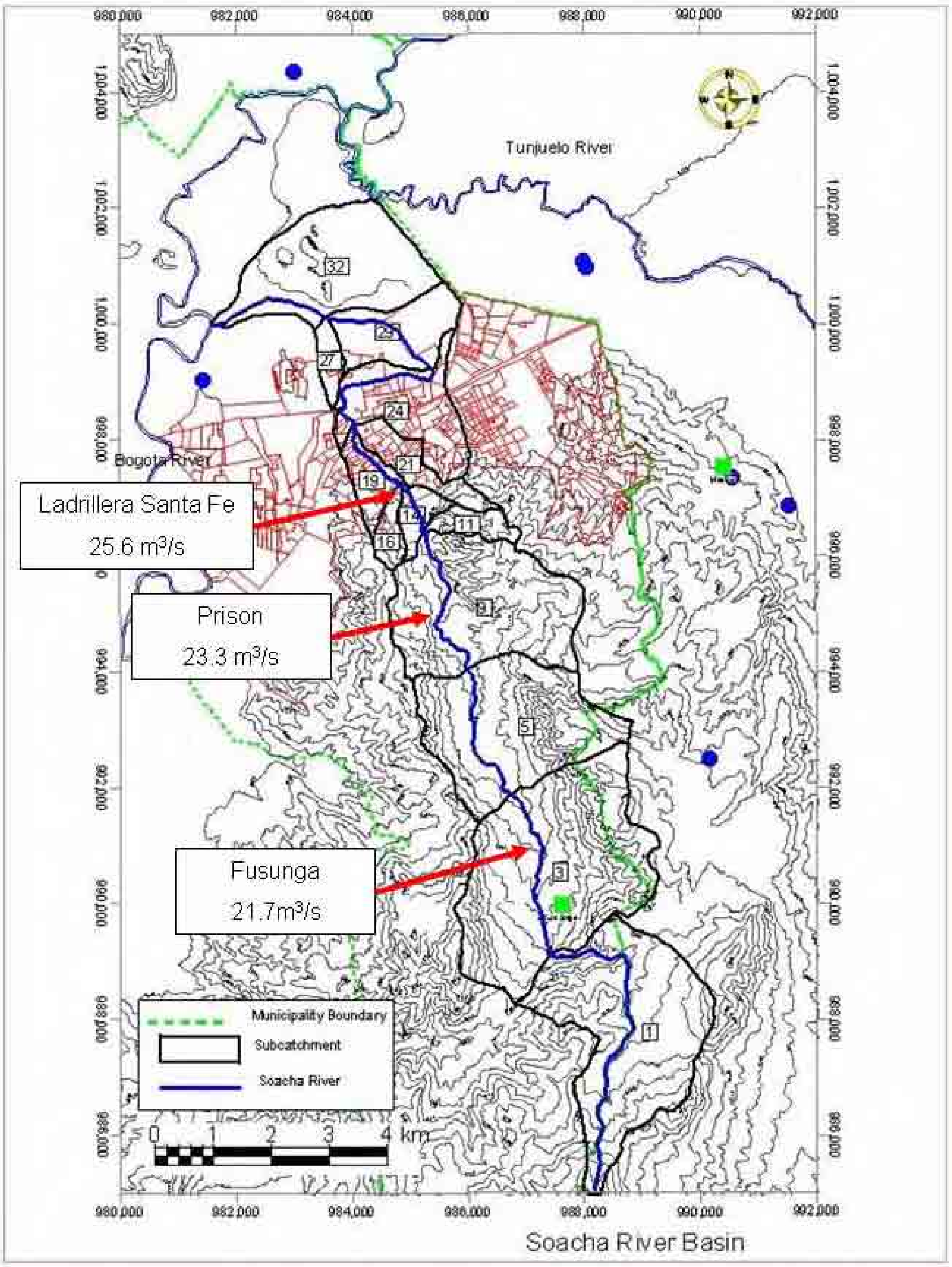

Figure 9-20 Rainfall-Assumed Peak Discharge in May 11, 2006 Flood

(2) Channel Capacity

The flow capacity of river cross section is defined by passable water discharge within both banks at the bank elevation. Usually the elevations of left and right banks are different, so the flow capacity was evaluated for each bank elevation. The conveyance value “K” at the given bank elevation for each cross section. The Manning roughness coefficient is set 0.04 for conservative side. If the river bed slope is given, the flow capacity can be calculated as follows,

$$Q_c = K \times \sqrt{S}$$

K : conveyance (m3/s)

S : River bed slope for flow capacity calculation

Qc : Flow capacity in m3/s

Figure 9-21 is the longitudinal profile of the channel capacity of the Soacha river. The reach between Fusunga and Carcel has a low capacity due to the mild longitudinal slope. The reach from Ladrillera Santa Fe and el Silo has a capacity of 15 m^3/s at minimum. The section below 5+000 is quite low capacity, less than 10 m^3/s.

Soacha City conducted river channel dredging after May 2006 flood, especially the section below El Cardal to Autopista Sur. The channel capacity in Figure 9-21 already considered the channel after dredging. The capacity around El Silo is comparatively still smaller than the upstream.

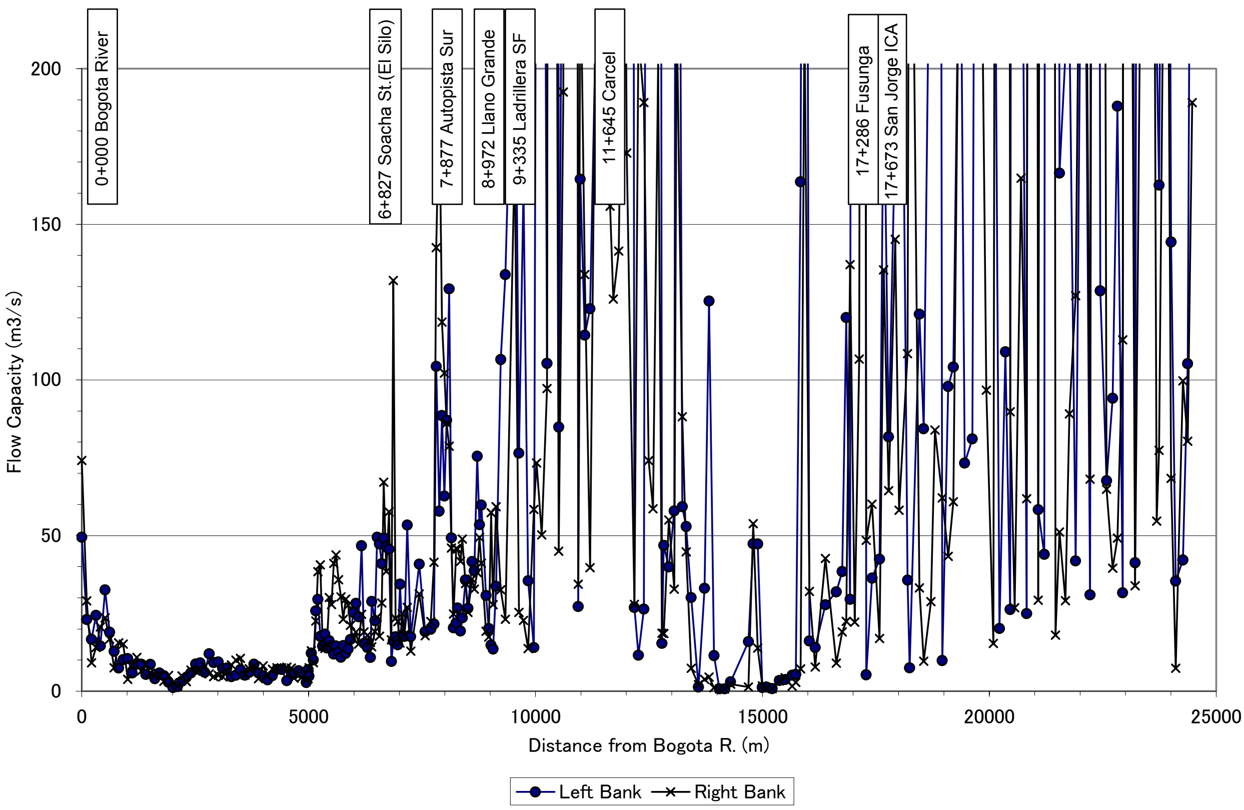

Figure 9-21 Channel Capacity of Soacha River

Figure 9-22 is the longitudinal profile of the channel capacity of the Tibanica river. The reach between spillway and Autopista Sur is high capacity because of the dike. The reach from Autopista Sur and 1+600 has the capacity less than 10 m^3/s.

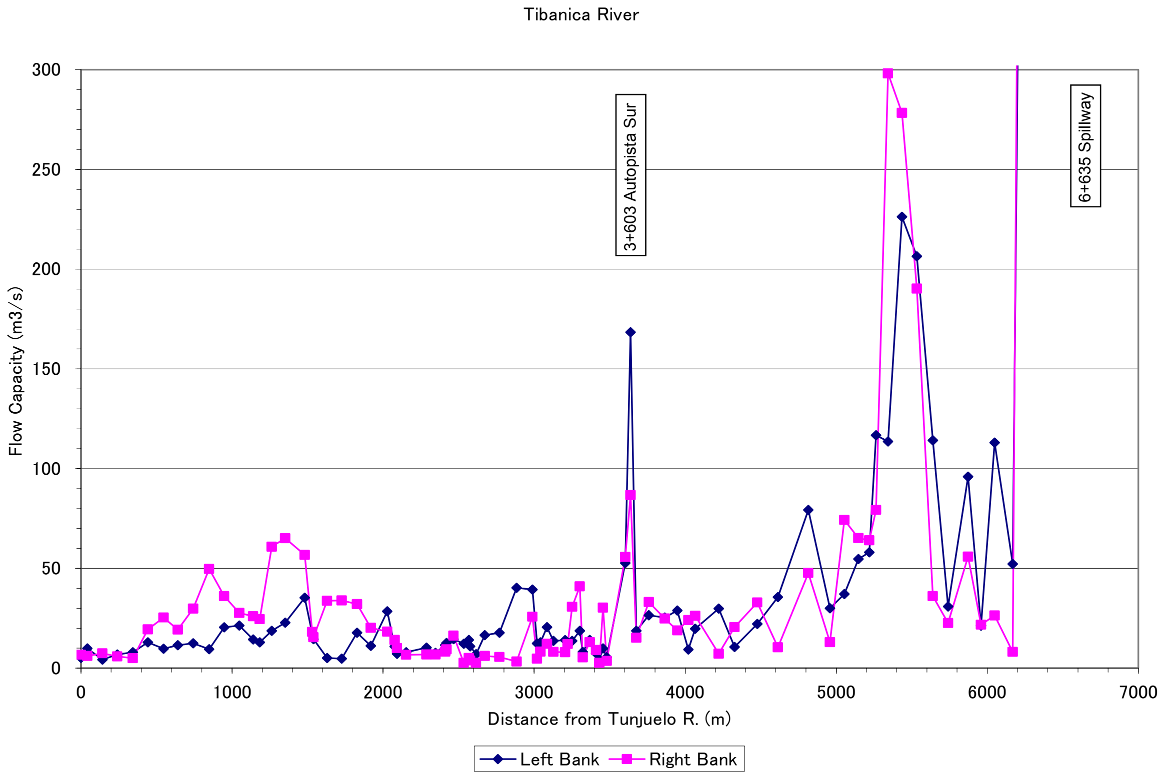

Figure 9-22　Channel Capacity of Tibanica River

9.4.3　Flood Mapping

(1) Methodology

The methodology for flood mapping in the Study Area of Soacha composed of three (3) ways. One is the mapping of past flood (May 11, 2006) based on the interview survey by the Study Team. And one is the hydraulic mapping based on one (1) dimensional calculation. Another method is inland flood mapping based on the waterlevel in the Bogota river.

The hydraulic mapping was done using software called HEC-RAS. This software was also used in the evaluation of flow capacity of rivers in the Study Area.

(2) Mapping of May 11, 2006 Flood

Using the results of flood interview survey for May 11, 2006 flood, the affected area was delineated on the topographical map as shown in Figure 9-23. The exact boundary of affected areas was decided based on the people’s answers during the interview survey. In the flood map, the areas whose inundation depth was less than 1 meter and more than 1 meter were distinguished.

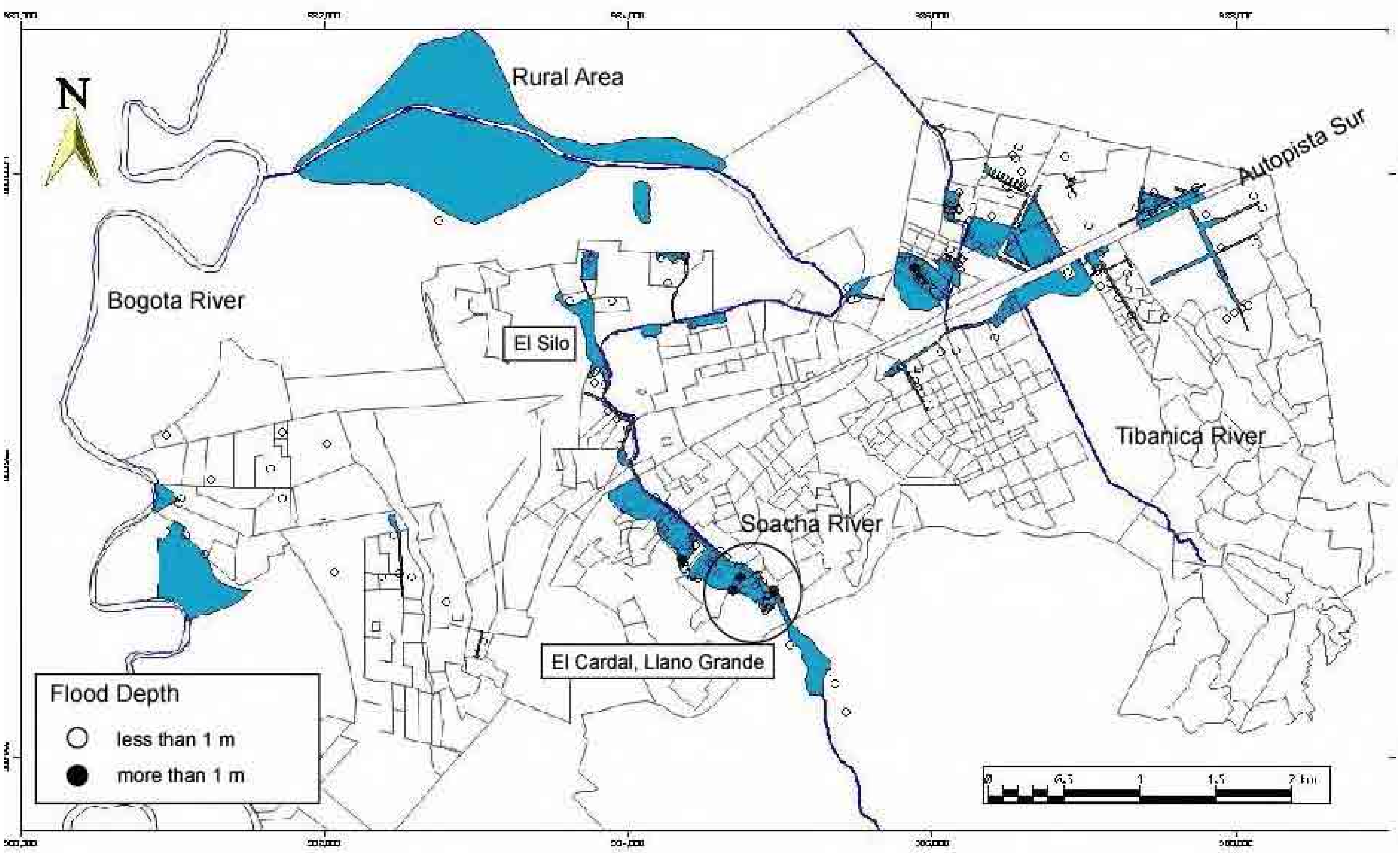

Figure 9-23 Flood Area and Depth for May 11, 2006 in Soacha River and Tibanica River

(3) Hydraulic Mapping of Soacha River

1) Used Basic Data

In the Study, river cross section survey was conducted along the Soacha river and the Tibanica river. The cross section interval was basically 100 m and 50 m in urban area. The elevation in the floodplain along the surveyed cross section was supplemented by topographical data of 2 m contour line and SRTM3 data.

