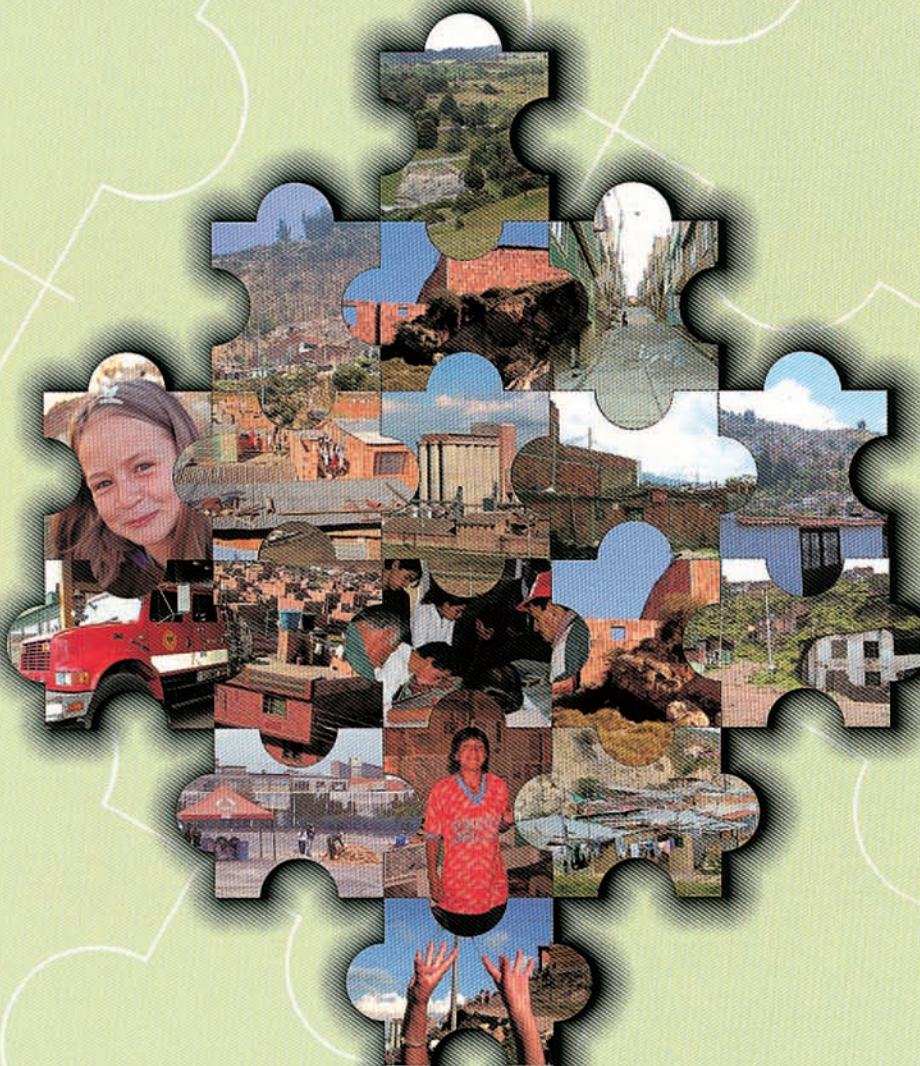


# The Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia



**Japan International Cooperation Agency (JICA)**  
**The City of Bogotá**

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THE STUDY ON  
DISASTER PREVENTION  
IN THE BOGOTÁ METROPOLITAN AREA  
IN THE REPUBLIC OF COLOMBIA

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Final Report  
- Main -

March 2002

**Pacific Consultants International**  
**OYO Corporation**

The exchange rate applied in the Study is:

US\$ 1.00 = Colombian Peso 2,289

(2001 Banco de la República Reference rate)

## PREFACE

In response to a request from the Government of Colombia, the Government of Japan decided to conduct a development study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia and entrusted the Study to the Japan International Cooperation Agency (JICA).

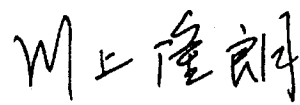
JICA sent to Colombia a study team headed by Mr. Hajime Tanaka of the joint venture of Pacific Consultants International Co. Ltd. and Oyo Corporation Ltd. to Colombia, between March 2001 and March 2002. In addition, JICA set up an Advisory Committee headed by Mr. Masayuki Watanabe of Institute of International Cooperation between March 2001 and March 2002, which examined the Study from specialist and technical point of view.

The Study Team held discussions with the officials concerned of the Government of Colombia, and conducted field surveys at the study area. Upon returning to Japan, the Study Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of the project and promotion in Colombia, and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Colombia for their close cooperation extended to the Study Team.

March 2002



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Takao Kawakami  
President  
Japan International Cooperation Agency

March 2002

Mr. Takao Kawakami  
President  
Japan International Cooperation Agency  
Tokyo, Japan

## Letter of Transmittal

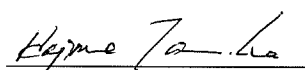
Dear Sir,

We are pleased to submit the final report entitled the "The Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia". This report compiles the results of the Study in accordance with the contracts signed on March 16 2001 and April 12, 2001 between the Japan International Cooperation Agency and the joint venture of Pacific Consultants International and Oyo Corporation Ltd.

In the Study, the Study Team presents the Master Plan Study based on the analysis of the existing conditions and problems. The report consists of the Summary, Main Report, GIS Maps and Data Book.

