

# HURRICANE MITCH RECONSTRUCTION PARTNERSHIPS AND PROGRESS

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## ABSTRACT

A review of reconstruction efforts since Hurricane Mitch occurred and the application of information collected during the response stage are presented. A sample of geospatial technologies applicable to disaster management is presented. The application of Geo-spatial technologies following Hurricane Mitch in Central America is presented. Natural disasters have a major impact, globally and within the United States (U.S.) causing injury and loss of life, as well as economic losses. To better address disaster response needs, new approaches to leverage technological capabilities are described to improve disaster management. Geospatial analysis is one of these important capabilities.

**KEY WORDS:** Hurricane Mitch; Disaster management; Central America; Information Infrastructure; Disaster recovery; mapping; Geo-spatial library; LIDAR; Geographic Information Systems; Global Positioning System; satellite sensors; 3-D fly through.

## 1. INTRODUCTION

This paper will focus on an update of the reconstruction efforts that have occurred since the devastation of Hurricane Mitch in the fall of 1998. Particularly, the application of geospatial technology and methods to assist or support recovery and reconstruction activities will be reviewed and assessed. There has been significant capability growth in the geospatial areas of remote sensing, spectral analysis, global

positioning systems (GPS), geographic information systems (GIS), and modeling and simulation techniques (Roper, 1998). Each adds important value in characterizing infrastructure, risk areas, disaster zones, and control points that are essential to rapid deployment of scarce resources in the most effective manner.

Natural disasters are a constant threat to mankind on a global scale. Global disaster costs are continuing to rise. Annual global economic costs related to disaster events average \$440 billion per year (World Disaster Report, 1996) with floods being the major cause. In the U.S., the number of lives lost due to natural disasters has been decreasing over the last several decades, largely because of advances in disaster indication and warning capabilities. In terms of damage to property, however, the trend is reversed. For the period 1992-1996, the average cost of natural disasters in the U.S. has been \$54.3 billion, with hurricanes and earthquakes tied as the leading cause. These rising costs are the combined result of increased urbanization, particularly in high-risk coastal areas, and the increased complexity and size of our infrastructure.

The loss of life and property continues to rise in many regions of the world because of these events. One example is the Bangladesh weather event of 1970, when a tropical cyclone slammed into its delta region killing 300,000 people (Tobin and Montz, 1997). The crop losses were estimated at \$63 million, and more than 280,000 cattle were drowned (Burton, Kates, and White, 1993). The rich delta soil is an agricultural

resource that still draws people to settle there; therefore a recurrence of this type of weather event could likely pose a similar disaster.

## **2. GEOSPATIAL RESEARCH COMMUNITY INVOLVEMENT**

The flow of disaster related information could be conceptually shown as a seven-step process as shown in Figure 1. The geospatial research community may have a role in each of these steps, depending on the particular disaster situation.

This could include assistance in defining the problem through current image analysis. Assistance in determining collection and analysis methodologies assists in defining the requirement. A key area of support is providing supporting data in the form of maps, imagery, and spectral information. An even more important support area is data exploitation. This includes the processing of digital data, image integration, feature classification and attribution, classification output, accuracy assessments, and post-processing operations. It is most technically challenging step in process. The decision support phase includes geospatial visualization, merged data analysis, and specialized decision support products. This involves the synthesis of data types in order to generate data layers (such as, soils, vegetation, terrain) along with models and simulation techniques that use the various data layers.

It is during this phase that the concept of virtual forums could take place. These forums would allow expert input from multiple locations to be jointly focused on problem solving for the disaster situation. Within the geospatial community this could include virtual fly-through support showing the impacts of possible decisions on the natural environment, and on the population, including those with special needs. It also could include analysis of changing

situational information, and image-based change detection and analysis. In the final two phases, tailored map products and GIS overlay information can be used as integral parts of directives and guidance to disaster managers in the field. These specific products could be maps delineating evacuation routes, area identification for damage assessments, or point locations for water distribution.

The geospatial research community has typically been interdisciplinary, including the natural sciences, engineering, architecture, land use planning, photogrammetry, etc. However, in the disaster management arena, broader interdisciplinary teaming will be required. This could include public policy and health specialists at the Federal, state, and local level. It may include other medical specialists, police, National Guard, and communications experts.

The greatest potential for loss reduction is during the mitigation phase (Disaster Information Task Force Report, 1997), when communities can be made more disaster resistant. The largest share of costs, however, are directed toward the recovery phase, where good mitigation principles also need to be put into practice rather than just rebuilding to be impacted by a similar disaster in the future. Geospatial products and location specific tools developed during the response phase of the disaster may be excellent vehicles for planning and implementing effective mitigation.