2) Results

The hydraulic mapping using software called HEC-RAS is shown in the Data Book 1 as the case of May 11, 2006 flood scale.

(4) Inland Flood Mapping by EAAB Las Huertas Waterlevel

The area near the Bogota river confluence is affected by the high water of the Bogota river. There is a telemeter watelevel station of EAAB called Las Huertas just downstream of the Soacha river confluence. The waterlevel 2,541.5 m at Las Huertas could cause inland flood in the rural area of Soacha. The area whose ground elevation is below 2,541.5 m was mapped as probable inland flood area. The map is included in the Data Book 1.

9.5 Monitoring and Early Warning Plan

9.5.1 Introduction

Soacha Municipality is frequently suffering from flood and landslide disasters. Most recently, floods and landslide occurred in May 2006, and affected thousands of people living near the river and the sleep slope and their economic activities in the municipality.

There are two types of countermeasures such as structural countermeasures and non-structural countermeasures to mitigate the damage of disasters. It is obvious that structural countermeasures are effective to reduce the damage of disaster, however implementing them sometimes take longer time due to various reasons (e.g. large scale investment, resettlement and land acquisition, etc.) comparing to the implementation of non-structural one (e.g. installation of monitoring and early warning system, land use regulation and relocation, community based disaster management (CBDM) activities, etc.).

With consideration of the seriousness of disaster situation, insufficient technical resources and budget limitation of the municipality, installation of the monitoring and early warning system (MEWS) with CBDM would be the most effective solution to minimize the damages at this moment. On the other hand, it is understood that the MEWS is not perfect, and it is effective only if it is operated properly. It is also understood that MEWS has limitation to minimize the damage of disaster especially damage to immovable and some movables like cars, furniture, etc.

The proposed Plan on Monitoring and Early Warning System for Soacha Municipality will be presented in the following sections with close examination and consideration of the existing problems and above-mentioned MEWS characteristics. The scope of the system planning includes the design of the monitoring and the early warning system for short, middle and long term, determination of requirement for data analysis and processing system, determination of threshold level for issuing warning, and community based evacuation planning.

Since the main contents of the plan is the MEWS, other effective measures such as relocation and structural measures may not be include the proposed plan and are described as optional recommendations in chapter 13 of this Report.

9.5.2 Objectives and Purposes

The overall objectives of the proposed plan are to protect the citizens (to avoid any human loss) especially victims of past disaster, from future one, and to minimize the damage (to minimize loss of assets and properties, to minimize stop of economic activities) of flood and landslide disaster in Soacha Municipality by evacuating them appropriately in time.

To achieve the overall objective, the followings are set as planning purpose of the proposed plan:

- To establish effective monitoring and early warning system in Soacha Municipality
- To set warning criteria
- To propose institutional arrangement
- To enhance the capacity on disaster management in Alcaldía de Soacha by establishing of MEWS
- To enhance the capacity on disaster management in communities by preparing of the community based early warning and evacuation plan.

9.5.3 Planning Principle

(1) Target Year and Area

The proposed MEWS plan was prepared for the short, middle and long terms. The target year of the plan is set up for 2020. Since the pilot project(s) implemented in the study which is considered to be a part of the proposed plan, the implementation starts in 2007 and takes fourteen (14) years for the completion. The target area of the plan is Soacha Municipality including the Soacha river, Tibanica river.

(2) Planning Concept

In order to formulate the effective MEWS plan, the following planning concepts are applied.

<u>Provision of warning and evacuation information to communities in secure and timely manner</u>

To mitigate the damage, people living in hazard area and agencies concerned should take proper action. In this connection, the warning and evacuation information should be provided with security and timely manner with appropriate accuracy. Therefore, the proposed MEWS will be set up with careful examination of information transmission method and reliability of the system.

<u>Maximum utilization of existing information monitored by other organizations</u>

As for Soacha Municipality, meteo-hydrological monitoring stations and communication system owned by the municipality have not been installed at this moment. On the other hand, there are several stations operated by other organizations in and around the city. Therefore, existing information monitored by other organizations will be utilized as much as possible to reduce initial investment cost and avoid duplication efforts for monitoring.

<u>Maximum mobilization of local resources</u>

Since floods and landslide events in Soacha are mostly local event, hazard monitoring at hazardous areas are key to mitigate the damage. Automated monitoring system may be useful for monitoring activities in real-time basis however the cost for the equipment will be high. It is also important to take local actions during the disasters to reduce the damage. Therefore, maximum utilization of local resources (e.g. community organization, people, commercial and industry) will be considered for monitoring activities and actions when disaster happens.

<u>Optimum combination of advanced technology and “low”-technology</u>

To provide the information to the community security and timely, optimum combination of advanced technology (e.g. telemetric observation system, the Internet technology, etc.) and “low”-technology (e.g. manual observation of staff gauge, simplified automatic rain gauge etc.) will be applied for setting up the system.

<u>Setting of appropriate warning criteria</u>

The warning information should have enough accuracy and reliability, and should be understandable. Therefore, appropriate warning criteria (threshold level, organizational arrangement by phase, etc.) will be set based on the hydrological examination and institutional consideration, and then understandable form of information to the community will be considered.

9.5.4 Alternative Studies for Monitoring and Information Dissemination

(1) Monitoring

1) Hydrological Monitoring

For hydro-meteorological monitoring for Soacha area, there are hydro-meteorological stations of IDEAM, DPAE, EAAB and CAR. Some of the stations are equipped with a telemetering system. However the observed data has not been transferred and shared by the Soacha Municipality and the community.

For the discussion on the monitoring system in Soacha, it is better to start to clarify how to receive the monitoring data. Although at present the Soacha municipality does not have an automated real-time monitoring system, there are quite a few hydro-meteorological stations around the municipality as shown in Chapter 2.2. In this sense, the following two (2) options which are supposed to be extreme cases are considered. Option 1 is that the Soacha municipality will receive hydro-meteorological data from other organizations, based on the necessary agreement as well as community based monitoring stations. Option 2 is that Soacha municipality will have its own monitoring system like DPAE.

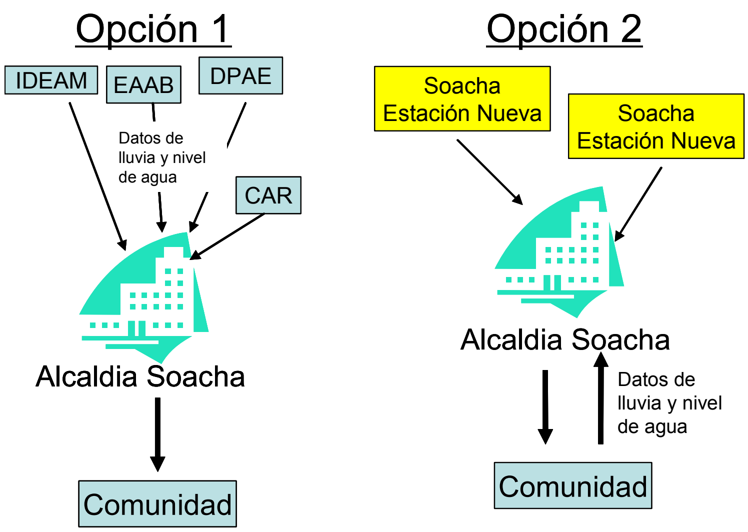

Figure 9- 24 Options for Future Monitoring System in Soacha

In order to select the best option, the following are considered:

- Disaster characteristics
- Reliability on data receiving
- Maintenance for the monitoring system including technical support
- Promotion of coordination with related organizations

<u>Option 1:</u>

The flood disaster in the area has been caused by heavy rainfall in the upper part of the Tibanica and

Soacha river basins. This option plan to use Sierra Morena Station (Tibanica river basin, DPAE, telemeter, rainfall), San Jorge Climatology station (Soacha River, IDEAM, conventional, need to upgrade for real-time monitoring) for rainfall monitoring. As for water level monitoring, the Las Huertas station (Bogotá river, EAAB, telemeter) can be useful for critical areas of inundation in and the low part, however, no water level monitoring gauge is installed in the middle reach of the river by other organizations.

As monitoring stations are managed by the other organizations, Soacha Municipality must wait for the data coming and this situation is not sufficient in terms of reliability of data receiving. In addition, the municipality is not able to get the water level data in the middle reach of the river from any organizations thus this also insufficient situation for issuing flood warning.

Option 2:

The option 2 is that the municipality will have all monitoring stations and communication networks by own management. As mentioned, the municipality has no existing monitoring system; it will cost much in initial investment and operation maintenance, and considered to be not sustaining from the technical and financial viewpoints.

Based on the considerations of above two extreme cases, Option 3, combination of the two extreme options is considered as shown below.

Option 3:

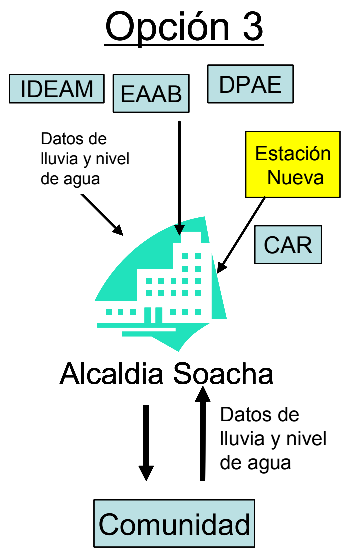

Figure 9- 25 Options for Future Monitoring System in Soacha

Option 3 is the combination of the Option 1 and 2, and has following advantages:

- Although the municipality has to wait for the data coming, the municipality would receive technical support from other organization for monitoring the hydrological information.
- The municipality could have necessary information for warning through community's monitoring activities.
- Since this option utilize existing monitoring network managed by other organizations and community based activities, the municipality could minimize initial investment cost for the monitoring system establishment.

(2) Information Dissemination System

The information dissemination system should provide the early warning information in security and timely. Aspects to be studied are information flow and its transferring method from Soacha

Municipality to community leaders and organizations concerned, and “last one mile” that means how to connect from community leaders and/or concerned organizations to residents.

1) Information Flow and Method from Soacha Municipality to Community and Concerned Organizations

Based on the existing information flow and past experience, information flow and method to the community are examined. The examination was done with the consultation of stakeholders of Soacha such as CLOPAD, Defensa Civil, Fire Brigade, etc. As a result of the examination, the flow of information is rather simple because Municipality of Soacha is a responsible organization to disseminate all information to communities and related organizations and no intermediate organizations in between.

As for the method of information dissemination, there are some options such as existing radio communication system, telephone, fax, SMS by cellular phone, e-mail, etc. Applicability of these methods are carefully examined both initial stage of implementation and future plan, and the results of the examination are summarized the following table.

Table 9-3 Comparison of Information Transferring Method

<table>
<tr><th rowspan="2"></th><th colspan="2">Community</th><th colspan="2">Government Organizations</th><th colspan="2">Commercial and Industry</th></tr>
<tr><th>Initial Stage</th><th>Future</th><th>Initial Stage</th><th>Future</th><th>Initial Stage</th><th>Future</th></tr>
<tr><td rowspan="2">Existing Radio System</td><td>***</td><td>***</td><td>***</td><td>***</td><td rowspan="2">*</td><td rowspan="2">*</td></tr>
<tr><td colspan="2">Special Channel will be allocated.</td><td colspan="2">Equipment will be provided by Soacha Municipality</td></tr>
<tr><td rowspan="2">Telephone/Fax</td><td>*</td><td>**</td><td>***</td><td>***</td><td rowspan="2">***</td><td rowspan="2">***</td></tr>
<tr><td colspan="2">Diffusion of telephone is still in low in the hazardous areas</td><td colspan="2">Duplicated communication system will be needed.</td></tr>
<tr><td rowspan="2">SMS/e-mail</td><td>*</td><td>**</td><td>**</td><td>***</td><td>**</td><td>***</td></tr>
<tr><td colspan="2">Diffusion of cell phone and Internet are still in low in the hazardous areas. Automated SMS/e-mal generation will be done in future</td><td></td><td>Automated SMS/e-mal generation will be done in future</td><td></td><td>Automated SMS/e-mal generation will be done in future</td></tr>
<tr><td>Other options</td><td colspan="2">Announcement by car, moto. etc. also useful to make sure. Siren installed in the community will be applied in future</td><td></td><td></td><td></td><td></td></tr>
</table>

*Note: 1) ***: Highly applicable, **: Applicable, *: Not applicable* *Source: JICA Study Team*
2) Government organizations include fire brigade, police, defense civil, military, Red Cross, etc.