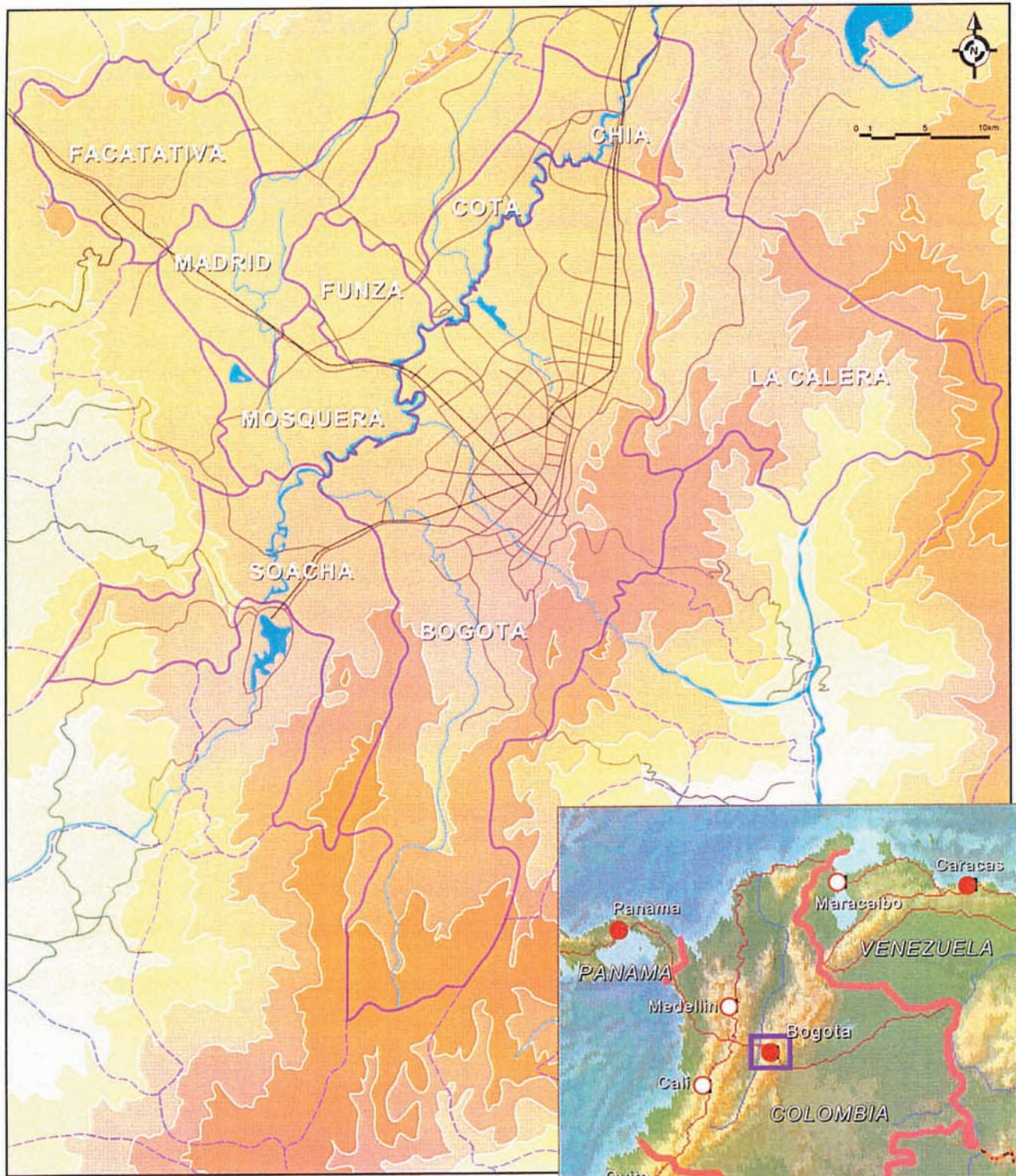
All members of the Study Team wish to express sincere appreciation to the personnel of your Agency, Advisory Committee, and the Embassy of Japan in Colombia, and also to the officials concerned of the Government of the Republic of Colombia, the Government of Bogotá City and the Government of Cundinamarca Prefecture for their cooperation extended to the Study Team. The Study Team sincerely hopes that the results of the Study will contribute to the disaster prevention for the Bogotá Metropolitan Area and also to the promotion of socio-economic development for the area.

Yours Faithfully








Hajime Tanaka  
Team Leader

The Study on Disaster Prevention  
in the Bogotá Metropolitan Area  
in the Republic of Colombia



**Legend**

- |   |  |   |         |
|---|--|---|---------|
|  | Study Area<br>(Bogota Metropolitan Area) |  | Road    |
|  | City Boundaries                          |  | Railway |
|   |  |  | River   |



**Study Area**

# **THE STUDY ON DISASTER PREVENTION IN THE BOGOTÁ METROPOLITAN AREA IN THE REPUBLIC OF COLOMBIA**

## **OUTLINE**

### **1. INTRODUCTION**

This is an outline of the Summary Report of the Final Report (March 2002) for the Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia, which has been carried out in accordance with the Scope of Work and the Minutes of Meetings agreed and signed between the Government of Colombia (Direction of Prevention and Attention of Emergencies of Bogotá D.C. (DPAE), Office For Prevention and Attention of Disaster Cundinamarca (OPAD) and Colombian International Cooperation Agency (ACCI) and the Japan International Cooperation Agency (JICA) on November 27, 2000.

The Study Area, the Bogotá Metropolitan Area, consists of the city of Bogotá and the eight municipalities of the prefecture of Cundinamarca and covers 1,949 km<sup>2</sup> with a population of 6.99 million (in 2000). The city of Bogotá is the capital district of Santa Fe de Bogotá, which is also the capital of the Republic and of Cundinamarca Prefecture. Currently, the population of the city of Bogotá was rapidly increased, from 0.67 million in 1951 to 6.4 million in 2000, consequently, the urban area of Bogotá has been expanding to the surrounding municipalities of Cundinamarca.

In the Study Area, various types of disasters such as landslides, floods and earthquakes, and also industrial hazards are actualized due to the rapid urban development. Since the beginning of the 1990s, the national and local governments have prepared their organizations to cope with landslides and floods, but not against earthquakes yet.

As for earthquakes, the events over MSK VII in the Bogotá Metropolitan Area were recorded in 1917, 1923 and 1967 since the beginning of 1900; therefore, it is necessary for the area to be ready to cope with this magnitude of disaster. As for earthquake proof design in Colombia, the government of Colombia issued the seismic design code in 1984 and has been promoting its application for building construction. However, the seismic design has not come into wide use yet. In the Study Area, there are a large number of masonry buildings, of which a large part is lacking seismic resistance capacities. In a major earthquake, a large number of buildings and bridges will be collapsed and severe damages will occur. However, the public awareness for the disaster is still very low among the government, non-government entities and local communities in the Bogotá Metropolitan Area. In order to cope with the disaster, the Bogotá Metropolitan Area has to arrange the disaster prevention entities of the government, non-government entities and local communities and to strengthen the urban areas by enhancing public awareness for the disaster.

In response to the request of the Government of Colombia (hereinafter referred to as "GOC"), the Government of Japan (hereinafter referred to as "GOJ") decided to conduct "The Study on Disaster Prevention in the Bogotá Metropolitan Area in the Republic of Colombia (hereinafter referred to as "the Study") through JICA, the official agency responsible for the technical cooperation program of GOJ, in accordance with relevant laws and regulations in force in Japan. In November 2000, JICA dispatched the Preparatory Study Team to Colombia for the preliminary survey for the Study and discussed the Scope of Work with DPAE, OPAD and ACCI. The Study was conducted from mid April to mid September 2001 to March 2002.