## **3. HURRICANE MITCH STORM TRACK AND CHARACTERISTICS**

Hurricane Mitch, the strongest October hurricane ever recorded, formed in the southwest Caribbean sea from a tropical wave about 360 miles south of Kingston, Jamaica, late on October 21. The system initially moved slowly westward and intensified to a tropical storm (Atlantic Hurricane Summaries, 1999). Mitch

then moved slowly northward. Its course changed to north northwestward on the 23<sup>rd</sup> and 24<sup>th</sup> while gradually gaining strength. Early October 24, Mitch became a hurricane. Later that day, as it turned towards the west, Mitch began to intensify rapidly. In about 24 hours, its central pressure dropped 52 MB to 924 MB by the afternoon of October 25. Further strengthening took place and the central pressure reached a minimum of 905 MB about 40 miles southeast of Swan Island on the afternoon of October 26. This pressure is the fourth lowest ever recorded in an Atlantic hurricane this century. It is tied with Hurricane Camille in 1969. This is also the lowest pressure ever observed in an October hurricane in the Atlantic Basin.

At its peak, the maximum winds were estimated to be 180 mph, a strong Category 5 hurricane. After passing over Swan Island, Mitch began to gradually weaken on October 27 while moving slowly west, then southwest toward the Bay Islands off the coast of Honduras. The center passed very near the Island of Guanaja wreaking havoc there. From mid-day on the 27<sup>th</sup> to early on the 29<sup>th</sup>, the minimum central pressure rose 59 MB. The center of the hurricane meandered near the north coast of Honduras from late on the 27<sup>th</sup> through the 28<sup>th</sup> before making landfall during the morning of the 29<sup>th</sup> about 70 miles east of LaCeiba with 100 mph winds. Mitch moved southward over Honduras, weakening to a tropical storm early on the 30<sup>th</sup>. Mitch moved slowly over Honduras and Guatemala on September 30-31, gradually weakening to a depression. The storm generated torrential rains over portions of Honduras and Nicaragua where the associated floods were devastating. Some heavy rains also occurred in neighboring countries.

Although Mitch originally dissipated near the Guatemala/Southeast Mexico border Sunday afternoon, November 1, the remnants continued

to produce locally heavy rainfall over portions of Central America and eastern Mexico for the next couple of days. On November 3, a low-level circulation became evident in the eastern Bay of Campeche and an Air Force Reserve reconnaissance aircraft investigating the system reported tropical storm-force winds and a 99-MB central pressure. Mitch had regenerated into a tropical storm on the afternoon of the 3<sup>rd</sup> while located about 55 miles west-southwest of Campeche, Mexico. Mitch weakened to a depression early on the 4<sup>th</sup> as it moved inland over the northwest Yucatan Peninsula. The center re-emerged over the south central Gulf of Mexico by mid-morning on the 4<sup>th</sup> regaining tropical storm strength. Mitch began to accelerate to the northeast as it became involved with frontal zone moving through the aster Gulf of Mexico. Mitch made landfall on the morning of the 5<sup>th</sup> in southwest Florida near Naples with maximum sustained winds near 60 mph. By mid-afternoon of the 5<sup>th</sup>, Mitch moved offshore of south Florida and became extra tropical. Figure 2 shows the storm track of Hurricane Mitch.

#### **4. INITIAL GEOSPATIAL SUPPORT OF MITCH RECOVERY ACTIVITIES**

##### **4.1 Initial Response Efforts**

U.S. military forces were some of the first international support units on the ground conducting recovery operations. As a result, a number of requirements for geospatial products were identified early in the operations (Operations Summary, January 1999). In support of these requests, maps, country studies, water aerial appraisals and other available materials were collected and provided to the U.S. Army Corps of Engineers (USACE) Operations Center for use in immediate recovery operations, planning any additional deployments and future reconstruction efforts. Separate requests for ground water resource data were received from

support elements of the Second Marine Expeditionary Force and two Air Force Red Horse Squadrons (well drilling units) in Honduras. Maps and water area appraisals were provided to two Marine Expeditionary Forces. Water detection data was also provided to the Air Force Unit.

Initial analytical activities focused on assessing road and bridge damage in Honduras. Satellite imagery was reviewed and road and bridge assessment data were tabulated and served over the communication links. These data were keyed to a regional map, provided by the National Imagery and Mapping Agency (NIMA), to which a grid was added as an orientation aid for the user. Photomaps of the Soto Cano Air Base and a slide area along the Chaluteca River in Tegucigalpa were also prepared and provided to the Army Corps of Engineering Operations Center. The 30<sup>th</sup> Engineer Battalion, also in Honduras, requested specific Digital Topographic Data, and loan of high capacity hard drives to process data. The Topographic Engineering Center imbedded current imagery data on the affected areas onto 14 CDs and provided them to the 30<sup>th</sup> Engineers. These CDs contained Landsat and Spot imagery (Collier, 1999).

#### **4.2 Joint Government and Private Sector Support**

A cooperative effort of U.S. Government agencies and the private sector developed a Digital Atlas of Central America to assist in recovery efforts and planning for reconstruction. The geographic information system (GIS) based product provided a framework for displaying and organizing information in multiple layers useful to those responding to the disaster. Products were produced showing, for example, the path of Hurricane Mitch over a map with country boundaries and color-coding to illustrate terrain elevation (Digital Atlas, January 1999).