2) Last One Mile (to the residents)

The “Last One Mile” is the most important part of the information dissemination system because saving life of people is highly relying on this part. Among several options of verbal communication using speaker installed at the community leader’s house, face to face communication by community people, siren and flash light installed in the community, tel/fax, etc., the verbal communication using speaker is the most appropriate method to disseminate the warning in the initial stage with consideration of time and certainty, and the siren and flash light may be considerable if the community peoples capacity is enhanced.

To disseminate the information widely and rapidly, role of media is important and using the media is also considerable in future stage. However, to avoid any affright situation of community people, appropriate form of warning through media will be studied with participatory process of community people.

(3) Warning Criteria

In the case of flood warning, it is obvious that rainfall and water level are main issue, especially since the catchments size is small in the study area the monitoring of rainfall amount and intensity is important. Regarding the determination of the threshold for the early warning, in the study area, observed data at the event of past floods are very limited, so it is difficult to determine the reliable warning criteria. Fortunately the Soacha river experienced May 2006 flood and people's memory for flood is still fresh. Therefore, rainfall amount and water level observed at May 2006 should be used as the basis of the tentative early warning criteria.

To set the appropriate warning criteria, following procedure will be taken.

Table 9-4 Procedure for Warning Criteria

Step	Activity	Remark
1)	Identification of Flood Hazard (Preparation of Inundation map)	To understand the past flood phenomenon (e.g. relationship between rainfall and discharge, discharge and inundation, water level and rainfall) is the most important thing.
2)	Analysis of past flood phenomenon by accumulated hydrological information	
3)	Setting of tentative warning criteria	
4)	Observation of rainfall and water level by community that affected by past flood	Those who really need the warning information only can continually observe the hydrological information.
5)	Training and Drills	To confirm effectiveness of warning criteria
6)	Hydrological analysis	Simulation of flood discharge and water level calculation using the recorded collected data.
7)	Setting of revised warning criteria	

9.5.5 Overall System Planning

The proposed MEWS for Soacha Municipality is a total system composed of four sub-systems namely, 1) Monitoring and Data Gathering System, 2) Data Analysis and Processing System, 3) Information Dissemination System, 4) Warning Criteria, in accordance with community based evacuation plans.

The overall system planning (schematic diagram of information flow and system components) is shown in Figure 9-26, and brief descriptions of each sub-system are shown in Table 9- 5.

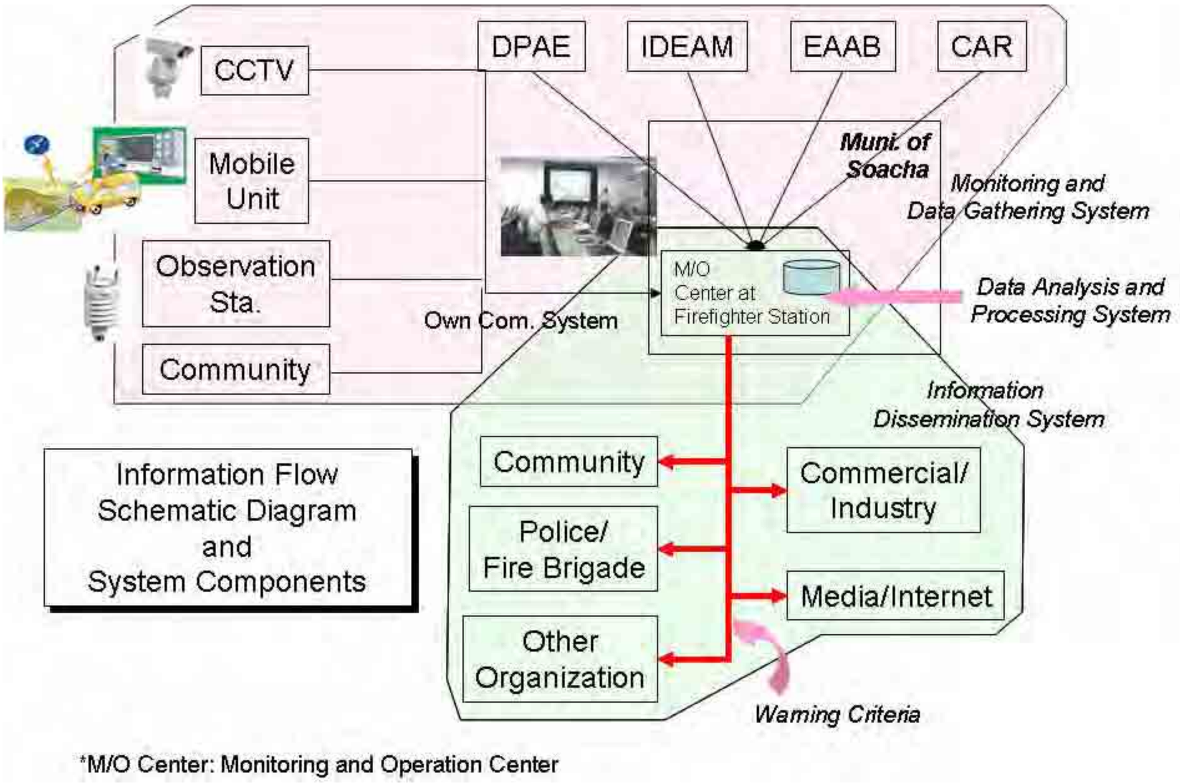

Figure 9-26 Overall System Planning (Future Image)

Table 9- 5 Brief Descriptions of Sub-Systems

Name of Sub-System	Description
Monitoring and Data Gathering System	To collect the information for issuing the warning, this sub-system consists of a monitoring network with other organizations, monitoring station, and communication network between stations and Soacha Municipality office.
Data Analysis and Processing System	The collected information is processed and analyzed in Soacha Municipality office which plays a center of monitoring and operation. Based on the analysis and the Warning Criteria, Soacha Municipality is to issue warnings.
Information Dissemination System	To disseminate warnings and related information, the communication network with community people and concerned organizations using certain warning methods is installed.
Warning Criteria	Warning criteria includes threshold levels which are determined by hydrological analysis, organizational arrangements by warning phase, and form of warning.

9.5.6 Detailed Planning

(1) Monitoring and Data Gathering System

1) Monitoring Plan

a) DPAE, EAAB and IDEAM Stations to be Monitored

It is proposed that the municipality can make use of the monitoring data available from other related organizations in its own monitoring system. The proposed telemetering stations to be monitored by Soacha are shown in the table below.

Table 9-6 List of Telemeter Stations to be monitored by Soacha

Organization	Stations to be monitored	Main purposes
DPAE(PG)	Sierra Morena	To monitor the rainfall in the Tererros Dam catchment and Altos de Cazuca
EAAB(LG)	Las Huertas, La Isla	To monitor the flood condition in the Bogota river and backwater effect for Soacha river and Tibanica river downstream.
IDEAM(PG)	Minutos	To monitor the rainfall in advance in the eastern part of the Soacha municipality

San Jorge Station of IDEAM is located in the upper part of the Soacha river catchment which is currently operated as the mechanical station; however, the real time observation of the rainfall is quite effective to issue the flood warning along the Soacha River. The Study Team is proposing a new rainfall station near San Jorge and the municipality will monitor the rainfall data through the community.

b) Soacha's own Monitoring Station

To monitor the meteo-hydrological situation in the city area properly, its own monitoring station will be installed. The Firefighter Station of the municipality which is attended by staff on a 24-hour base, is located along the Autopista Sur, between Tibanica and Soacha Rivers, because it is the best location that the station is near Altos de Cazuca in terms of the rainfall monitoring in the municipality from the view point of initial investment.

The rainfall measurement equipment should be a self-recording type and the measured and processed data should be presented on the personal computer display periodically.

This rain-gauge is utilized for collecting information about landslide occurrence as well as for flood monitoring.

c) Community-Based Monitoring Station

As proposed, the MEWS for Soacha will mobilize local resources as much as possible, and some of monitoring stations will be monitored by community people.

The community-based monitoring stations are proposed in the following locations:

Table 9-7 Community Based Monitoring Station

River	Type of Station	Location	Purposes
Soacha	Water level staff gauge	Middle reach of the Soacha River (Funsunga, Prison, Ladrillera Santa Fe and Llano Grande)	To monitor the water level in the Soacha river
	Rainfall Gauge	San Jorge(ICA), Prison	To monitor the rainfall in upstream and mid stream
Tibanica	Water level staff gauge	On the crest of the spillway of the Terreros Dam	To monitor the overflow depth from the Terreros Dam
	Water level staff gauge	Rincon	To monitor the waterlevel

In addition to the hydro-meteorological monitoring station, monitoring CCTV at the critical point and mobile operating units for monitoring and collecting the disaster information is installed in future. Overall monitoring plan is shown in the figure below.

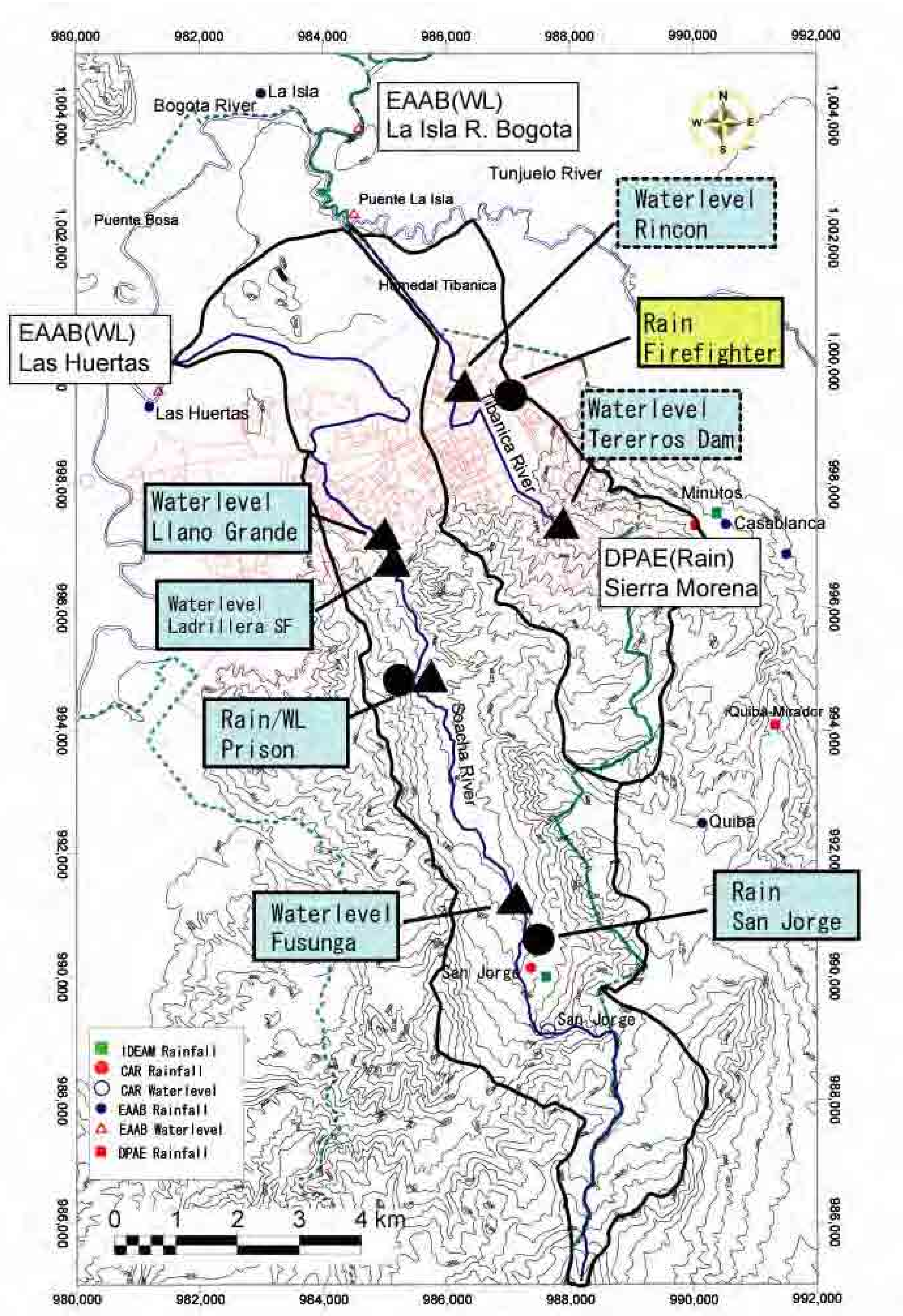

Figure 9-27 Overall Monitoring Plan

Table 9-8 Overall Concept for Community-based Monitoring Station in Soacha River

Station name	Catchment area	Basic point (distance from target area)	Monitoring item	Reason for Monitoring and Hydraulic or catchment features	Hydraulic or catchment feature	Equipment	Reasons for selection of the equipment	Security of Equipment	Person in charge of maintenance	Capacity of person in charge of maintenance	Other remarks
San Jorge (entrance of ICA,Colombian Agriculture Institute)	13.0km^2	Distance of 90 minutes as flood concentration time	Hourly rainfall	Since the flood concentration time at the target area is in the order of 1 hour, the hourly rainfall should be monitored.	It is located at the center of the upper stream of the target area.	Automatic rainfall gauge (tipping bucket) and data logger with display	Since short duration rainfall should be monitored, the automatic type with data display was selected in order that people can read the data in real time.	The equipment is installed inside of the ICA and the security guard can watch the equipment for 24 hours.	Security guard and their family（ICA）	Soacha city is planning to hold training for the security guard.	This station intended to promote the collaboration mind among people in upstream area to downstream.
Fusunga (residential area)	14.9km^2	Distance of 45 minutes as flood concentration time	Waterlevel	To confirm the runoff by rainfall in San Jorge, and flood at the upstream area.	The distance from the target area is long enough, the concentration time is longer than the time for evacuation (30 minutes)	Staff gauge	People's daily monitoring should be set up.	Resident and her family	resident	The resident is the lady who emphasizes the collaboration between upstream and downstream in the workshops and seminars.	
Prison (Prison of Soacha city)	25.4km^2	Distance of 30 minutes as flood concentration time	Waterlevel and rainfall	The runoff at Prison is affected by flood storage of the upstream reach, and the correlation between Fusunga and Prison should be confirmed. Also the rainfall in the mid reach should be monitored.	This location is only location at which the flooding of the downstream can be forecast.	Staff gauge, simple alarm device for waterlevel, simple rainfall gauge with alarm device	Since this is temporary station, simple equipment was selected.	The equipment is installed inside of the Prison and the security guard can watch the equipment for 24 hours.	City's security guard	Since the prison is now empty, the security guard can concentrate on the monitoring for 24 hours.	
Ladrillera Santa Fe (brick factory)	31.2 km^2	Distance of 15 minutes as flood concentration time	Continuous waterlevel	Warning can be issued from this point for the area in the lower stream of Autopista Sur.	The catchment area is 70 % of the entire catchment area of Soacha river and the river course is straight.	Staff gauge, automatic waterlevel sensor and data logger with display	Continuous waterlevel is monitored to evaluate the discharge and effective rainfall. Warning can be issued from this point for the area downstream of Autopista Sur.	The equipment is installed inside of the brick factory and the security guard can watch the equipment 24 hours.	Security guard of brick factory	high	This waterlevel is referred as warning for Autopista Sur downstream (El Silo).
Llano Grande (residential area)	31.7 km^2	0(basic point)	waterlevel	The affected people in 2006 should monitor the waterlevel.	This location is inside of the May 2006 flooding area.	Staff gauge	The 2 people affected by the flood in 2006 should monitor the waterlevel in order that they can understand the meaning of warning criteria and also the reason of false alert.	People and their family	3 persons	The affected residents in 2006 have high awareness for the monitoring and collaboration to the downstream area.	
Firefighter Station of Soacha city			10 minutes rainfall	The firefighter station should be designated as operation and monitoring center of Soacha city.		Automatic rainfall gauge (tipping bucket) and data logger with display	To evaluate the relation with landslide as well as flood is necessary.	Firefighter(24hours)	Firefighter	The firefighter conducted rainfall measurement using simple rainfall gauge since Dec. 2006 until October 2007 and enriched their monitoring skill.	