For the protection of life and property of the people in the Bogotá Metropolitan Area from disasters, it is indispensable for the Bogotá Metropolitan Area to prepare for disaster prevention and emergency response and to strengthen the urban areas against seismic disasters. The basic measures studied are as follows:

- (1) Arrangement of disaster prevention entities;
- (2) Strengthening of buildings, infrastructure and lifeline facilities in the urban areas;
- (3) Arrangement of emergency response;
- (4) Enhancement of public awareness for disaster.

## 2. DISASTER SCENARIO

### 1) Scenario Earthquakes

For the Study, as scenario earthquakes, two faults and subduction event are selected and they are as follows:

**Table 1 Scenario Earthquakes for the Study**

Case	Fault name	Type	Magnitu de	Peak Ground Acceleration (g)	Seismic Intensity (MMI)	Distance (km)*
Case-1	La Cajita	Near	6.4	0.1- 1.0	VII- X	20
Case-2	Guayuriba	Regional	7.0	0.1- 0.5	V - IX	60
Case-3	Subduction	Subduction	8.3	0.1- 0.2	V - VII	400

Source: Microzonificación sísmica de Santa Fe de Bogotá, INGEOMINAS 1997

Note:  $MMI = (\log(PGA) - 0.014) / 0.3$

\* Closest distance from INGEOMINAS

Some liquefaction potential area is identified in the southern part of Bogotá's urban area.

### 2) Seismic Damage Estimation

The estimated largest seismic damages among the scenario earthquakes are listed as follows:



**Table 2 Estimated Damage**

Items		Case 1	Case 2	Case 3	
Heavily Damaged Buildings (numbers)		399,384	421,989	61,829	
Casualties	Deaths (numbers)	39,249	40,438	3,265	
	Injuries (numbers)	272,627	281,560	23,749	
Lifeline Facilities	Water Supply Pipeline	Damaged Points	3,753	1,545	16
		Ratio (Points/Km)	0.6	0.2	0.0
	Gas Supply Pipeline	Damaged Points	428	139	1
		Ratio (Points/Km)	0.05	0.02	0.00
	Electric Power Supply Cable	Damaged Length	2,409	1,001	0
		Ratio (%)	0.04	0.02	0.00
	Telecommunication Cable	Damaged Length	5,583	2,189	0
		Ratio (%)	0.05	0.02	0.00
Bridges	Vehicular Bridges (numbers)	53	58	0	
	Pedestrian Bridges (numbers)	27	28	0	

The main secondary seismic damages triggered by earthquake are landslide and Industrial fire. The high-risk area for the landslide caused by earthquake is the southern part of the Study area, for the case of the earthquake scenario case 1. Highly seismic damage for industrial facilities is forecasted in Puente Aranda and Martires localities in Bogotá, for the case of the earthquake scenario case 1 and 2.

### 3. BASIC DISASTER PREVENTION PLAN

The basic disaster prevention plan for the Bogotá Metropolitan Area consists of Preparedness for Disaster Prevention, Emergency Response and Other Support Measures and the related organizations are the government of Bogotá City, the government of Cundinamarca Prefecture and the National Government.

#### 3.1 Preparedness for Disaster Prevention

##### 1) Arrangement Disaster Prevention Organizations

The government organizations of the Bogotá Metropolitan Area consist of three administrative levels, i.e., the government of Bogotá City, the government of Cundinamarca Prefecture and the National Government. Each of them has a Committee for Prevention and Attention of Disaster as follows:

- District Committee for Disaster Prevention and Attention
- Regional Committee for Disaster prevention and Attention
- National Committee for Disaster Prevention and Attention

It is necessary for them to arrange the government organizations for preparedness of disaster prevention and emergency response through the committees because of the responsibilities required to coping with the disaster. The leading agencies and coordinating agencies required are as follows:

Responsible Entity	Bogotá Metropolitan Area		
	Bogotá	Cundinamarca	National
Leading Agency	District Planning of Administrative Department (DAPD)	Government Secretary	Ministry of Interior
Coordinating Agency	DPAE-FOPAE	Government Secretary/OPAD	DGPAD

## 2) Strengthening of Urban Areas by Structural Measures

For strengthening the urban areas to cope with the disaster, structural and non-structural measures are planned as follows:

- (1) Strengthening of emergency and strategic public buildings;
- (2) Reinforcement of private buildings and control of informal building construction;
- (3) Identification of emergency transportation road networks and strengthening of bridges as strategic infrastructures;
- (4) Strengthening of strategic lifeline facilities;
- (5) Arrangement of open spaces and evacuation places;
- (6) Improvement and strengthening of vulnerable areas;
- (7) Execution of protection works for landslide hazard areas (La Carbonera, Montebello, El Espino, Jerusalen, Montebello San Luis, El Paraiso);
- (8) Execution of flood protection works for the Rio Bogotá and its tributaries;
- (9) Installation of seismometer and emergency shut down system for industries.

## 3) Strengthening by Non-structural Measures

- (1) Arrangement of monitoring systems for earthquake, landslide and flood, and warning systems for landslide and flood;
- (2) Land use control for landslide hazard areas, flood hazard areas and areas along the rivers.

## 3.2 Emergency Response

In and after a disaster, the local and national governments require immediately to undertake emergency response and recovery activities in order to track the disaster: saving lives, protecting property, and meeting basic human needs; restoring the disaster-affected area; and reducing vulnerability to future disasters. It is necessary for the organizations to prepare themselves to conduct their functions in a disaster.

### **1) Arrangement of Emergency Response Organization**

It is necessary for the Bogotá Metropolitan Area to arrange the emergency response organizations due to the required functions in and after the disaster. The necessary functions for the emergency response are categorized as follows:

- Emergency support functions: Transportation, communication, public works and engineering, fire fighting, information and planning, mass care, resources support, health and medical care, urban search and response, hazardous materials, food and energy.