#### **4.3 Geospatial Technology Applications**

For the initial reconstruction phase, a number of geospatial products are needed to enhance planning and project execution. Virtually all activities associated with the reconstruction effort required large-scale (high resolution) base maps showing topography, drainage, and the location of roads, bridges, and massive sediment deposits from the flooded Rio Choluteca River within the city limits is of particular concern with the fast approaching rainy season. Also a major landslide during Mitch has left a large area of unstable ground immediately above the city. Figure 3 is an airborne image of a major sediment deposit area on the Rio Choluteca River where a major bridge was destroyed and many homes were washed away. Figure 4 shows the integration of the image information into a GIS database for use in planning reconstruction and also to potentially form a future framework for the information infrastructure in this geographic area.

Because of the vulnerability of the city of Tegucigalpa to additional flooding and landslides during the rainy season and the limited time available to put protection measures in place; the majority of the initial effort in developing action plans was placed on short-term solutions to the flooding and landslides. The effort to develop more long-term solutions required substantial additional data gathering and engineering analysis to determine the most cost effective solutions. These studies and data collection efforts have been underway and a series of proposed approaches have been developed. One of the focus areas is the reconstruction sewage treatment system. The report on this project should provide a plan showing the preliminary layout of the sewage collection system, pumping station locations, and location/alternate locations for the treatment plant. This effort would address alternate

treatment plant processes and the reason for selecting a particular process. The report would be coordinated with the city officials and three design review meetings would be held at Tegucigalpa. It was estimated that the report would take 12 months to prepare. For this project topographic maps and existing sewer system plans have been reviewed and used extensively in developing the alternative treatment plant and system options. The service area and potential locations of the treatment plants have been developed and some construction has been initiated, but the progress over the last year has been slow and is well behind the original plan for reconstruction.

#### **4.4 Summary of Initial Response Lessons From Hurricane Mitch**

Hurricane Mitch was a natural disaster of epic proportion to Central America. The recovery and reconstruction efforts have also been of a magnitude not encountered before in that region. For the first time in a major disaster, extensive application of geospatial technology was used to assist in all phases of the recovery. A digital atlas and Geographic Information System was created for the impacted area to form a framework to integrate new data information over time in a systematic manner. Satellite, aircraft, and ground information sources were used to collect data and information to support the recovery activities. A variety of products were successfully generated tailored to user needs in the field and higher-level decision-makers in the recovery effort.

### **5. INTER AMERICAN DEVELOPMENT BANK RECONSTRUCTION SUPPORT**

The Inter-American Development Bank (IDB) approved \$597 million in financing for the countries of Central America that suffered severe damage from Hurricane Mitch during the

one-year period immediately following one of the worst natural disasters ever suffered by the region. Simultaneously, at the request of Central American governments, the Bank identified more than \$280 million in resources for projects that had been approved prior to the impact of storm that could be converted into financing for new programs for disaster recovery. Disbursements to the region reached \$540 million in support of reconstruction in Honduras, Nicaragua, Guatemala and El Salvador. A major portion of Bank reconstruction financing was focused on social sector investments.

The IDB resources are part of a commitment by the international community to provide more than \$9 billion in humanitarian assistance, long-term financing, and debt relief to countries stricken by Mitch. IDB President Enrique V. Iglesias reiterated that the institution expects to contribute about \$3.4 billion over five years to the task of recovery and transformation of Central America, a region with deep and persistent social problems and a high level of vulnerability to natural disasters. "A year ago Central America's peoples suffered a catastrophe of biblical proportions," Iglesias said. "Now they are making progress on the monumental task of rekindling development. Although the challenge ahead is not something that can be resolved quickly and easily, progress is being achieved in the context of democracy and macroeconomic stability with the support of the international community" (Inter American Development Bank Web Page, 2000).

Hurricane Mitch unleashed over Central America in less than a week the equivalent of one year of rainfall on a region parched by eight months of drought. Its destructive force, made worse by diverse environmental problems, triggered massive flooding and landslides. Nearly 10,000 persons died because of the disaster and thousands more disappeared. Millions of Central Americans lost their homes,

their land, and their crops. Infrastructure that had represented decades of investment was swept away. Economic losses rose to more than \$5 billion, the equivalent of 17 percent of the region's gross domestic product. The IDB responded immediately to the Central American crisis. The Bank sent technical missions to the four countries most affected by the disaster in order to assist IDB country offices in evaluating the damage, identifying available resources, and preparing the most urgent counter-measures. President Iglesias personally visited the region to learn the priorities of the Central American countries.

In the first few months following the destruction of Mitch, the Bank concentrated its assistance on emergency programs covering a wide program of activities, ranging from help in the preparation of national plans for reconstruction and transformation to support for social programs. Among other projects, the Bank supported rehabilitation of water and sanitation systems, rural roads, bridges, schools, rural health clinics, and other high-priority social services.