2) Communication Planning

The monitoring and Data Gathering System should handle raw and processed information including images, voices and movies in real time basis. The conceptual communication plan is shown in Figure 9-28.

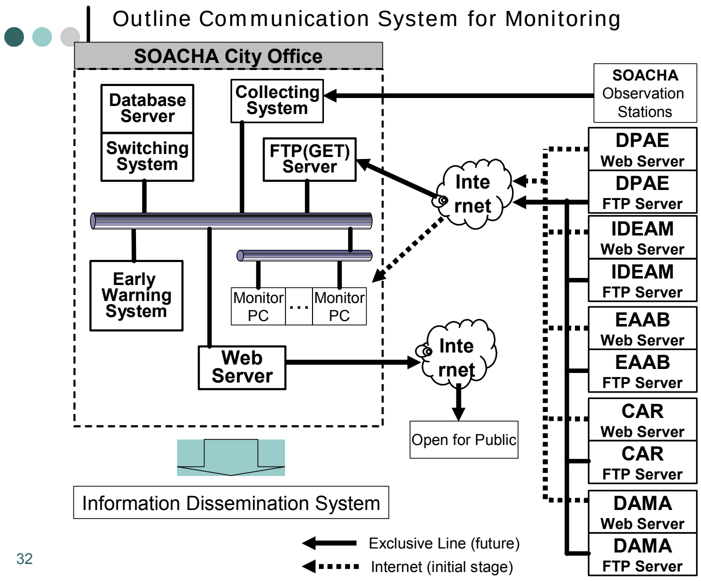

Figure 9-28 Communication Plan (Conceptual)

In the initial stage, communication link between EAAB and DPAE and Soacha Municipality using the Internet established. Communication link between community observation stations established at the same time. Radio communication system (UHF) will be applied to this communication system.

Exclusive link with data provider (IDEAM, DPAE, EAAB, CAR and Other related organizations) and own communication network between Soacha Municipality owned observation stations, CCTV Camera at critical points, Mobile Station etc. will be established in future.

3) Monitoring Frequency

Proposed frequencies for hydro-meteorological monitoring are shown in Table 9-9.

Table 9-9 Monitoring Item and Frequency (Pilot Project Stage)

	Normal Situation:	Warning Situation:
Rainfall (Fire Station)	Every hour	Every 10 min.
Rainfall (San Jorge Station)	8 hour	Every 60 min.
Rainfall (Community Stations)	8 hour	Stand-by at equipment
Waterlevel (EAAB stations Las Huertas and La Isla)	Half a day	Every hour
Waterlevel (Community Stations)	Every 8 hours	Stand-by at equipment
Waterlevel (Terreros Dam)	Every 8 hours	Stand-by at equipment

The rainfall stations installed at Fire Station and San Jorge Station in the pilot project phase are automatic-recording type with display monitor. The rainfall stations for community are normal rainfall gauge without any timer function.

The Study Team is placing strong emphasis on monitoring by community people. In San Jorge, Fusunga, Prison, Ladrillera Santa Fe and Llano Grande, the rainfall and waterlevel at each station should be monitored at same time as much as possible. In this way people can understand the waterlevel variation along the Soacha river.

Also in Fusunga and Llano Grande, in their upstream, there are another type of station such as rainfall station at San Jorge and automatic waterlevel station at Ladrillera Santa Fe. In order that downstream people should understand the entire monitoring system, periodically they should visit the upstream station to check the real time data.

(2) Data Analysis and Processing System

This sub-system includes four (4) system units of 1) Data Analysis and Processing System, 2) Early Warning System, 3) Database System, and 4) Internet Server. Function of each system units are summarized in the following

1) Data Analysis and Processing System Unit

This system unit process rainfall and estimates water level for generating the warning information. To complete this unit, unified simulation system of rainfall and run-off discharge will be required as well as continuous observation of rainfall water level and flood discharge. However, only a little hydro-meteorological information is currently available in this area, and impossible to establish the complete system unit at this moment. In this sense, installation of this unit will be the latest stage of implementation.

To fulfill the immediate needs for issuing the warning, simplified analysis system is proposed to be developed and installed during the pilot project. The simplified system will show the rainfall amount in certain time period and water level change in real time basis.

2) Early Warning System Unit

The ultimate goal of the Early Warning System Unit is to generate and issue early warning information automatically based on the output of the data analysis and processing system unit. Since the events occur in short time period, decision of warning issue should be done promptly, and the system should be useful to support the decision making.

Fully automated system cannot be developed at this moment due to the insufficient information for the data analysis and processing system unit. Therefore, in the initial stage of the implementation, semi-automated system (e.g. showing the monitored value with colored signal) will be developed and installed. The system details will be determined during the Pilot Project Period.

3) Database System Unit

Database system is basically designed to store monitoring information for future use. The system will be developed and installed at the beginning of the project of implementation, and information stored will be rainfall and water level at the initial stage.

Database system should be developed in GIS base and should be expandable to store the hazard map, past disaster information, disaster preparedness resources, etc. Hazard map and other products of this study will be a part of this database system.

4) Internet Server Unit

The Internet server is a server for the Web site that provides all information related to disaster preparedness. The server also equipped with the system that generates an e-mail and SMS automatically based on the information generated by the early warning system.

(3) Information Dissemination System

Information dissemination system planning is defined as information flow planning with communication system (method) planning.

Information will be disseminated to different target by disaster situation (or phase of operation) therefore the information dissemination planning especially information flow planning will be made by situation. To plan an effective information flow, streamlining of warning activities, such as identification of activities by situation, role allocation in each situation, etc., is requited. Figure 9-29 shows the summary of activities for warning activities by phase.

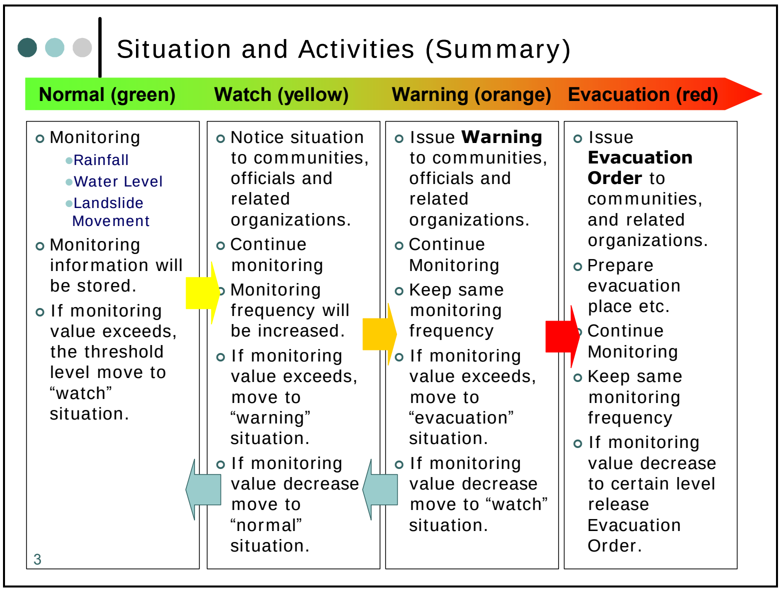

Figure 9-29 Summary of Activities by Situation

1) Role of Stakeholders and Information Flow

Based on the activities shown in Figure 9-29, role allocation study was carried out with consultation of stakeholders, and results are summarized in Table 9- 10.

Table 9- 10 Role Allocation for Stakeholders

Name	Normal	Watch	Warning	Evacuation
			Flood Warning 45	Flood Warning 15
Soacha (CLOPAD)	Monitor Information	Order communities and organizations to watch. Conti. Monitoring	Issue warning and Operation for preparedness Release warning	Issue evacuation order and Operation for evacuation Release evacuation order
Community Leader	Volunteer for monitoring	Watch situation and Monitor Value Ready to Action	Watch situation and Monitor Value Necessary action	Lead community people to safer place
Community	Volunteer for monitoring	Watch situation Communicate with communities of upstream and downstream	Pass information Operation for countermeasures Ready to evacuate	Evacuation
Fire Brigade		Consolidation of Information and inform situation to CLOPAD Watch situation Ready to Action	Consolidation of Information and inform situation to CLOPAD Operation countermeasures Saving life	Consolidation of Information and inform situation to CLOPAD Issue order based on the criteria if necessary
Police		Watch situation Ready to Action	Announce Warning Security of Site	Security of Site
Civil Defense	Volunteer	Watch situation Ready to Action	Watch situation Ready to Action	Assist Evacuation
Media			Disseminate Information	Disseminate Information
Cell Phone			Disseminate Information	Disseminate Information
Commercial /Industry			Assist operation Provide equipment and resources	Assist operation Provide equipment and resources
OPAD	Assistance in case of large disaster			

(Note: Roles shown on this table are only the role in the warning activity)

In the evacuation situation, other organizations (e.g., health department of the city, army, red cross, etc.) become to be the stakeholder organizations, and thus, the study on information flow includes these other related organizations. Figure 9-30 shows the results of the information flow study by situation.

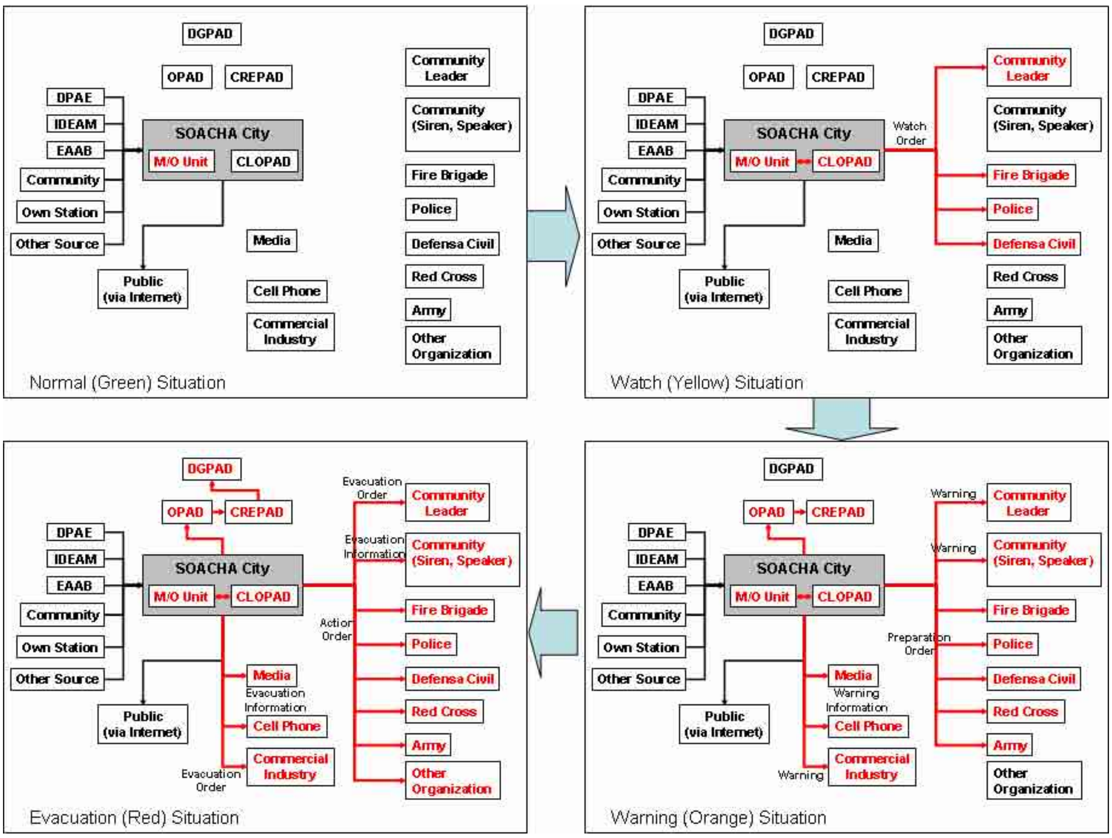

Figure 9-30　Information Flow by Phase

In addition to the "official" information flow presented above, a community to community information flow is established during the pilot project period. Details are presented in Chapter 9.6 and 10.

2)　Information Transferring Method

To ensure the transfer of information, communication methods shown in

Table 9-11 are proposed. The methods are carefully examined with current situation of the Soacha municipality and proposed in two phases of “Pilot Project” and “Future” phase.

Table 9-11 Information Transferring Method

Target	Method		Remarks
	Pilot Project	Future	
CLOPAD Members	Radio Telephone	Radio Telephone Internet, SMS	Using radio communication, can monitor conversation done other members like meeting
Fire Brigade	Radio Telephone	Radio Telephone Internet, SMS	Only organization 24/7 operation under AL. Soacha Centralized communication station
Police	Radio Telephone	Radio Telephone Internet, SMS	Police has special frequency and not utilize communication with other organizations. Soacha radio system will be provided for communication.
Defensa Civil	Radio Telephone	Radio Telephone Internet, SMS	Has special frequency for internal communication. Soacha radio system will be provided for communication.
Community Leader	Radio Telephone	Radio Telephone SMS	Assign special channel to community leaders using Soacha radio system will be provided for communication.
Community Site (direct to residents)	-	Siren Speaker and flashing light	Careful consideration of social situation Enhancement of community people is required for proper operation.
Media	Tel/Fax	Internet Tel/Fax	Special agreement will be necessary.
Cell Phone	-	Internet	Special agreement will be necessary. Automated SMS generation system will be considered in future.
Commercial/ Industry	Tel/Fax	Tel/Fax SMS, Internet	Own procedure on warning and evacuation situation will be prepared.