### **2) Preparation for Emergency Response**

For the emergency response, each responsible organization is to prepare for emergency response. The functions and resources to be prepared are as follows:

- Organization of specialized teams for damage estimation, emergency communications, medical assistance and support, search and rescue, etc.;
- Preparation of required equipment and supplies like food, water, power generators, camping goods, etc. for affected areas;
- Preparation of required facilities for disaster field offices and disaster recovery centers, etc.;
- Preparation of emergency activities (opening critical transportation routes, establishment of shelters and feeding facilities);
- Preparation of financial support (loan and grants) to repair or replace damaged housing for reducing damages and recovery period after the disaster;
- Preparation of financial arrangement to repair roads and public buildings,
- Arrangement of technical assistance to identify and implement mitigation opportunities to reduce future loss, and other assistance, including crisis counseling, tax relief and legal services.

### **3) Arrangement of Initial Response**

In order to minimize the damage in a disaster, it is important for emergency response entities to prepare the following:

- For arrangement of initial response, it is necessary for each emergency response organization to prepare a manual for initial activities;
- Arrangement of base offices for emergency response activities and preparation of equipment;
- For strengthening of communication systems, it is necessary for related organizations to reinforce the existing communication and monitoring systems, and equipment;

- For strengthening of rescue and support systems, it is necessary for emergency response organizations to arrange evacuation places and evacuation roads, and to strengthen shelters, and to secure water and food;
- For arrangement of fire fighting and rescue activities, it is necessary for emergency response organizations to strengthen the fire fighting capacity, fire fighting apparatus and rescue equipment;
- For arrangement of first aid and medical care system, it is necessary for emergency response organizations to arrange a first aid system, communication system, initial medical care system, back-up medical facilities and medical care environment;
- For arrangement of transportation system, it is necessary for emergency response organizations to arrange emergency traffic control system, emergency transportation system, teams and equipment for opening of emergency transportation routes and airport facilities.

#### **4) Emergency Response Headquarters**

It is required for the Bogotá Metropolitan Area to arrange the emergency response command center and sub-centers at national and local levels. The incident commander is local mayor, while for the Bogotá City or Cundinamarca government, it should be the Mayor of Bogotá City or Governor of Cundinamarca, respectively. The incident commanders for the Bogotá Metropolitan Area should be clarified by law.

The location of the Emergency Response Headquarters are proposed as follows:

- National: Ministry of Interior/DGPAD (in the building of the Secretary of Health, Bogotá City),
- Bogotá City: The building of the Secretary of Health, Bogotá City,
- Cundinamarca Prefecture: The building of the government of Cundinamarca,
- Localities and Municipalities: The buildings of Locality and Municipality governments.

#### **5) Recovery and Rebuilding**

It is proposed that, for the most vulnerable areas, a redevelopment plan be prepared during the period leading to preparedness for disaster prevention. The recovery and rebuilding plan can be divided into two categories: restoration of normal life and restoration of urban area. It is necessary for the governments to prepare the necessary institutional arrangements for recovering normal activities as follows:

- Promoting actions by disaster victims that enable to begin the process of rebuilding their homes, replacing property, resuming employment, restoring their business;
- Government programs of repairing, rebuilding public buildings, infrastructure and mitigating future disaster losses;

- Government programs of assistance, support, technical services that facilitate disaster victims' recovery, such as grants and low-interest loans for repair or replacement of homes, business, and technical assistance and education and information.

**6) Other Support Measures planned are as follows:**

- Emergency health and medical measures,
- Disaster information management system, and
- Public education.

### **3.3 Implementation Schedule**

**1) Implementation Period**

The projects are planned to be implemented by 2010 considering the target year of the Territorial Ordering Plan (POT) and the implementation schedule is divided into three terms corresponding to the mayoral term of office in the city of Bogotá as follows:

1. Short term: 2002 - 2004
2. Mid-term: 2005 - 2007
3. Long-term: 2008 - 2010

**2) Proposed Projects**

1. Arrangement of government organizations for disaster prevention and emergency response;
2. Improvement of important buildings, including diagnostic studies;
3. Improvement of bridges;
4. Seismic reinforcement of lifeline facilities, including diagnostic study of:
  - Water supply facilities, provision of emergency water supply tanks,
  - Gas supply facilities,
  - Electric supply facilities,
  - Telephone facilities
5. Urban redevelopment of vulnerable areas;
6. Earthquake engineering study;
7. Landslide protection works;
8. Flood protection works;
9. Management improvement of hazardous materials by industrial facilities;
10. Improvement and reinforcement of health and medical sector;
11. Educational program for enhancement of awareness of disaster prevention;
12. Strengthening disaster management information systems;
13. Strengthening of monitoring programs of earthquake, landslide and flood, and establishment of warning systems for landslide and flood.

### **3) Implementation Agencies**

The responsible agencies are divided into the following government sectors of Bogotá City, Cundinamarca Prefecture and national, privatized or private lifeline sectors, specifically, they are EAAB, CODENSA, EMGESA, ETB, CAPITEL, and private individuals.

For implementation of the Basic Plan, it is necessary to have a strong leading agency and mutual cooperation among the related organizations.

### **4) Implementation Schedule and Project Cost**

Implementation schedule and project cost is planned for short, mid and long terms. The total project cost is COP 1,671,676 million (US\$ 730.3 million) and due to the disbursement schedule, it is expected to use 22% of the total cost in the short term, while in the medium term, it is expected to use 51.5% of the total cost. More than 70% of the cost will be used by the end of the second term.

Implementation schedule and disbursement schedule are shown in the following tables:

**Table 3 Summary of Project Implementation**

Program	Project Name	Implementation Agency	Cost (Million Pesos)	Implementation Schedule								
				Short			Medium			Long		
				2002	2003	2004	2005	2006	2007	2008	2009	2010
1	Improvement of Important Buildings	1-1 Seismic Diagonosis Study of Important Buildings	Each Governmental Organization	5,340								
		1-2 Strengthen Important Buildings	Each Governmental Organization	264,303								
2	Improvement of Bridges	2-1 Sismic Doagonosis Study of Vehicular and Pedistrian Bridges	Bogota City	13,650								
		2-2 Seismic Reinforcement of Vehicular and Pedstrian Bridiges	Bogota City	288,500								
3.1	Seismic Reinforcement of Water supply Facilities	3-1 Seismic reinforcement of waster supply facilities	EAAB	447,140								
		3-1-2 Provision of Emergency Water Supply Tanks	EAAB	79,760								
3.2	Seismic reinforcement of gas supply facilities	3-2-1 Seismic diagnostic study of gas supply facilities	Gas Natural Company	770								
		3-2-2 Seismic reinforcement of gas supply facilities	Gas Natural Company	5,660								
3.3	Seismic reinforcement of electronic supply facilities	3-3 Seismic diagnostic study of electronic supply facilities	CODENSA/EMG ESA	1,160								
		3-4 Seismic reinforcement of electronic supply facilities	CODENSA/EMG ESA	20,600								
3.4	Improvement of telephone facilities	3-3-1 Seismic diagnosis study for telephone facilities	ETB/CAPITEL	420								
		3-3-2 Seismic reinforcement of telephone facilities	ETB/CAPITEL	9,200								
4	Urban Redevelopment of priority area	4-1 Urban redevelopment of priority area	Bogota City	87,913								
		4-2 Road development	Bogota City	109,862								
		4-3 Open space development	Bogota City	27,380								
5	Earthquake engineering	5-1 Geophysical Study of subsurface structure	DPAE/ INGEOMINAS	-								
		5-2 Geotechnical study for site response and liquifaction evaluation	DPAE/ INGEOMINAS	-								
6	Landslide	6-1 Landslide protection works	DPAE	14,034								
7	Foolding	7-1 Structure Measures	EAAB/ Cundinamarca	251,790								
		7-2 Non structure Measures	EAAB/ Cundinamarca	982								
8	Industrial Facility	8-1 Handling of hazadous materials	DAMA/CAR	-								
9	Health sector	9-1 Health sector improveemnt	Bogota/ Cundinamarca	33,436								
10	Education sector	10-1 Education Program	Bogota/ Cundinamarca	-								
11	Disaster management information system	11-1 Establishment of disaster management information system	Bogota/ Cundinamarca	9,620								
12	Monitoring program	12-1 Establishment of monitoring program	DPAE	157								

Source: Study Team

**Table 4 Cost Distribution of the Projects (Unit: Million COP)**

Items Year	Cost Distribution									Total
	Short			Medium			Long			
	2002	2003	2004	2005	2006	2007	2008	2009	2010	
Seismic Diagnosis Study of Important Buildings	927	926	30	625	626	52	1,001	1,002	152	5,340
Strengthen Important Buildings	9,232	18,316	18,342	24,713	31,229	22,118	45,363	45,364	49,627	264,303
Seismic Reinforcement of Vehicle and Ped. Bridge	6,825	6,825	57,700	57,700	57,700	57,700	57,700	-	-	302,150
Water Supply	4,805	4,805	88,420	101,580	101,580	101,380	99,680	12,200	12,450	526,900
Gas Supply system	775	575	1,110	1,110	1,130	1,130	200	200	200	6,430
Electronic Supply Systems	780	780	1,320	3,320	3,370	3,820	3,820	3,300	1,250	21,760
Telecommunication Systems	410	410	1,250	1,750	1,750	1,750	700	800	800	9,620
Urban Development	8,658	8,658	8,660	66,391	66,391	66,397	-	-	-	225,155
Earthquake Engineering	-	-	-	-	-	-	-	-	-	-
Landslide Program	830	2,471	2,471	2,364	2,364	2,375	579	580	-	14,034
Flooding Program	27,028	27,028	27,030	19,078	19,078	19,079	38,150	38,150	38,150	252,771
Industrial facility	-	-	-	-	-	-	-	-	-	-
Health Program	4,216	4,226	4,246	4,136	4,136	4,196	2,716	2,716	2,848	33,436
Education Program	-	-	-	-	-	-	-	-	-	-
Information System	1,603	1,603	1,603	1,603	1,603	1,605	-	-	-	9,620
Monitoring Program	70	66	3	3	3	3	3	3	3	157
Total	66,158	76,689	212,185	284,373	290,960	281,605	249,912	104,315	105,480	1,671,676
Total (Time span)			355,032			856,937			459,707	

Source: Study Team

### 3.4 Evaluation

The proposed programs in the basic plan for disaster prevention of the Bogotá Metropolitan Area are evaluated in technological, social, environmental and economic terms. The programs are evaluated from A to C based on the expected impacts by each program. The results are summarized and shown in Table 4.



**Table 5 Evaluation of Programs**

No	Program	Expected Impacts	Evaluation Items			
			Technology	Social	Environment	Economy
1-1	Seismic diagnosis study of important buildings	Reduction of weak building for the governments and emergency response organizations will reduce the seismic damage. The number of improved building is more than 700 in total.	A	C	C	C
1-2	Strengthen important building facilities		A	A	A	A
2-1	Seismic diagnosis study of vehicular and pedestrian bridges	Improvement of existing vehicular bridges and pedestrian bridges will secure the emergency transportation networks required. The number of improved bridges is 58 in total.	A	C	C	C
2.2	Seismic reinforcement of vehicular and pedestrian bridges		A	B	A	A
3-1-1	Seismic reinforcement of water supply facilities	The seismic reinforcement of the water supply facilities (13 stations) will secure the water supply capacity.	A	C	A	C
3-1-2	Provision of emergency water supply facilities	Emergency water supply system will secure the emergency water supply by strengthening the water supply facilities (110,800m <sup>3</sup> in total).	A	C	A	A
3-2	Seismic reinforcement of gas supply facilities	Improvements of existing gas supply facilities will secure the gas supply service.	A	C	B	B
3-3	Seismic reinforcement of electronic supply facilities	Improvement of existing electronic supply facilities will secure the power supply service.	A	C	B	B
3-4-1	Seismic diagnosis study for telephone facilities	Improvement of existing telephone facilities will secure communication service.	A	C	C	C
3-4-2	Seismic reinforcement of telephone facilities		A	C	B	B
4-1	Urban redevelopment of priority area	Improvement of vulnerable urban area. Total area, more than 7,000 ha in the Study Area will reduce the damage.	B	A	A	B
4-2	Road development		B	A	B	B
4-3	Open space development		B	A	A	C
4-4	Education and enlightenment program	Technology improvement will reduce secondary damage	-	-	-	-
5-1	Geophysical study of subsurface structure	Provision of more accurate information for seismic reinforcement for infrastructure and buildings.	A	C	C	C
5-2	Geotechnical study for site response and liquefaction evaluation		A	C	C	C
6	Landslide protection works	Five locations identified for priority area will be improved.	B	A	C	C
7-1	Flooding (Structural Measures)	The development of five rivers will protect the people in the hazard area from the floods	A	B	C	A
7-2	Flooding (Non-structural Measures)	Warning system installation and preparation of flood map will protect and mitigate the flood hazard area from the floods	A	B	C	C
8	Handling of hazardous materials	Establishment of inspection system	A	B	A	C
9	Health sector improvement program	Improve health sector capacity and improvement of emergency response capacity.	C	A	C	C
10	Education program	Disaster management education for all level will reduce the damage	-	-	-	-
11	Establishment of disaster management information system	Establishment of information system in the Study Area	B	A	C	B
12	Establishment of monitoring program	Establishment of warning system	B	A	C	B

Note: A: High impact

B: Medium impact

C: Low impact

#### 4. CONCLUSION AND RECOMMENDATION

For disaster prevention of the Bogotá Metropolitan Area, the related entities are the city government of Bogotá, the Prefecture government of Cundinamarca and the National government. The existing disaster prevention organizations have already been prepared for landslides and floods, but not for earthquakes. It is necessary for the related three governments to arrange the responsible organizations for preparedness of disaster prevention and emergency response in order to cope with seismic disaster.