At the request of governments of the isthmus, the IDB organized a meeting of donor countries and multilateral organizations to form the Consultative Group for the Reconstruction and Transformation of Central America, an initiative to coordinate international cooperation. The group met at the headquarters of the Bank in Washington, D.C. in early December 1998 to analyze the response to the emergency and the preliminary studies, prepared by the United Nations, on the damage caused by the hurricane. The Consultative Group, chaired by the IDB, met again at the end of May in Stockholm, with support from the Swedish government. There the Central American countries presented their national plans for reconstruction and transformation. During that meeting the donor community also had an opportunity hear the

opinions of representatives of diverse civil society organizations from Central America on the impact of Mitch. At the end of the conference, donors pledged more than \$9 billion in assistance, an unprecedented amount for this kind of aid effort.

The Central American recovery plans, whose main documents can be accessed on the IDB's website ([www.iadb.org](http://www.iadb.org)), are designed to reactivate the economies, generate productive employment, reduce poverty, and promote the sustainable use of natural resources. They also seek to strengthen the democratic system of government at all levels, encourage the participation in government by the citizenry, and improve the mechanisms of prevention and mitigation of natural disasters.

In response to Mitch the IDB also organized regional workshops attended by officials from Central America and by experts from donor countries on social and environmental vulnerability, the reduction of the risk of natural disasters, and emergency management measures. The Bank also sent several missions to the region to discuss initiatives with the governments to improve the transparency and efficiency in the use of public funds, one of the major concerns of the donor community.

The IDB put special emphasis on programs to alleviate poverty, rehabilitate basic infrastructure, and protect natural resources. These projects are designed to improve the efficiency of services and increase their coverage to include the most vulnerable social groups as well as to encourage decentralization and the participation by the private sector and civil society organizations. One outcome of the financial assistance effort by the IDB has been a net positive flow of resources to the four countries hardest hit by the hurricane. In keeping with the Stockholm agreements, the Bank is due to hold in February a round of consultations at

the national level with Honduras and Nicaragua to analyze the progress in reconstruction and transformation.

In November of 2000, the regional consultative group will meet in Madrid at the invitation of the Spanish government to discuss Central American proposals. This forum will help highlight the region's strategic advantages in terms of its geographic location, access to major markets, and recent economic reforms designed to stimulate trade and investment. At the same time, a series of workshops will be held on regional development. Among the issues that will be discussed are the benefits of furthering Central American integration through road and electricity projects and initiatives to reduce environmental and social vulnerabilities by means of improved management of shared watersheds and the establishment of early warning systems for natural disasters.

## **6. PRIVATE SECTOR SUPPORT ACTIVITIES**

An important component over the overall reconstruction effort in Central America has been voluntary contributions and support from private, commercial and charitable organizations. Such support is usually coordinated through international organizational structures and the host country receiving the support. Several illustrative examples are provided in this section.

### **6.1 Catholic Relief Services**

On September 18, 1999 a bridge donated by J.F. White Construction in Massachusetts was inaugurated yesterday in Moseli, Nicaragua, a small village 250 kilometers north of Managua (Catholic Relief Services Web Page, 2000). Catholic Relief Services, which has an office in Nicaragua, worked with the construction

company to relocate the bridge from Massachusetts to Central America. The bridge replaced one that was destroyed one year ago by Hurricane Mitch. The bridge spans the river between the states of Jalapa and San Fernando (Catholic Relief, 1999).

Following last year's hurricane, the Commonwealth of Massachusetts and local construction companies, working with the Archdiocese of Boston, joined forces and donated 37 Bailey bridges and related equipment to Catholic Relief Services for assembly in Honduras and Nicaragua. "Catholic Relief Services is extremely appreciative of the efforts of the Commonwealth of Massachusetts, the Archdiocese of Boston, and the numerous firms and individuals that have helped to make this assistance happen," said Louise Wilmot, Deputy Executive Director of Catholic Relief Services, who attended the ceremony. "This bridge will not only reconnect the 60,000 people who were left isolated since the hurricane destroyed the bridge, it will also link the people of Massachusetts and Moseli."

People in the rural region primarily support themselves through the production of rice, corn, coffee, lumber, and cattle. Without the bridge, they were unable to deliver their products to the markets, resulting in great losses of income. "This is an example of a public/private partnership responding in an innovative and important manner," commented Mark Snyder, Catholic Relief Services' Country Representative in Nicaragua. In Nicaragua, more than 100 bridges on primary and secondary roads were destroyed by the storm leaving many areas completely isolated. "The technical support and the bridges will make a tangible difference in people's lives here," Snyder said.

Catholic Relief Services is the official overseas relief and development agency of the U.S. Catholic community. Founded in 1943, today

the agency provides assistance to needy people in more than 80 countries.

## 6.2 Environmental Systems Research Institute (ESRI)

As part of the early support to Hurricane Mitch ESRI provided multi-hazard maps and information to emergency response organizations, military, national and local governments. The data will serve as an educational tool across the Central America by sharing geographic knowledge about local hazards and prompting mitigation of those risks (ESRI Web Site, 2000). These same geospatial based information resources can be used to assist in reconstruction and building Disaster-Resistant Communities. The focus is on promoting local preventive measures that will help reduce the loss of lives and property during disaster events. It is a commonsense approach based on three principles--preventive actions must be decided at the local level, private sector participation is vital, and long-term preventive efforts and investments are essential.