For the "Pilot Project" phase, the existing information handling methods are basically applied because introducing new method may cause the confusion of information transfer both officials of Soacha and community people.

(4) Warning Criteria

1) General

IDEAM is issuing daily meteorological bulletin including alert and warning in regional level in its web site and sending it to CLOPAD. The subjective area of the bulletin are eight (8) regions in Colombia, one of them is "Sabana de Bogotá". The bulletin includes the alert and warning regarding landslide and torrential rainfall in general way. The daily bulletin should be downloaded every day to confirm the current situation of "Sabana de Bogotá", and if there is a warning issue for Sabana de Bogotá, the Municipality should regard it as serious and raise the phase on organizational arrangement.

This May of 2006 happened the most serious flooding during last twenty (20) years on record in the Soacha River. The flooding was the highest on May 11, 2006. The IDEAM bulletin on May 10 issued warning ("alerta") for many regions in Colombia, but Sabana de Bogotá was not included. The subjective area of IDEAM warning is so wide that even though there is not a warning issue the flooding could happen locally such as Soacha`s case.

2) Flood Warning

a) General Warning

General Warning will be issued using the monitored rainfall amount. According to the disaster records and rainfall data in and around the study area, most of the disasters have occurred by a rainfall amount of 5 mm per day. The time distribution of the 5 mm rainfall is not measured, however, 5 mm for 1 hour is proposed considering the rainfall characteristics.

Also the waterlevel at Las Huertas (EAAB) can be made use of for inland flood in the rural area near Bogota River. The waterlevel 2,541.5 m is warning level, which can be monitored through the EAAB Web site in real time.

b) Specific Warning for Soacha River Basin

The most upstream critical area (barrio) is the area around Llano Grande. The flood concentration time at this point is 1.3 hours according to the Plan Maestro EAAB. The newly installed staff gauge at upstream of Llano Grande would be an appropriate index to foresee the possibility of overflow. The warning level at the staff gauge shall be evaluated by rainfall amount at San Jorge during the concentration time (this case approx. 1hour).

May 2006 flood was caused by 7.5 mm per hour at San Jorge Station. Recently the end of October 2006 in Llano Grande there was an inundation with the depth 20 cm on the street. At this time the rainfall for 1 hour was 6.7 mm at San Jorge, however, the inundation was minimum compared to the May 2006 flood. There is uncertainty in the spatial distribution of rainfall and antecedent rainfall, however, sedimentation in the Soacha river due to the upstream bared land can be regarded as significant factor.

Table 9-12 10 minutes Rainfall at San Jorge Station (IDEAM)

Date	11-May-06		30-Oct-06		31-Oct-06	
Starting time	8:40		15:30		23:10	
	10 min. Rainfall	Accum. Rainfall	10 min. Rainfall	Accum. Rainfall	10 min. Rainfall	Accum. Rainfall
10min.	4.3	4.3	4.3	4.3	1.3	1.3
20min.	1.2	5.5	1.4	5.7	2.1	3.4
30min.	0.8	6.3	0.2	5.9	0.1	3.5
40min.	0.7	7.0	0.6	6.5	0.2	3.7
50min.	0.3	7.3	0.1	6.6	0.0	3.7
60min.	0.2	7.5	0.1	6.7	0.1	3.8
70min.	0.2	7.7	0.1	6.8	0.4	4.2
80min.	0.1	7.8	0.0	6.8	0.3	4.5
90min.	0.1	7.9	0.0	6.8	0.1	4.6
100min.	0.0	7.9	-	-	0.0	4.6
110min.	0.0	7.9	-	-	0.2	4.8
120min.	0.0	7.9	-	-	1.8	6.6
130min.	-	-	-	-	0.2	6.8
140min.	-	-	-	-	0.5	7.3
150min.	-	-	-	-	0.1	7.4
160min.	-	-	-	-	0.1	7.5
170min.	-	-	-	-	0.2	7.7
180min.	-	-	-	-	0.2	7.9
190min.	-	-	-	-	0.3	8.2
200min.	-	-	-	-	0.3	8.5
210min.	-	-	-	-	0.1	8.6
220min.	-	-	-	-	0.0	8.6
230min.	-	-	-	-	0.0	8.6
240min.	-	-	-	-	0.0	8.6

Figure 9-31 explains the flood waning criterion in the Soacha river. The thick black line below the waterlevel station name is the flood discharge in May 11, 2006 based on the flood mark. For example, at Fusunga, the flood mark elevation was 2.5 m, whose discharge is 22 m^3/s. At Llano Grande , the discharge to start overflow is 11 m^3/s while the assumed discharge at the flood mark is 19 m^3/s. The ratio of 11 to 19 was applied to the flood discharge at Ladrillera Santa Fe, Prison and Fusunga to decide the warning waterlevel. The warning waterlevel level at each station is shown in Table 9-13.

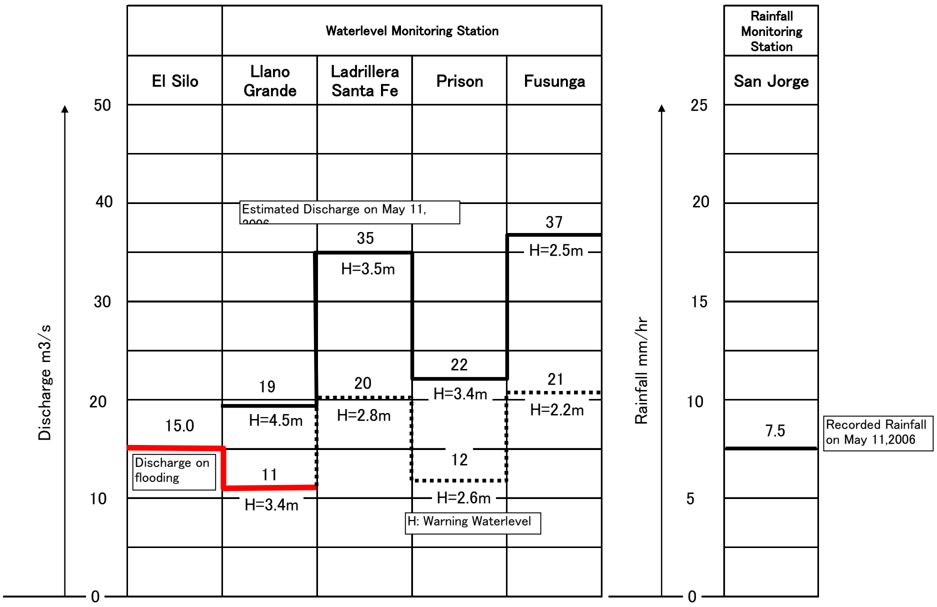

Figure 9-31 Flood Warning Criteria for Soacha River

Table 9-13 Warning Waterlevel

Station Name	Llano Grande	Ladrillera Santa Fe	Prison	Fusunga
Warning Waterlevel	3.4 m	2.8 m	2.6 m	2.2 m

c) Specific Warning for Tibanica (Claro) River Basin

The flooding in the Tibanica is caused by local rainfall associated with insufficient rainwater drainage system as well as flooding in the river itself. Considering the seriousness, the flood warning should be focused on the flooding in the Tibanica River. The flood discharge is the total of the overflow discharge from the Terreros Dam and the runoff from the residual catchments the Dam downstream.

By installing and watching of staff gauge at the side wall of the spillway, the water level (overflow depth) shall be monitored by local person and informed to the monitoring center.

Table 9-14 Waterlevel and Discharge relation at Terreros Dam Spillway

NIVEL DE [1] AGUA, N (msnm)	CAUDAL ESTRUCTURA HIDRAULICA, Q [2] (m^3/s)
2615.82	0.00
2616.00	2.52
2616.50	18.50
2617.00	42.30
2618.00	106.22
2619.00	187.13
2620.00	282.02
2621.00	389.05
2622.00	506.99
2623.00	634.89
2624.00	772.05
2625.00	917.86
2626.00	1071.85

Notas: (1) Sistema EAAB
(2) $Q = CL*(N-2615.82)^{1.5}$
$C = 2.0$
$L = 16.5$ m

(Source: "Cuadro 17, Hoja 1/3", Plan Maestro Soacha, EAAB)

By evaluating the channel capacity in the critical reach downstream, the warning level can be proposed. The minimum flow capacity in the Tibanica river is 2.7 m^3/s, so when the overflow depth at the spillway is more than 20 cm, some downstream sections could overflow.

9.5.7 Institutional Aspects

(1) Institutional Aspects within the Soacha Municipality

1) Organizational Arrangement by Phase

Since Soacha Municipality has no surplus staff for full time engagement on disaster monitoring and warning operation and there was a good practice of emergency operation in disaster occurred in May 2006, maximum utilization of existing organizational arrangement is proposed.

In the past disaster, although the committee was called after disasters have happened the emergency operation committee was sufficiently operated and provided aid for disaster victims. Therefore, it is proposed that this committee is utilized as operation body during warning and evacuation stage.

2) Establishment of Monitoring (and Operation) Unit

Monitoring meteo-hydrological information effective, establishment of the Monitoring (and Operation) Unit is proposed. Since natural phenomena happen anytime around the clock, the unit shall operate on a 24-hour base.

Staff requirements are tentatively proposed as follows, and this will be modified after the pilot project implementation.

- Chief of Unit: 1
- Senior Staff: 2 (monitoring, operation)
- Other staff: 20 (including ad-hoc staff)
- Server Administrator: 1

As mentioned several times, Soacha Municipality dose not have surplus staff at this moment and difficulty of new staff recruitment is also understandable. However, at least, the chief of unit and two (2) senior staffs should be proper and fulltime staff of the municipality while other staffs are concurrent or ad-hoc.

In this connection, establishment of the Monitoring and Operation Center (M/O Center) in Soacha Municipality is also proposed for effective monitoring and operation of early warning activities. The requirements of the center will be as follows:

- 24-hour base operation when necessary
- Monitoring Equipment
- Communication Equipment (Radio, Tel, Fax)
- Meeting Facility
- Relief Equipment/Storage

It is better to have the M/O center in the same building of the Soacha Municipality Building. On the other hand the center should have the staff around the clock and have enough space to accommodate equipment for monitoring. Taking into account of these requirements, it is practical to have the center at the fire station (headquarters of fire department of Soacha Municipality).

During the pilot project , rainfall gauge, personal computers were installed to the Fire Station as an initial investment for M/O unit.

(2) Institutional Aspects with Other Related Organizations

1) Agreement with Related Governmental Organizations

Since the proposed MEWS for Soacha Municipality require the sharing information with other organizations, mutual agreements are necessary to get the information.

To ease the information acquisition from other organizations, it is proposed that two kinds of agreement namely a “general agreement” and a “respective/individual” agreement will be prepared. The general agreement will be an agreement with all related organizations that mentioned mutual cooperation for sharing the information related to disaster mitigation of Soacha Municipality. The respective/individual agreement will be an agreement between Soacha Municipality and respective organizations which is mentioning detailed items of information shared.

During the pilot project, an agreement between Soacha Municipality and IDEAM was prepared and discussed regarding the monitoring station maintenance and information exchange. As of December 2007, it is still under discussion between IDEAM and Soacha Municipality.

2) Agreement with Community

For effective operation of the proposed MEWS, community participation for monitoring and dissemination of information is desired. To make sure the community participation, it is recommended to have agreements between community organizations and Soacha Municipality.

Based on this proposal, communities and Soacha Municipality prepared agreement on November 13 in the JICA Study Seminar. The signature in the agreement should be finalized as soon as possible.

3) Agreement with Commercial and Industry

To disseminate the warning and other related information in time, the role of media (radio and TV stations) and Cellular Phone Company are important. Role of other commercial and industry than media and Cellular Phone Company are also important when disaster happens. Therefore, it is recommended to make service agreement with them.

9.5.8 Cost Estimates and Implementation Program

(1) Project Cost Estimates

1) Basis for cost estimate

<u>Items to be estimated</u>
Equipment Cost
Installation Cost
Construction Cost (if necessary)
Land Acquisition (if necessary)
Physical Contingency
Price Contingency
Engineering Fee
Operation and Maintenance Cost

2) Project Cost Estimate

In Table 9- 15, the estimated cost for each activity is inputted in US dollar.

Telemeter system equipment and CCTV camera equipment will be replaced within ten (10) years.

River improvement works shall be conducted by EAAB. In this sense, the cost for that is not indicated in the figure.

For Data Analysis and Processing System and Set Appropriate Warning Criteria, only remuneration of engineers or researchers is considered in the cost.

Community-based disaster management activity such as hydrological measurement and drill shall be conducted by Soacha city together with the Study Team and other related organizations. In this sense, the cost for them includes remuneration of staff, educational materials and communication equipment, etc.

In the pilot project phase (year 2007), the necessary cost is about US$92,900.

The total cost until 2020 is about US$436,100.

(2) Implementation Program

As previously mentioned, the target year of the plan is 2020 and the project will start in 2007. With consideration of necessity and urgency, implementation program is set as shown in Table 9- 15.