The Basic Plan has proposed to reduce the number of weak buildings by strengthening by phased expansion until 2010. As for the vulnerable Localities and Municipalities identified in the Bogotá Metropolitan Area, the vulnerable areas are proposed to be improved through pilot studies. The government organizations for disaster prevention and emergency response for earthquake shall involve the whole government organizations, and it will be necessary to prepare themselves to handle their responsibilities and functions.

The proposed Basic Plan for disaster prevention of the Bogotá Metropolitan Area will be effective in technical, economic, financial, social and environmental terms. By implementation of the proposed projects, it is hoped that the vulnerability of the area to seismic disaster would be sufficiently addressed.

It is concluded and recommended that the related governments of the Bogotá Metropolitan Area to take immediate actions for implementation of the following:

- 1) It is recommended that the government of Bogotá D.C., the government of Cundinamarca and the National government take immediate actions to arrange the government organizations for the preparedness of disaster prevention and the emergency response before, in and after a seismic disaster.
- 2) It is recommended that the related agencies hold a common database and maintain it properly because the database developed in the Study is a basic tool for disaster management.
- 3) For alleviation of the seismic damage, it is most important for the Bogotá Metropolitan Area to reduce the number of weak buildings or those without seismic resistance by strengthening (seismic retrofitting); moreover, it is important to reduce the number of informal building constructions. Also, it is recommended that the CURADURIA, which is responsible for giving approval of construction of new buildings in Bogotá, expand its capacity to meet the demand of new building constructions and to extend the responsibility to the seismic retrofitting or strengthening projects. Further, it is recommended that the governments of Bogotá and Cundinamarca introduce an authorized inspection system of

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the Locality office for inspection of construction works after getting the approval of the design from the CURADURIA.

- 4) It is recommended that the governments of Bogotá and Cundinamarca review the seismic design and construction standards for masonry buildings duly based on the actual conditions, building damages estimated and the assessment of the building damages in the 1999 Quindio earthquake.
- 5) It is recommended that the Bogotá Metropolitan Area review the existing information or communication systems and promote the development of a Disaster Management Information System as a basic management tool for disaster prevention and emergency response of the Bogotá Metropolitan Area.
- 6) It is recommended that public or service entities prepare their emergency response plans, which consist of preparedness for disaster prevention, strengthening the facilities like water supply tanks for emergency response in a disaster due to their seismic diagnosis studies based on the damages estimated, and for restoration of the damaged facilities after a disaster, including materials and equipment.
- 7) Public education for disaster prevention is necessary for the government staff to strengthen the government organizations and for communities to enhance the public awareness. The government organizations should be strengthened to cope with their responsibilities in preparedness for disaster prevention and also responsibilities in emergency response. Also, enhancement of disaster prevention awareness of the inhabitants, and communities in general, is recommended, to make it easier for the people to understand the need to follow the regulations related to disaster prevention. Seismic-resistant design for new buildings and strengthening of existing building structures are also recommended.
- 8) Early execution of a pilot study is necessary to promote the Basic Plan for Disaster Prevention of the Bogotá Metropolitan Area. It is recommended that the pilot study on disaster prevention include organization of local communities, emergency response facilities and restoration plan and that the pilot area be selected from the vulnerable localities and municipalities prioritized from disaster prevention aspects in Bogotá and Cundinamarca. They are localities of Santa Fe, San Cristobal, Usme, Bosa, Kennedy, Suba, Rafael Uribe and Ciudad Bolivar, and municipalities of Cota and Soacha.
- 9) For further study of the existing conditions of the Bogotá Metropolitan Area, studies required to be conducted are listed as follows:
  - Development study on disaster prevention for pilot areas in the Bogotá Metropolitan Area,
  - Geophysical study on Cundinamarca,
  - Geotechnical study on Cundinamarca,
  - Study on Water Resources and Environmental Management for Upper Rio Bogotá.

- 10) This basic plan for disaster prevention shows the direction of the prevention and attention of disasters. The following are recommended:
- It is necessary to arrange the disaster prevention organizations for the Bogotá Metropolitan Area through each committee for prevention and attention of disaster, the city of Bogotá, the prefecture of Cundinamarca and National levels. The responsible and supporting agencies assigned by the committee should implement the disaster prevention plans and prepare for the emergency response. Also, it is necessary to arrange coordination agreements with other cities and prefectures and international agencies.
  - It is indispensable to decide a leading coordination agency for the Bogotá Metropolitan Area in order to coordinate the related agencies and the implementation of projects.
  - It is important for the city of Bogotá to assign DPAE as an Administrative Department considering the required coordination among the administrative organizations for planning the disaster prevention measures before, in and after a disaster, especially seismic disaster.
  - It is necessary for the agencies, which are responsible for infrastructure and lifeline facilities, to conduct diagnostic studies on the proposed projects and effect reinforcements as proposed by the study.
  - It is necessary for the Localities of Bogotá and the 8 municipalities of Cundinamarca to prepare their disaster prevention plans and emergency response plans

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## **List of Abbreviations**