Some of the technology applications and methods provided to Hurricane Mitch recovery and reconstruction parallel current efforts in the United States under Project Impact being lead by the Federal Emergency Management Agency (FEMA). FEMA is taking a proactive approach to change the way the public deals with disasters. Project Impact: Building Disaster-Resistant Communities is a nationwide initiative that FEMA launched in October 1997. It helps communities protect themselves from the devastating effects of natural disasters with preventive actions that dramatically reduce disruption and loss. The initiative focuses on promoting local programs that will prevent extensive loss of lives and property during disaster events. It is a commonsense approach based on three principles—preventive actions must be decided at the local level, private sector

participation is vital, and long-term preventive efforts and investments are essential.

Local agencies have detailed, hands-on knowledge of local issues, which makes them ideally suited to facilitate disaster planning, mitigation, and preparedness. And currently 120 communities throughout the United States are participating in Project Impact. FEMA is also recruiting other federal agencies and businesses into the program to help get the latest technology and mitigation practices implemented at the local level. Additionally, Project Impact is serving to empower communities as they pursue smart growth strategies while strengthening the federal government's partnership with local government.

A common thread that weaves its way through every phase of Project Impact is GIS. Most of the data requirements for disaster management are of a spatial or geographic nature, and that makes GIS the logical tool. Identifying potential hazards, planning mitigation programs, and assisting in disaster preparedness activities are some of the critically important roles GIS has taken on for the Project Impact communities. With GIS, local agencies can compare maps of hazards such as earthquake faults, fire risk areas, or flood areas to other map data. Locating streets, pipelines, hospitals, residential areas, power lines, and storage facilities in relation to known hazards on maps makes the process seamless.

## 7. CENTRAL AMERICA RECONSTRUCTION ACTIVITY SUMMARY

Since Hurricane Mitch struck Central America, project participants and local governments have worked to help people recover from the storm's tremendous damage. The four Central American

countries hardest hit by Hurricane Mitch in 1998 have made immense progress. More than 21 million storm victims have been assisted through programs in Nicaragua, Honduras, El Salvador and Guatemala.

The first two phases of post-storm operations in the Central America emergency response and rehabilitation are largely finished. In the next phase, project participants will adapt long-term development work to incorporate ongoing recovery work that has at its core the promotion of community organization, building capacity of local governments, and the formation of a trust-based link between communities and their governments. This critical link is needed to achieve a sustainable recovery. Transportation will be one of the focus areas. There are many remaining bridges and roads that need repair and replacement throughout Central America (Figure 5). Simultaneously, capitalize will continue on its efforts to strategize regionally across the four Central American countries. From the geophysical to the political, the social to the economic, Honduras, Nicaragua, El Salvador and Guatemala share characteristics that should be addressed across national borders (US AID Web Site, 2000).

There remains a commitment to the transformation of Central America over the long term, and programs will continue to work in collaboration with communities, local governments and local nongovernmental organizations -- as well as to advocate at the national and international levels -- ways to improve the lives and livelihoods of the marginalized people of the region. A summary of activities completed and underway in each of the four countries are described in the following sections.

## 7.1 Nicaragua

Mitch-related activities are being transformed into larger development programs, mirroring the approach used in neighboring countries. The current work includes, categorized as sustainable agriculture and environmental protection; housing repair and reconstruction; temporary employment; and water and sanitation, are summarized below:

**Sustainable Agriculture and Environmental Protection:** In Matagalpa Department, Agricultural Rehabilitation Project now largely focuses on development rather than rehabilitation activities, although farmers badly affected by Mitch will continue to receive extra assistance until the end of the year. This project helped over 3,000 households rehabilitate and protect their agricultural and forested lands and reestablish crop production. The Agriculture and Environment Project, operational throughout 1999 in León and Matagalpa Departments, helped 1,785 families diversify their food production and reforest about 250 acres of land. It is intended to extend this project for at least an additional year, and link it to agricultural rehabilitation and improvement in Posoltega. There, work will continue through November 2001 with residents of Finca Santa Maria (see housing repair and reconstruction, below) and 1,150 other families in the area to reestablish crop and small livestock production, identify and test alternative crops, and develop irrigation schemes where feasible. The Seeds and Tools Project (Estelí and Matagalpa) included Erosion Control Project (Matagalpa) and La Esperanza Project (Ciudad Darío).

**Housing repair and reconstruction:** The Vivienda Estelí Project helped 142 homeless families reconstruct their houses. By October, all 142 houses were completed, each with a water tap and a sanitary latrine. Participants in the Estelí Rural Infrastructure Project will soon finish building a road to the small community, after which residents, and the municipal

government of Estelí, will hold an official opening ceremony.