Table 9- 15 Implementation Program

unit: US$

Actions	Short Term 2007	Short Term 2008	Middle Term 2009	Middle Term 2010	Middle Term 2011	Middle Term 2012	Long Term 2013	Long Term 2014	Long Term 2015	Long Term 2016	Long Term 2017	Long Term 2018	Long Term 2019	Long Term 2020	
Monitoring and Early Waning System Establishment															
Monitoring and Data Gathering System															
Installation of Monitoring Equipment for Pilot Project															
1 Monitoring Equipment for DPAE, EAAB, IDEAM via Internet	10,000					10,000 (replace)					10,000 (replace)				
2 Rainfall Gauge at San Jorge (ICA)	9,300										9,300				
3 Rainfall Gauge at Firefighter Station	8,400										8,400				
4 Water Level Gauge in Fusunga	600														
5 Water Level Gauge in Ladrillera Santa Fe	13,500										13,500				
6 Water Level Gauge in Prison	2,500					2,500 (replace)					2,500 (replace)				
7 Water Level Gauge in Llano Grande	1,600														
Installation of Monitoring Equipment for Future Stage															
1 Monitoring Equipment for DPAE, EAAB, IDEAM, CAR via Exclusive Line				12,000										12,000	(upgrade)
2 Water Level Gauge at Los Terreros Dam		3,000												3,000	(replace)
3 CCTV Camera at Critical Point (Flood and Landslide)												5,000	5,000		
4 Mobile Monitoring and Operation Unit												10,000	10,000		
5 Installation of Own Communication System							10,000	10,000						10,000	(upgrade)
Data Analysis and Processing System															
Data Analysis and Processing System															
Development of Simplified System (incl. the Pilot Project)	6,000														
Development of Complete System						6,000	6,000						6,000	6,000	(upgrade)
Early Warning System															
Development of Semi-automated System (incl. the Pilot Project)	6,000														
Development of Automated System						6,000	6,000						6,000	6,000	(upgrade)
Database System															
Development of Information Storage Database	1,000					1,000	1,000						1,000	1,000	(upgrade)
GIS Database for Hazard Map, Disaster Record etc.	1,000					1,000	1,000 (upgrade)						1,000	1,000	(upgrade)
Internet Server															
Internet Server for Disclosing Monitoring Information		2,000													
Internet Server for SMS, e-mail generation				2,000	2,000								2,000	2,000	(upgrade)
Information Dissemination System															
Establishment of Information Dissemination System using Existing Method	1,000														
Establishment of Information Dissemination System using Future Option						20,000	20,000						20,000	20,000	(upgrade)
Set Appropriate Warning Criteria															
Hydrological Analysis using Past Disaster Record	10,000														
Setting of Tentative Warning Criteria															
Hydrological Analysis using Observed Data during the Pilot Project Period															
Modification of Warning Criteria				2,500			2,500			2,500			2,500		
Institutional Arrangement															
Institutional arrangement in Soacha															
Establishment Special Organization/Committee working on Warning Situation	1,000														
Establishment Monitoring and Operation Unit and Center	10,000					20,000 (upgrade)					20,000 (upgrade)				
Agreement on Data exchange															
General Agreement with IDEAM	1,000														
Respective/Individual Agreement with CAR		1,000													
Community Based Disaster Management (CBDM) Activities															
Training on Hydro-meteorological Observation	10,000														
Information Transfer Simulation and Drill		CBDM activities should be done continuously even after the pilot project completion.													
Evacuation and Rescue/Response Drill															
Community Based Hydro-meteorological Observation															
River Improvement															
Rio Soacha Dredging, Drainage with Revetment			-	-	(by Soacha and EAAB)										
Rio Tibanica Dredging, Drainage with Revetment			-	-	(by EAAB)										
Total	92,900	6,000	0	16,500	2,000	66,500	46,500	10,000	0	2,500	63,700	15,000	53,500	61,000	436,100

9.6 Pilot Project

9.6.1 General

The pilot project for Soacha in the Study area is that of implementation of the proposed short term projects in Section 9.5. They are installation / operation of monitoring equipment and monitoring / maintenance activity by Soacha city-supported community, hydrology and hydraulic analysis, and study of tentative early warning criteria.

9.6.2 Outline of Pilot Project

(1) Installation / Operation of Monitoring Equipment

1) Simple Rainfall Gauge Installation and Operation in Firefighter Station

The simple rainfall gauge with sound alarm device was installed in Fire fighter station on December 2006. The purpose of the installation was to accumulate firefighter's own experience for rainfall measurement and start the rainfall monitoring as Soacha Municipality. Because the Firefighter station was planned to be the monitoring center in the monitoring and early warning plan, the Study Team regarded that at first the firefighter should understand the rainfall monitoring and the city should have their own data.

The installed simple rainfall gauge is shown in Photo 9-2. It composed of a funnel, hose, measurement cylinder and sound alarm box. In the measurement cylinder, there are four sensors to detect the stored rainfall amount (depth). It was made by Takuwa Co. Ltd.

Photo 9-2 Simple Rainfall Gauge

The rainfall measurement was started on December 2006 and continued until October 2007, when the automatic rainfall gauge was installed in the firefighter station by the Study Team.

2) Riverbed Measurement by Community in Soacha River

In Soacha River, after the May 11, 2006 flood, the riverbed dredging was done by Soacha Municipality. People in communities in the Soacha river have recognized that the sedimentation of the river is significant and despite of the dredging by the Municipality, some people are afraid that the river would be filled up by one flood. This is an example of exaggerated understanding for the Soacha river. People should understand the Soacha river's change and pay attention to the river itself.

The purpose of the riverbed measurement by communities is as follows,

- To monitor the riverbed elevation change
- To promote community's attention to the Soacha river

Figure 9-32 shows the location map of the riverbed measurement points along the Soacha river.

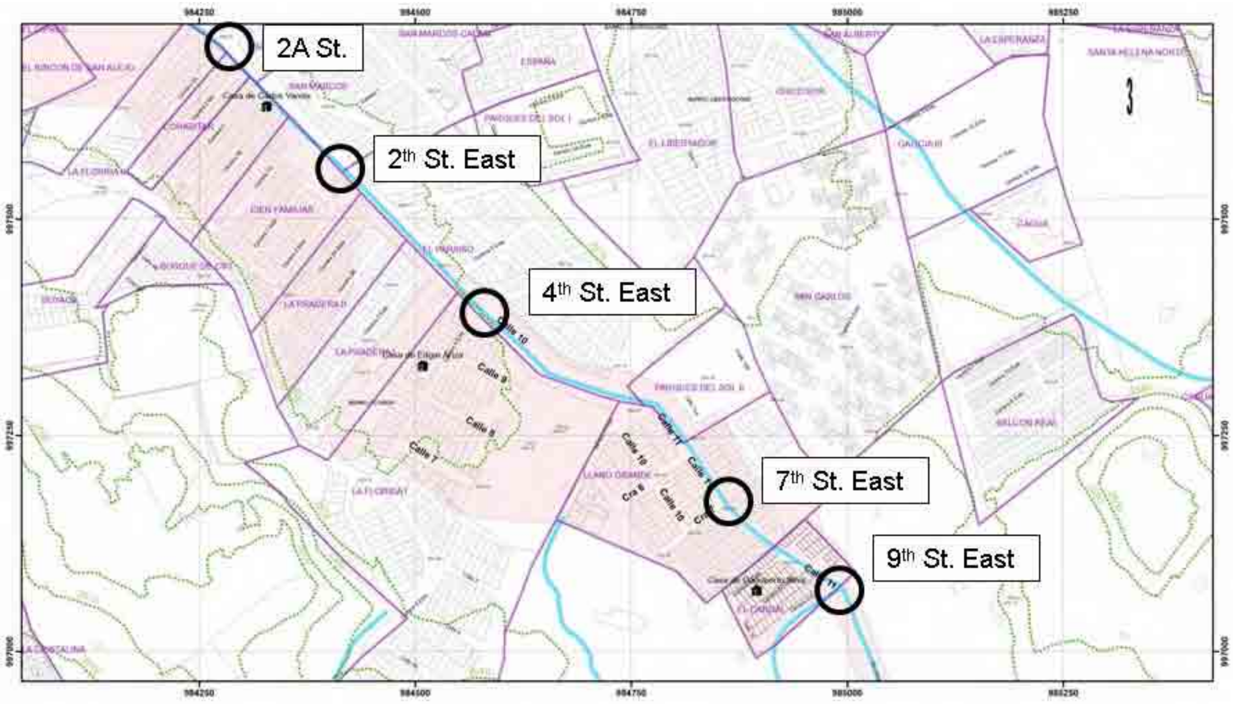

Figure 9-32 Location of Riverbed Monitoring for Soacha River

3) Installation of Rainfall Gauge and Waterlevel Gauge

a. Objectives

There are two (2) main objectives for the installation in the Soacha River basin. One is the enhancement of hydrological data collection to improve our knowledge of flood and provide better warning capabilities, in particular, making use of modern detection instruments. The other is to let people know the importance, limitation and uncertainty of hydrological observation, involving them in the observation activities using the modern equipment and manual equipment.

b. Candidate Locations

Basically the upstream of the target area is rural area in the Soacha river catchment. The house and public facility are located scattered way. Therefore once an candidate area is considered from technical viewpoint, the installation point has no wide choice.

c. Proposed Location and Equipment

Considering the advantage and disadvantage for each candidate location, the following locations were selected by the Study Team.

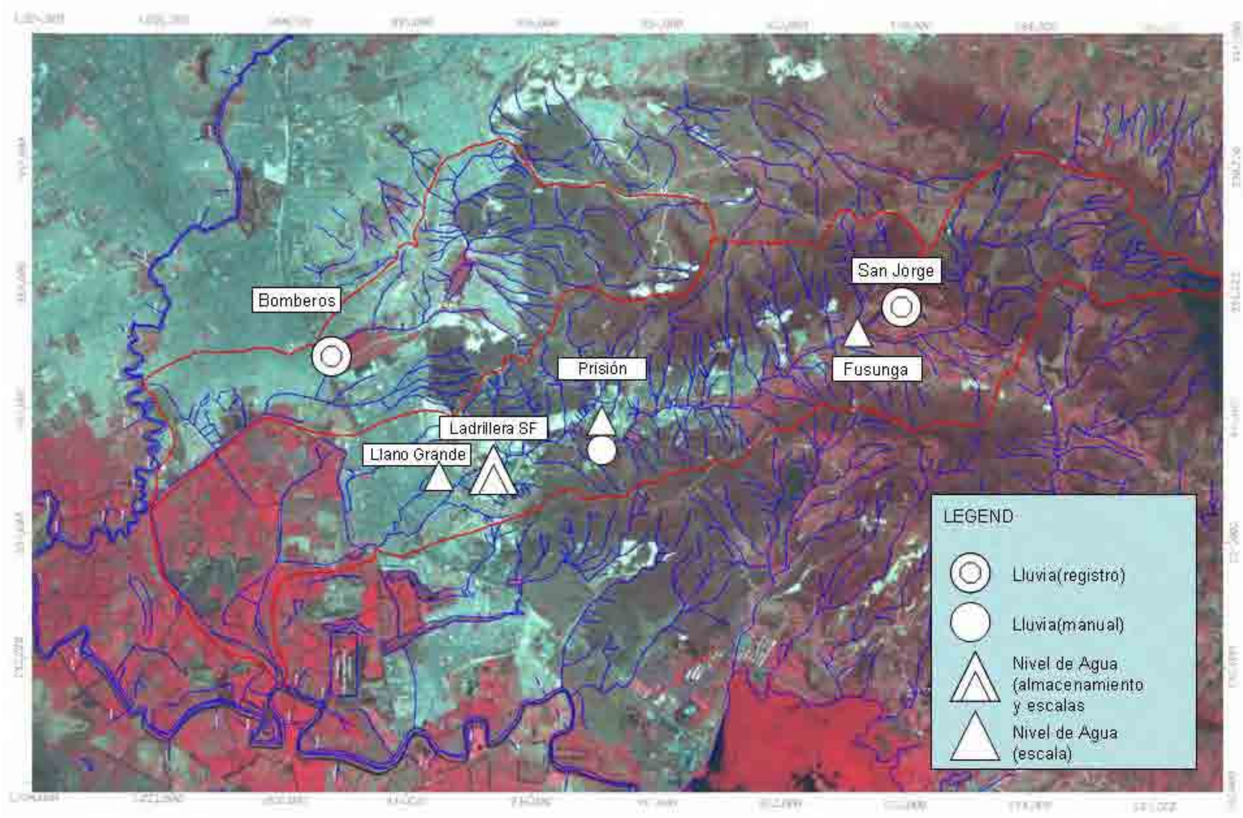

Figure 9-33 Locations of Hydrological Equipment Installation for Pilot Project in Soacha River

The specification of equipments is follows.

Table 9-16 Specification of Equipments in Soacha

Station	Element of Observation	Type	Specification
Fire Station		PC system	Desk top PC : HP Compaq dx2300 Microtorre Lap top PC : HP Compaq nx6320 notebook PC Router : D-Link Air Plus G UPS : POWERWARE 9120
	Rainfall	Tip-bucket	Rain gauge : Texas Electronics TR-525 Rainfall Sensor Resolution : 0.1 mm Metric Accuracy : 1.0% up to 50 mm/hour Collector diameter : 245 mm Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
San Jorge (ICA gate)	Rainfall	Tip-bucket	Rain gauge : Texas Electronics TR-525 Rainfall Sensor Resolution : 0.1 mm Metric Accuracy : 1.0% up to 50 mm/hour Collector diameter : 245 mm Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
Fusunga	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing
Prison of Soacha	Rainfall	Conventional	Rain gauge : TAKUWA Rain fall gauge with water storage bottle and measure cup Collector diameter : 150 mm Resolution : 1 mm Metric Alarm : Preset the level optionally Stuck on the roof
	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing and stuck on the river wall
	Water Level	Electrode	Water level gauge : APCYTEL simplified water level gauge Resolution : 20 cm Metric 10 sensors Alarm : Preset the level optionally Gauge device : PVC tubes and telephone cable Stuck on the board fixed on the bridge
Ladrillera Santa Fe	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Self standing and stuck on the river wall
	Water Level	Ultra sonic	Water level gauge : Sonder Ultrasonic Level Meter Measuring range : 0.5m – 12m Resolution : 0.35% of measured range Beam angle : 8deg. at -3dB Logger : MOTOROLA MOSCAD-L Remote Terminal Unit Solar panel : SUNTECH STP080S-12/Bb Battery : VISION 6FM55 DC12V 55Ah Regulator : Sun Saver 10
Llamo Grande	Water Level	Staff gauge	Water level gauge : APCYTEL staff gauge Resolution : 1 cm Metric Gauge rod : steel Stuck on the river wall

4) Radio Receiver and Speaker System

As a tool for information transfer among the station, Soacha city and the community, the Study Team shall provide with radio system and speaker system in the Soacha River. The location and Barrio name of the speaker installation is shown in Figure 9-34.

The totally nine (9) handy radios shall be provided to five (5) stations, three (3) community leaders with the speaker system and one (1) community leader of the Autopista Sur such as barrio El Silo. The radio system is compatible to the existing Soacha city radio system (Motorola system).