AASHTO	American Association of State Highway and Transportation Officials
ACCI	Colombian Agency of International Cooperation (Agencia Colombiana de Cooperación Internacional)
ACERCAR	Environmental Technical Attendance Unit for Micro, Small, and Medium Sized Companies (Unidad de Asistencia Técnica Ambiental para la Micro, Pequeña y Mediana Empresa)
ACGIH	American Assembly of Government Industrial Hygienists
ACOTOFA	Colombian Association of Toxicology and Pharmacology (Asociación Colombiana de Toxicología y Farmacología)
AIS	Colombian Earthquake Engineering Association (Asociación Colombiana de Ingeniería Sísmica)
AMBAS	Generating Company of Electricity in Facatativa (Compañía Generadora de Electricidad en Facatativa)
ANDI	National Association of Industrialists (Asociación Nacional de Industriales)
ANSI	American National Standard Institute
API	American Petroleum Institute
ARP	Professional Risks Administrator (Administradora de Riesgos Profesionales)
ASEMGAS	Association of Liquefied Petroleum Gas Companies (Asociación de Empresas de Gas Licuado de Petróleo)
ASTER	Advanced Space borne Thermal Emission and Reflection Radiometer
ASTM	American Society for Testing and Materials
ATC	Applied Technology Council
BOR	Beds Occupation Rate
CADELS	Administrative Center of Local Education (Centro Administrativo de Educación Local)
CAM	Municipal Committee of mutual Attendance for Prevention and Attention of Disasters
CAMI	Center of Immediate Medical Attention (Centro de Atención Médica Inmediata)
CAPS	Primary Attention Center (Centro de Atención Primaria)
CAR	Regional Autonomous Corporation (Corporación Autónoma Regional)
C.C.A.E.	Center for Coordination and Attention of Emergency (Centro de Coordinación y Atención de Emergencias)
CCF	Family Compensation Fund (Fondo de Compensación Familiar)
CCP	Colombian Code of Bridges (Código Colombiano de Puentes)
CCS	The Colombian Safety Council (Consejo Colombiano de Seguridad)
CDP	Productive Development Center (Centro de Desarrollo Productivo)
CEDERI	Center of studies about Disasters and natural Risks (Centro de Estudios sobre Desastres y Riesgos Naturales)
CEPREVE	Study Center for the Prevention of Disasters (Centro de Estudios para la Prevención de Desastres)
CISPROQUIM®	Safety Information Center of Chemical Products (Centro de Información de Seguridad sobre Productos Químicos)
CLE	Emergency Local Committee (Comité Local de Emergencia)
CLOPAD	Local Committee for the Prevention and Attention of Disasters (Comité Local para la Prevención y Atención de Desastres)
COE	Operational Emergency Committee (Comité Operativo de Emergencia)
CON-PNC	National Operative Committee of the National Contingency Plan (Comité Operativo Nacional del Plan Nacional de Contingencia)
CPVM	Promoting Fund of Military Housing (Fondo de Promoción de Vivienda Militar)

CRA	Regulation Committee for Water (Comité de Regulación para el Agua)
CREG	Regulation Committee for Energy and Gas (Comité de Regulación para la Energía y Gas)
CREPAD	Regional Committee for the Prevention and Attention of Disasters (Comité Regional para la Prevención y Atención de Desastres)
CRT	Regulation Committee for Telecommunications (Comité Regulador para las Telecomunicaciones)
CRU	Emergencies Regulating Center (Centro Regulador de Urgencias)
CRUC	Regulating Center of Urgencies of Cundinamarca (Centro Regulador de Urgencias de Cundinamarca)
CTE	Energy Transport Center (Centro de Transporte de Energía)
CTS	Information, Collection and Transmission System (Sistema de Recolección y Transmisión de la Información)
DABS	Administrative Department of Social Welfare (Departamento Administrativo de Bienestar Social)
DAMA	Administrative Department of the Environment (Departamento Administrativo del Medio Ambiente)
DANE	National Administrative Department of Statistics (Departamento Administrativo Nacional de Estadísticas)
DAPD	Administrative Department for District Planning (Departamento Administrativo de Planeación Distrital)
DB	Database
DBMSs	Database Management Systems
DGPAD	General Directive Office for Prevention and Attention of Disasters (Dirección General para la Prevención y Atención de Desastres)
DMA	Disaster Management Agency
DMIS	Disaster Management Information System
DNP	National Department of Planning (Departamento Nacional de Planeación)
DNPAD	National Office for the Attention of Disasters (Dirección Nacional para la Atención de Desastres)
DOT	Department of Transportation
DPAE	Direction for the Prevention and Attention of Emergency (Dirección para la Prevención y Atención de Emergencias)
DSS	Decisions Support System
EAAB	Company of Water Supply and Sewage Service of Bogotá (Empresa de Acueducto y Alcantarillado de Bogotá)
EAAB-ESP	Company of Water Supply and Sewage Service of Bogotá (Empresa de Acueducto y Alcantarillado de Bogotá)
ECOGAS	Colombian Company of Gas (Compañía Colombiana de Gas)
ECOPETROL	Colombian Company of Petroleum (Empresa Colombiana de Petróleos)
EEB	Company of Energy of Bogotá (Empresa de Energía de Bogotá)
EMGESA	Generating Company of Electric Energy (Empresa Generadora de Energía Eléctrica)
EMI	Emergency Management Institute
EOT	Territory Ordering Scheme (Esquema de Ordenamiento Territorial)
EPA	Environmental Protection Agency
EPM	Public Companies of Medellín (Empresas Públicas de Medellín)
EQT	Technical Team of DPAE (Equipo Técnico de DPAE)
ERG	Emergency Response Guidebook (Guía de Respuesta a Emergencias)
ESP	Public Services Company (Compañía de Servicio Públicos)
ESRI	Environmental System Research Institute