In October 1999, housing reconstruction projects were launched in La Trinidad and Posoltega. In both places, problems obtaining legal title to suitable land delayed project start-up. In La Trinidad, participants will build 49 houses in a jointly planned community. In Posoltega, 350 families will build homes over the course of the next two years. Figure 6 shows some of the reconstruction activities underway. In most cases reconstruction is being done above historical high water lines. There are still some areas where expedient reconstruction is occurring in the flood plain. The resulting Finca Santa Maria community will include a school, health facilities, green spaces and a water system. Participants also have been engaged in ongoing agricultural rehabilitation and a good local harvest from the first post-Mitch agricultural season was also very positive. Other organizations will contribute counseling through the agricultural training center and several small economic activities project to the residents of the future Finca Santa Maria.

**Temporary employment:** In Condega, Pueblo Nuevo and San Juan de Limay municipalities of Estelí Department, the Rural Infrastructure Project created short-term employment opportunities through cash for work projects. In October funding was secured for an additional two years of project activities. During the project's first phase, one or more members of more than 2,100 households in 60 communities rebuilt 101 kilometers of road, cleared riverbeds of flood debris, and built retention walls and sewers.

**Water and sanitation:** The Water and Sanitation Project in Matagalpa and Jinotega that was recently transformed into a one-year development project rehabilitated 65 water systems and 204 wells serving a total of 35,880

people. In Chinandega, the El Viejo Water Project will continue into 2000, providing participants with new water systems and latrines and the training to maintain and repair them. The Bethesda Water Project in Posoltega reestablished clean water for 800 people and built 92 latrines. As mentioned above, a water system forms part of the ongoing work in Finca Santa Mario, and also in the Posoltega area.

## 7.2 Honduras

There were seven Mitch-related projects in Honduras. Four of the projects are now finalized, and two will conclude within a few months. The seventh has evolved into a three-year development project, in line with a longer-term recovery strategy in the Central America region. Among these projects are river channel clearing and construction and stream bank stabilization to reduce the threat of future flooding. Figures 7 and 8 illustrate some of the ongoing projects in this area.

**Food for Work:** The food for work program began in December 1998 and ended in October 1999. The project encompassed agricultural recovery, environmental rehabilitation, and infrastructure repair and construction in 51 municipalities in 10 departments. In all, 36,000 families received basic food commodities -- maize and beans -- in exchange for their work. An additional 2,000 pregnant or lactating women and children under 5 received supplemental food in the chronically food-poor departments of Lempira and Intibucá. With tools and other relevant supplies participants rehabilitated farmland, restored water and sanitation systems, rebuilt bridges and retaining structures along riverbanks and repaired houses damaged by the storm. With the addition of seeds and tools from many Food for Work participants were able to again produce food for their families. The objectives were to ensure the short-term survival needs of families while

helping them restore their productive capacity and support their economic revitalization. In all cases, Food for Work projects was three-party agreements between project sponsors, participants and municipal governments. Construction and digging tools, seeds and agricultural tools, and other items required by communities in their rehabilitation and construction work were provided. This project component was finalized in September 1999.

**Resettlement of the Homeless:** In early October, heavy rains caused renewed flooding on the Choluteca River. Families were forced from temporary housing into their newly- or partially-built homes in Renacer Marcovia, a community planned and constructed for approximately 3,000 residents of the original Marcovia village, which was destroyed by floods a year ago. Today, 254 houses are complete and 226 houses are nearing completion. The project had installed temporary latrines and water tanks, which served until January 2000 when permanent sanitation systems were built. Renacer Marcovia's population has played an important role in planning the new village's public and residential areas, and has provided all the labor for the cement-block homes.

**Reactivating Household Economies (REMAM):** As of late October, 177 community credit committees in 150 communities had disbursed loans averaging \$195.60 to nearly 2,300 families. More than 70 percent of borrowers had launched small-scale commercial activities, and the remainder opted to begin production or food processing businesses. The REMAM project, an emergency economic rehabilitation program, will continue through January 2000, disbursing loans to a total of 3,000 families in six departments, including the families participating in the Renacer Marcovia project.

In the first phase of the Choluteca and Valle Water and Sanitation project 18 communities repaired or rebuild storm-damaged water systems in eight municipalities of Choluteca and Valle Departments. By the end of October, eight of the water systems had been designed and three systems were under construction. CARE and municipal authorities surveyed and registered as protected areas the fragile watersheds that feed these systems and that provide water for 500,000 people. Watershed management training was provided for municipal authorities, and a signed agreement was made with the Honduran National Forestry Authority to provide additional training and support to the project. This water, sanitation and environmental protection project will continue until April 2002.

**Debris and Sediment Management:** The cleanup, removal and disposal of debris and sediment is still underway in the branches and main stems of the major drainage basins. Much progress has been made, but many areas still need attention in order to reduce the risk of future flooding as shown in figure 9.