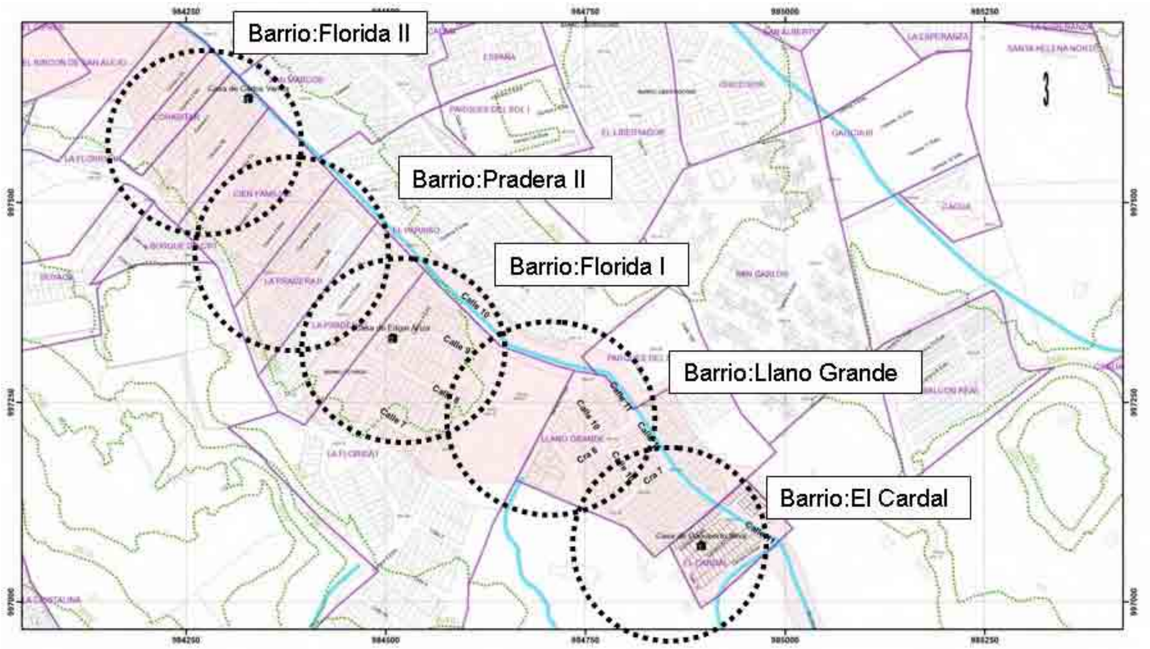

Figure 9-34 Locations for Installation of Speaker in Soacha River

(2) Monitoring and Information Transfer System

The equipment will be installed in August-October, 2007 and start to measure the data. The stations at San Jorge (ICA), Ladrillera Santa Fe and Firefighter Station are automatic recording type, but, the following manual activities are proposed.

Table 9-17 Proposed Monitoring Activity during the Pilot Project in Soacha River Basin

Station	Type of Measurement	Pilot Project (until December 2007)	
		Normal Time	Emergency
San Jorge	Rain (automatic recording)	3 times a day (a person reports to firefighter)	hourly (a person reports to firefighter)
Fusunga	Waterlevel (manual)	3 times a day (a community reports to firefighter)	hourly (a person reports to firefighter)
Prison	Rain (manual)	3 times a day (a guard reports to firefighter)	3 times a day (a guard reports to firefighter)
	Waterlevel (manual)	3 times a day (a guard reports to firefighter)	hourly or more frequent to report to Firefighter/Community
Ladrillera Santa Fe	Waterlevel (automatic recording)	3 times a day (a guard reports to firefighter)	hourly or more frequent to report to Firefighter/Community
Llano Grande	Waterlevel (manual)	3 times a day (a community reports to firefighter)	hourly or more frequent to report to Firefighter/Community
Firefighter	Rain (recording)	Hourly monitoring	Continues monitoring
	Receiving all information from above stations	Continuous monitoring and issuing of warning	

(3) Training for Soacha City and Community

The training for information transfer shall be conducted as a part of the pilot project in the Soacha River. The basic flow of information transfer during normal time and critical time is shown in Figure 9- 35 and Figure 9-36.

The training shall be separated into two (2), one is for information transfer among the stations and the Soacha city and another is for information transfer among the community. These activities were held a part of the drill in September to November 2007.

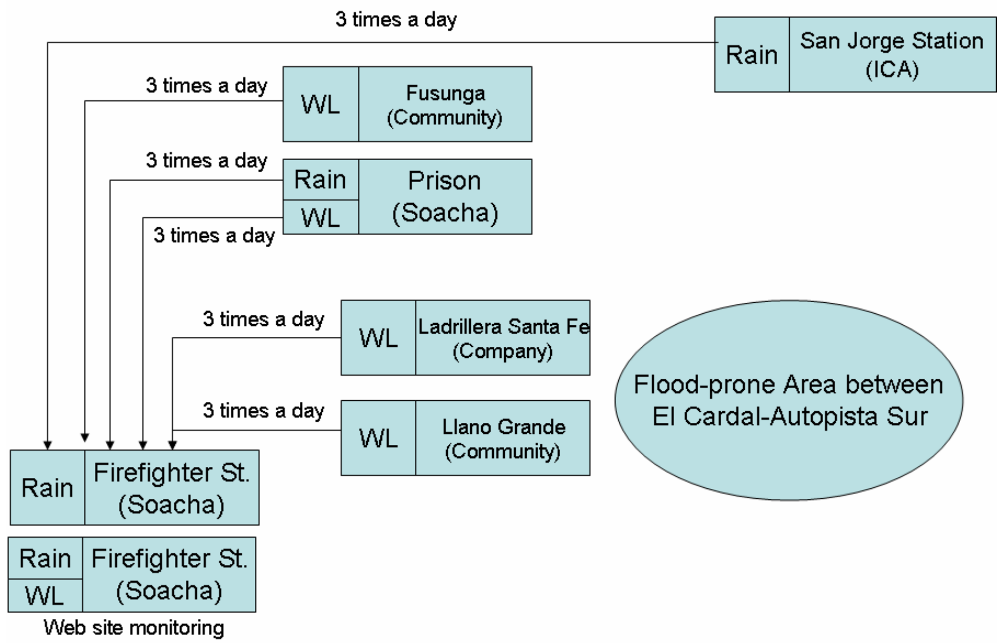

Figure 9- 35 Information Transfer Diagram (Normal Time)

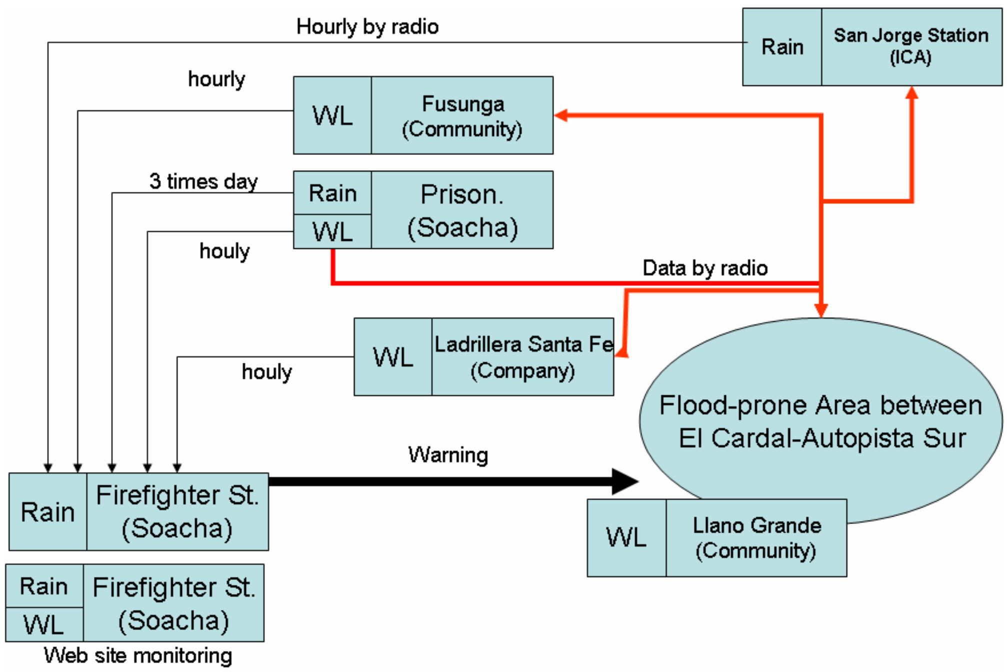

Figure 9-36 Information Transfer Diagram (Critical Time)

9.6.3 Lesson Learned from the Pilot Project

(1) Installation / operation of monitoring equipment

1) Simple rainfall gauge installation and operation in Firefighter Station

The firefighters of the Soacha city conducted rainfall measurement by themselves since December 2006 as a part of pilot project.

Since the end of December 2006, almost one (1) month there was little rainfall according to the monitored data in Firefighter station (Figure 9-37). At the end of January 2007 the forest fire took place in the upper part of the Soacha river catchment. Also same situation was repeated at middle of September 2007 after one month of little rainfall period in the Soacha river catchment. They are already the actual experience for the firefighter station of Soacha city. The experience should be taken into consideration of the Firefighter's operation in near future.

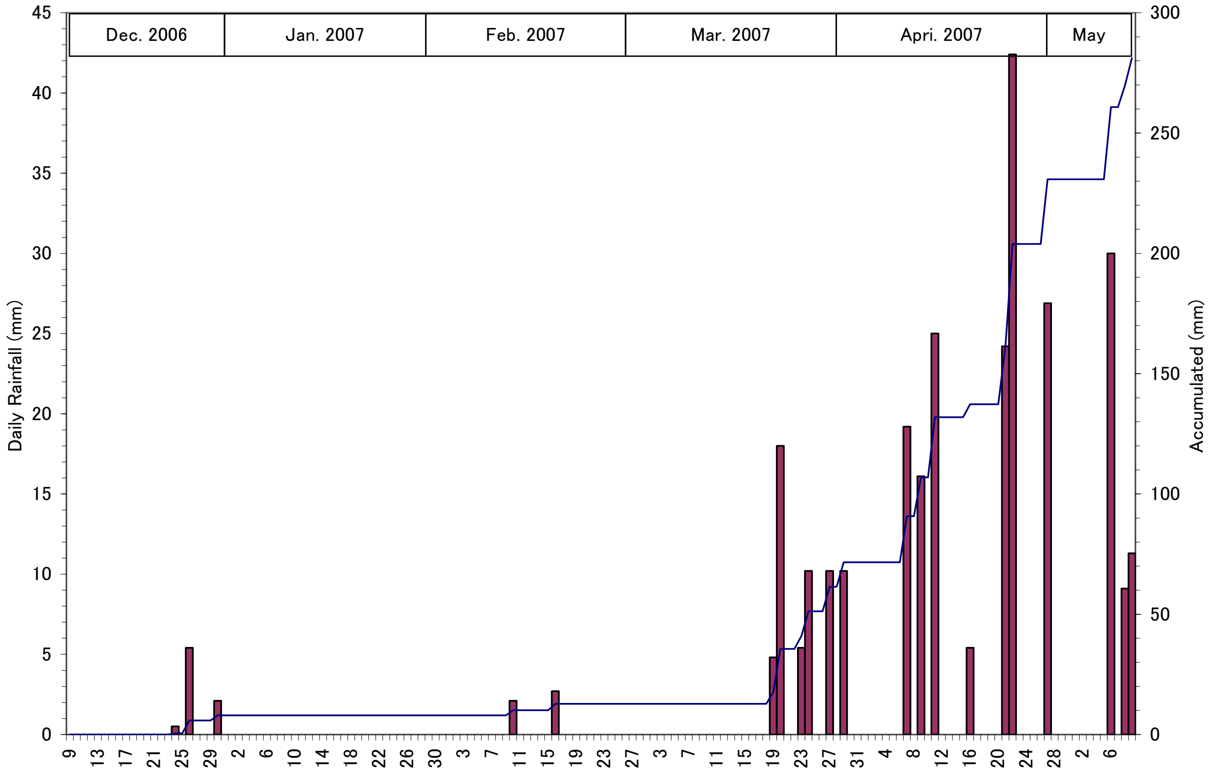

Figure 9-37 Monitored Rainfall by Simple Rainfall Gauge in Firefighter Station (Dec.2006 to May 2007)

In May 11, 2006 flood, it was reportedly said that there was big difference of rainfall amount in upper part and lower part of the Soacha river catchment. Figure 9-38 shows the daily rainfall correlation between San Jorge (IDEAM) and Firefighter station in 2007. According to this result, there is no correlation between these stations. It can be regarded that in the upper and lower part of the Soacha river, the rainfall phenomenon is quite independent. In this sense, the rainfall monitoring in the upper part , in real time, is required for the downstream of the Soacha river.

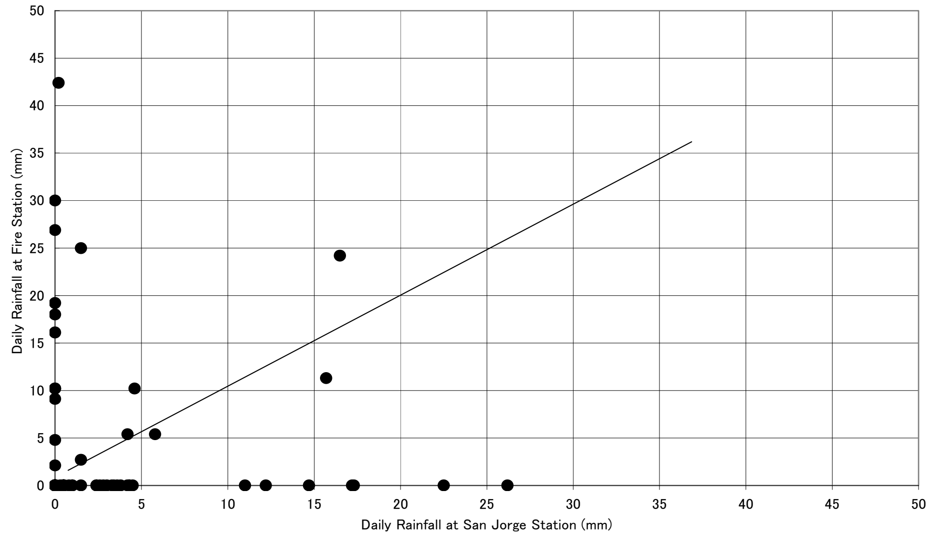

Figure 9-38 Correlation between San Jorge (IDEAM) and Firefighter Station on Daily Rainfall

2) Riverbed Measurement by Community in Soacha River

Figure 9-39 shows the monitoring results of the riverbed change in the pilot project. There are five (5) monitoring points. The measurement is the distance from bridge beam to the riverbed of left side and right side. The figure shows the average of each measurement of left and right side. The measurement reflects local scour and garbage, however, in the pilot project period there is no significant tendency of sedimentation.