ETB	Company of Telecommunications of Bogotá (Empresa de Telecomunicaciones de Bogotá)
E.U.	Uni-personal Company (Empresa unipersonal)
FAVIDI	Fund of Saving and Housing of the District (Fondo de Ahorro y Vivienda del Distrito)
FCS	Flood Control Structures
FEMA	Federal Emergency Management Agency
FERROVIAS	Colombian Company of Railroad (Empresa Colombiana de Ferrocarriles)
FFMM	Military Forces (Fuerzas Militares)
FINDETER	Financial Society for Territorial Development (Sociedad Financiera para el Desarrollo Territorial)
FNA	National Fund of Saving (Fondo Nacional de Ahorro)
FNC	National Railway of Colombia (Ferrocarril Nacional de Colombia)
FOPAE	Fund for Prevention and Attention of Emergencies (Fondo para la Prevención y Atención de Emergencias)
FOREC	Fund for Reconstruction of Coffee Axis Region (Fondo para la Reconstrucción de la Región del eje Cafetero)
FOVIS	Fund for the Family Subside of Well - Being Housing (Fondo para el Subsidio Familiar de Vivienda de Interés Social)
FPSF	Passive Social Fund of Railways (Fondo Pasivo Social de Ferrocarriles)
GDP	Gross Domestic Product
GIS	Geographic Information System
GMP	Good Manufacturing Practice
GNP	National Gross Product
GOC	Government of Colombia
GOJ	Government of Japan
GPS	Global Positioning System
GRE	Response Guide to Emergencies with Dangerous Materials (Guía de Respuesta a Emergencias con Materiales Peligrosos)
GTZ	German Technical Cooperation
HF	High Frequency
HMR	Hazardous Materials Regulation
HP	Horizontal Property
IAEE	International Association of Earthquake Engineers
ICA	Colombian Institute of Agriculture (Instituto Colombiano Agropecuario)
ICBF	Colombian Institute for Family Welfare (Instituto Colombiano de Bienestar Familiar)
ICONTEC	Colombian Institute of Technical Norms and Certification (Instituto Colombiano de Normas Técnicas y Certificación)
ICS	Incident Command System
ICT	Institute of Territorial Credit (Instituto de Crédito Territorial)
ICU	Intensive Care Unit
IDB	Inter-american Development Bank
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies (Instituto de Hidrología, Meteorología y Estudios Ambientales)
IDRD	District Institution of Sports and Recreation (Instituto Distrital de Recreación y el Deporte)
IDS	Information Distribution System
IDU	Institute of Urban Development (Instituto de Desarrollo Urbano)
IGAC	Geography Institute "Agustin Codazzi" (Instituto Geográfico Agustín Codazzi)
INGEOMINAS	Institute of Investigation and Geo-scientific, Mining-Environmental and Nuclear Information (Instituto de Investigación e Información Geocientífica, Minero Ambiental y Nuclear)

INURBE	National Institute of Housing of Social well – being and Urban Reform (Instituto Nacional de Vivienda de Interés Social y Reforma Urbana)
INVIAS	National Institute of Roads (Instituto Nacional de Vías)
INVEMAR	Institute of Marine and Coastal Investigations (Instituto de Investigaciones Marinas y Costeras)
IPC	Index of Consumer Prices (Índice de Precios al Consumidor)
ISA	Electric Interconnection (Interconexión Eléctrica)
ISO	International Organization of Standardization
JAC	Assembly of Community Actions (Junta de Acción Comunal)
JAL	Local Administrative Assembly (Junta Administradora Local)
JICA	Japan International Cooperation Agency
JIS	Japanese Industrial Standards
KFW	German Development Bank
LPG	Liquefied Petroleum Gas
MMI	Modified Mercali Intensity
NFPA	National Association for the Protection Against Fires
NGOs	Non-Governmental Organization
NHP	Non Horizontal Property
NNE-SSW	Northeast - Southwest
NSR	Norm for Seismic Resistant
NPGA	National Association of LPG of the United States
NTC	Colombian Technical Norm (Norma Técnica Colombiana)
OCCEL	Telecommunications Company of Occident (Compañía de Telecomunicaciones de Occidente)
ODBC	Open Database Connectivity
OPAD	Office for the Prevention and Attention of Emergency and Disasters of Cundinamarca Department (Oficina para la Prevención y Atención de Emergencias y Desastres del Departamento de Cundinamarca)
OPES	Coordination Office for Prevention and Attention of Emergencies (Oficina de Coordinación para la Prevención y Atención de Emergencias)
OPVs	Popular Housing Organizations (Organizaciones Populares de Vivienda)
OSHA	Safety and Occupational Health Association
PBOT	Basic Territory Ordering Plan (Plan Básico de Ordenamiento Territorial)
PBX	Phone Box
PCM	Project Cycle Management
PGA	Peak Ground Acceleration
P.M.U.	Unified Control Post (Puesto de Control Unificado)
PNC	National Contingency Plan (Plan Nacional de Contingencia)
POT	Territorial Ordering Plan (Plan de Ordenamiento Territorial)
PS	Information Processing System
PSI	Pound per Square Inch
PSM	Process Safety Management
RPM	Risk Management Plan
RSS	Social Solidarity Network
S.A.	Public Limited Company (Sociedad Anónima)
SAE	Society of Automobile Engineers
SAMU	Service for Medical Attention of Urgencies (Servicio de Atención Médica de Urgencias)
SDE	Spatial Data Engine

SDH	Synchronous Digital Hierarchy
SDPAE	Distrital System for Prevention and Attention of Emergencies (Sistema Distrital para Prevención y Atención de Emergencias)
SEAOC	Structural Engineers Association of California
SENA	National Service of Vocational Training (Servicio Nacional de Aprendizaje)
SIRE	Information System for Risk Management and Attention of Emergency (Sistema de Información para el Manejo y Atención de Emergencias)
SISBEN	Selection System of Beneficiaries for Social Programs (Sistema de Selección de Beneficiarios para Programas Sociales)
SMLM	Monthly minimum legal salary (Salario Mínimo Legal Mensual)
SNPAD	National System for the Prevention and Attention of Disasters (Sistema Nacional para la Prevención y Atención de Desastres)
SPT	Standard Penetration Test
SQL	Structured Query Language
SUME	Unified System for Emergency Handling
SURATEP	Professional Risks Administrator of South American Insurances
STF	Colombian Society of Railway Transport (Sociedad Colombiana de Transporte Férreo)
STFO	West Colombian Society of Railway Transport (Sociedad Colombiana de Transporte Férreo del Occidente)
STT	Secretary of Transit and Transportation (Secretaria de Tránsito y Transporte)
TELECOM	National Company of Telecommunications (Empresa Nacional de Telecomunicaciones)
TLV	Threshold Limit Value
TOAD	Tools for Oracle Application Development
U.K.	United Kingdom
UBA	Basic Unit of Attention (Unidad Básica de Atención)
UBC	Uniform Building Code
UHF	Ultra High Frequency
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nation Development Program
UPA	Primary Unit of Attention (Unidad Primaria de Atención)
UPES	Unit for the Prevention and Attention of Emergencies (Unidad para la Prevención y Atención de Emergencias)
UPZ	Unit of Zone Planning (Unidad de Planeamiento Zonal)
USAID	United States Agency for International Development
USEPA	United States Agency for Environment Protection
UVR	Unit of Monetary Adjustment (Unidad de Valor Real)
VIS	Social Interest Housing (Vivienda de Interés Social)
VHF	Very High Frequency



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