**Hygiene Education for Urban Populations:** This work, finalized in September, complemented the Tegucigalpa Child Survival Project by training 800 community members and health workers to deal with water and sanitation issues in disaster situations, to administer water committees, and to manage post-traumatic shock. Nearly 1,500 primary school students learned about health and hygiene through this project component, and residents of 24 urban slums completed infrastructure projects, repairing or building latrines, drainage canals and retaining walls in their neighborhoods. There remain many health and sanitation issues throughout the country as shown in figure 10. In the case of the Villaneuva Water and Sanitation Education Project it helped 1,275 families in

Villanueva municipality overcome water and sanitation problems resulting from the hurricane. Technical assistance was provided and materials to build a 80,000 gallon water storage system, the municipal government and other sponsors installed the principal branches of the water distribution system; and project participants were responsible for installing connections to bring water to their homes or communal taps. Training representatives of the participating communities in system maintenance was also part of the overall process of community organization and participation. Projects will continue in Honduras to address water and sanitation, environmental protection, sustainable agriculture, education and child health.

### **7.3 El Salvador**

Mitch-related emergency and rehabilitation work in El Salvador has transitioned into two longer-term development programs that will assist people in three Eastern and western regions of the country (360,000 people and 163,000 people, respectively) to manage clean water systems, maintain basic sanitation facilities, protect the environment and rehabilitate agricultural systems over the coming years. A third project in Usulután helped 12 families rebuild houses damaged by floods last year. The development programs in El Salvador will focus heavily on water supply, environmental protection and sustainable agriculture.

### **7.4 Guatemala**

The last of the Mitch rehabilitation activities in Guatemala helped residents rebuild 19 suspension footbridges damaged or destroyed by flooding. In all, these bridges provide access to 93 communities and about 4,000 families. Since the hurricane struck, Mitch-related work in Guatemala has included emergency response, water and sanitation system rehabilitation,

agricultural recovery, reforestation and watershed protection in the Polochic river basin, Alta and Baja Verapaz Departments. Ongoing development work in Guatemala includes village banks, health, agriculture and environmental protection and education.

## **8. CONCLUSION**

The opportunity to leverage technology in the geospatial area to assist in disaster management has never been greater. There are many tools and processes currently in use that have not been applied to assist in disaster management. Examples include the application of hyperspectral sensor data, use of digital multispectral video, and geospatial 3-D fly-through analysis. All of these capabilities could support and enhance the information available to the disaster management decision-maker.

There are exciting changes expected to occur during the next few years in the geospatial community. New aircraft and space-based sensor systems are planned that will revolutionize the spectral and spatial resolution of data available for commercial applications. There will be challenges, particularly in the data processing and management area, because of the extremely large spectral databases these new sensors will generate.

The spectral library project also provides an opportunity to expand cooperatively our global understanding of the vegetative and geologic spectral makeup of the earth. The baseline data from this effort would be invaluable in conducting change analysis assessments following a natural disaster, such as an earthquake or hurricane. Using some of the analysis tools described earlier, the analysts and decision-makers could virtually walk into the disaster situation. Other spectral technologies, such as fluorescence, could be used to precisely

locate very small underground gas and oil leaks remotely. Within the next decade, there may be the ability to better harness geospatial analysis capabilities to help reach the vision for the cooperative exchange of timely, relevant information useful during all phases of disaster management - to save lives and reduce economic loss.

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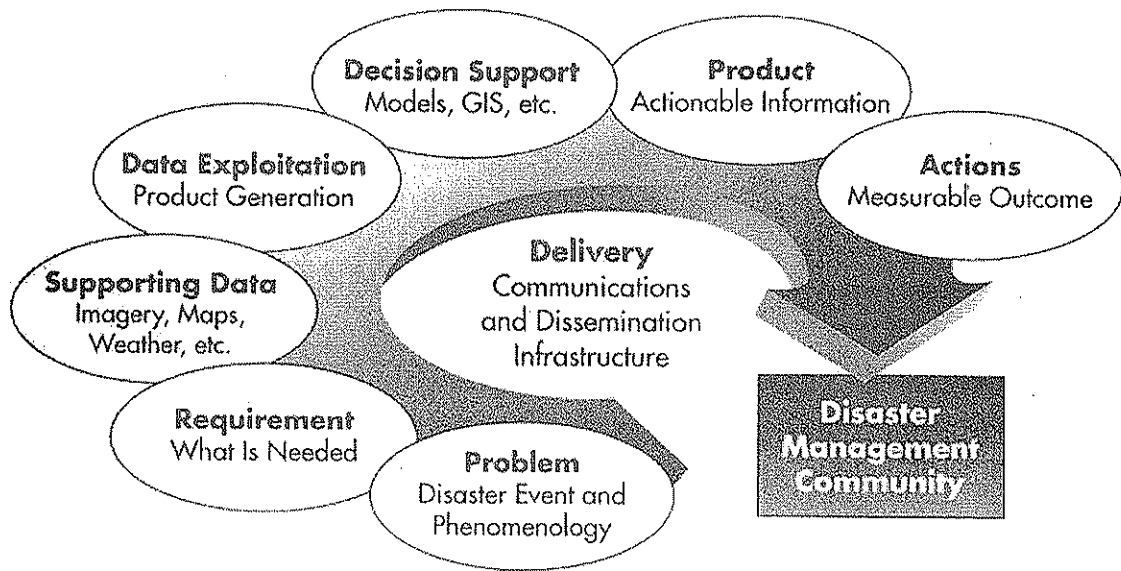