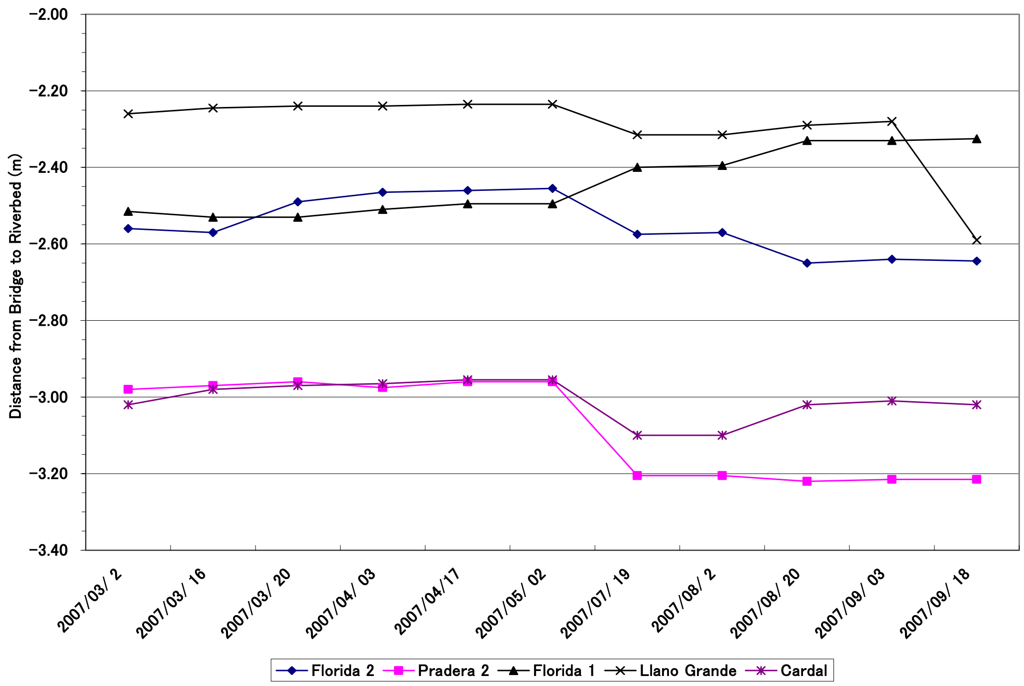

Figure 9-39 Riverbed Monitoring Results for Soacha River

(2) Information Transfer and Evacuation Drill

In November 7, 2007 the drill on information transfer and evacuation was held in the Soacha river catchment. The participants of the drill were communities, Soacha city (fire fighters and counterparts), police, Red Cross and civil defense. The total number of registered families in participating community was 462.

The information transfer drill is the real time training that the observers in the stations which the Study Team installed and set up in the pilot project inform / report the observed data to the firefighter station and among observers and community leaders by radio receiver. The scenario data of rainfall and waterlevel was provided to each station by the Study Team in advance (Figure 9-40).

Rainfall and waterlevel conditions of the scenario are based on the actual conditions of May 11, 2006.By setting up the scenario like this, people can exercise the evacuation activities, and know how to escape from the situation of May 11, 2006.

The evacuation drill is the collaboration of all the participants. The firefighter station was advised to decide and issue warning for the communities based on the information from the stations. After 1st warning is issued, police, Red Cross and civil defense support the fire fighters and communities. Figure 9-40 shows the structure of the participant and rainfall and waterlevel scenario of the drill dated on November 7, 2007.

Figure 9-41 and Figure 9-42 are the actions to be taken for each entities and information transfer diagram in the drill, respectively. In the drill, the situation that the waterlevel at Fusunga is 2.2 m is called “Flood Warning 45”, which means within 45 minutes the downstream (El Cardal to Autopista Sur) will be inundated, so people should prepare the evacuation. Furthermore, “Flood Warning 15” was set to reconfirm the inundation in the downstream area within 15 minutes based on the waterlevel at Prison.

The issued warning on flood and evacuation from CLOPAD through the Firefighter station was transferred by community leaders using speaker system. People in communities conducted necessary actions which were specified in advance.

As evaluation of the drill on November 7, 2007, the following was pointed out as further improvement.

- The meaning of warning (technical meaning such as “flood warning 45” and “flood warning 15”) was not understood by community very well.
- Information exchange between community and monitoring station was not done.

As a result, more than several hundred people evacuated smoothly during the drill. It is regarded as the results of repeated community workshops in the Study with the provided various resources by the Soacha city.

Nov.8,2007	Information given to Observers of Station					Contents of Message from Firefighter Station	
	San Jorge	Fusunga	Carcel	Ladrillera SF	Llano Grande	Nivel de Alerta	Mensaje de Bomberos para comunidad
	(mm/hora)	(m)	(m)	(m)	(m)		
9:00	1.0	1.30	1.30	1.30	1.50		
9:30							
10:00	7.5	1.70	1.70	1.30		ALERTA 1	"Se observó lluvia fuerte en la parte alta del Río Soacha San Jorge" "Se espera que el nivel de agua se eleve". "Por favor poner atención al reflujo de aguas por el alcantarillado Inundación en los lugares bajos"
10:30	10.0	2.20	1.80	1.40		ALERTA 2	"El nivel de agua del Río Soacha se va a subir. Se espera que se desborde" "Del Cardal hasta la Florida va a ser crítico…"
11:00	0.0	1.90	2.00	1.50			
11:30	0.0			2.30	2.80	ALERTA 2a	Para el barrio en la parte baja de "El Silo" "El Nivel de agua del río Soacha en la parte alta es más alta de lo normal" "El río Soacha se va a desbordar".
12:00	0.0	1.60	1.60	1.60			

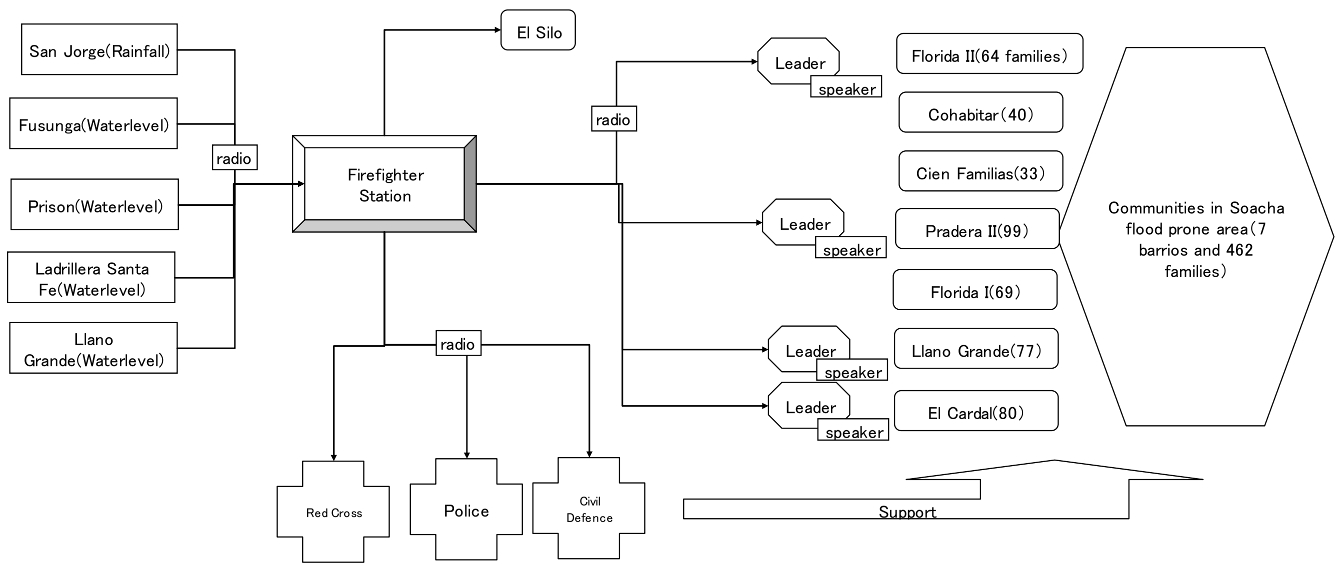

Figure 9-40 Drill Participants and Scenario of Waterlevel and Rainfall

Stage		Flood Watching Stage	Flood Warning & Evacuation 45	Flood Warning & Evacuation 15	Evacuation Completed
		10:00	**10:30**	**11:00**	**11:15**
Station	San Jorge	Observe Rainfall 7.5mm/hr Report to F/S & Report to Downstream Communities Florida1,2 Llano Grande, El Cardal	Observe Rainfall & Report to F/S	Observe Rainfall & Report to F/S	
	Fusunga	Observe Water Level & Report to F/S	Observe Water Level 2.2, Report to F/S & Report to Downstream Commnities, Florida1,2 Llano Grande, El Cardal	Observe Water Level & Report to F/S	
	Prison	Observe Water Level & Report to F/S	Observe Water Level & Report to F/S	Observe Water Level 2.0 & Report to F/S Report to Downstream Commnities, Florida1,2 Llano Grande, El Cardal	
	Ladrillera SF	Observe Water Level & Report to F/S	Observe Water Level & Report to F/S	Observe Water Level & Report to F/S	
	Llano Grande	Observe Water Level & Report to F/S	Observe Water Level & Report to F/S	Observe Water Level & Report to F/S	
Soacha	Fire Station	Receive Data from every stations Report to CLOPAD	Receive Data from every stations Report to CLOPAD	Receive Data from every stations Report to CLOPAD	
	CLOPAD	Decide "Flood Watching Stage" and order F/S to declair	Decide **"Flood Warning 45 "** and order F/S to declair	Decide **"Flood Warning 15 "** and order F/S to declair	
	Fire Station	Declair to every station **"Flood Watching Stage"** and start to observe every 30 minuites	**Declair "Flood Warning 45 "** to downstream communities and order them to evacuate untill 11:15	**Declair "Flood Warning 15 "** to downstream communities and order them to evacuate untill 11:15	
		Declair to Downstream Communities "Flood Watching Stage"	**Stage 2: Flood Warning 45**	**Stage 4: Flood Warning 15**	
Communities	Florida1,2 Llano Grande,	Receive Rainfall critical condition from San Jorge	Receive Water Level critical condidion from Fusunga	Receive Water Level critical condidion from Prison	JAC Leader check evacuation status
		Annonuce inside community about **"Flood Watching Stage"**	JAC Leader announce to community member to **evacuate untill 11:15**	JAC Leader announce to community member to **evacuate untill 11:15**	**Evacuation completed**
		Stage 1: Flood Watching	**Stage 3: Community Evacuation 45**	**Stage 5: Community Evacuation 15**	

Figure 9-41 Detailed Actions of Each Participant during the Drill

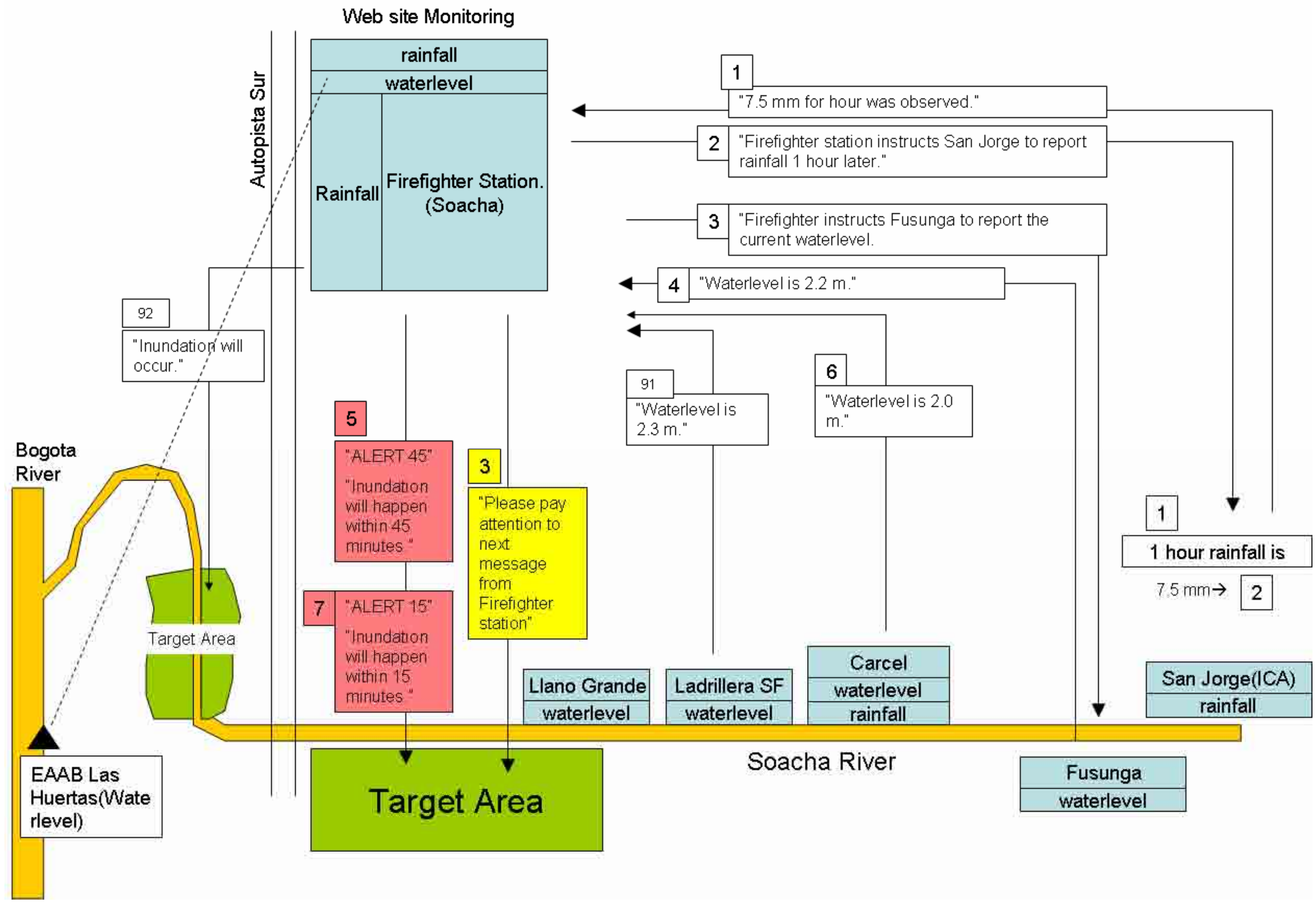

Figure 9-42 Diagram for Scenario of Drill on Information Transfer and Evacuation