Figure 1: The Primary Elements of Disaster Management

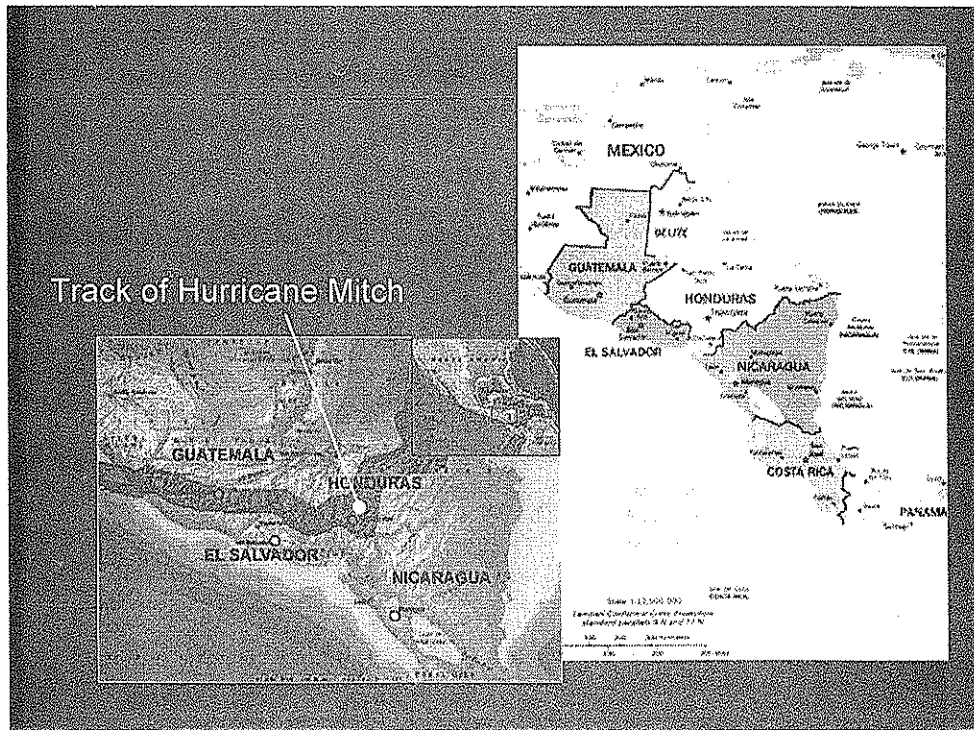


Figure 2: Storm Track of Hurricane Mitch Across Central America

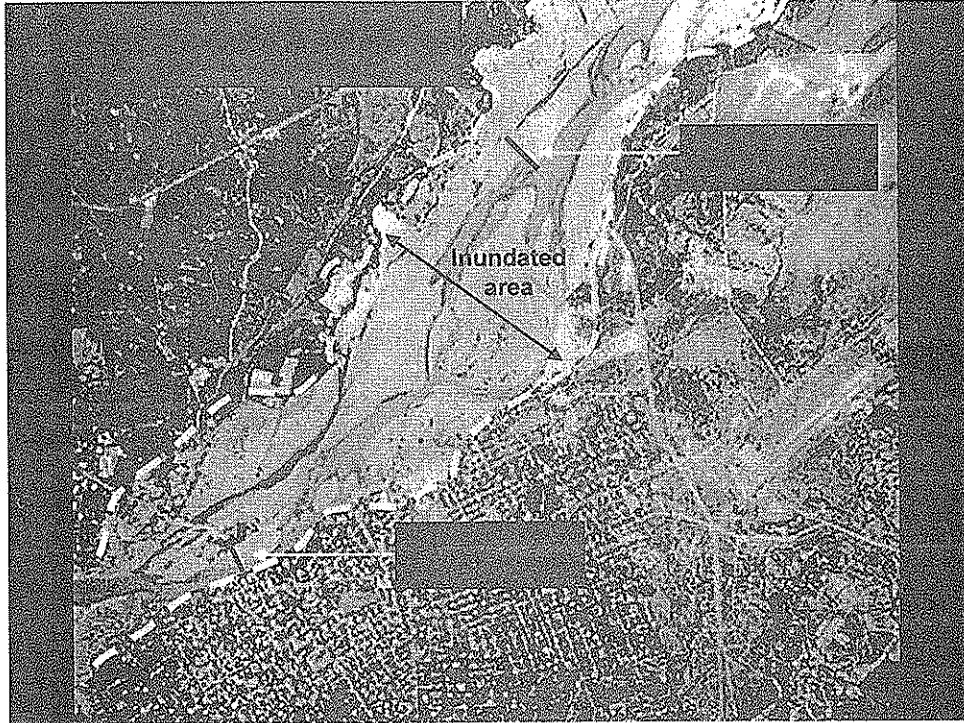


Figure 3: Airborne Sensor Image of Choluteca River Sediment Deposits near Choluteca City

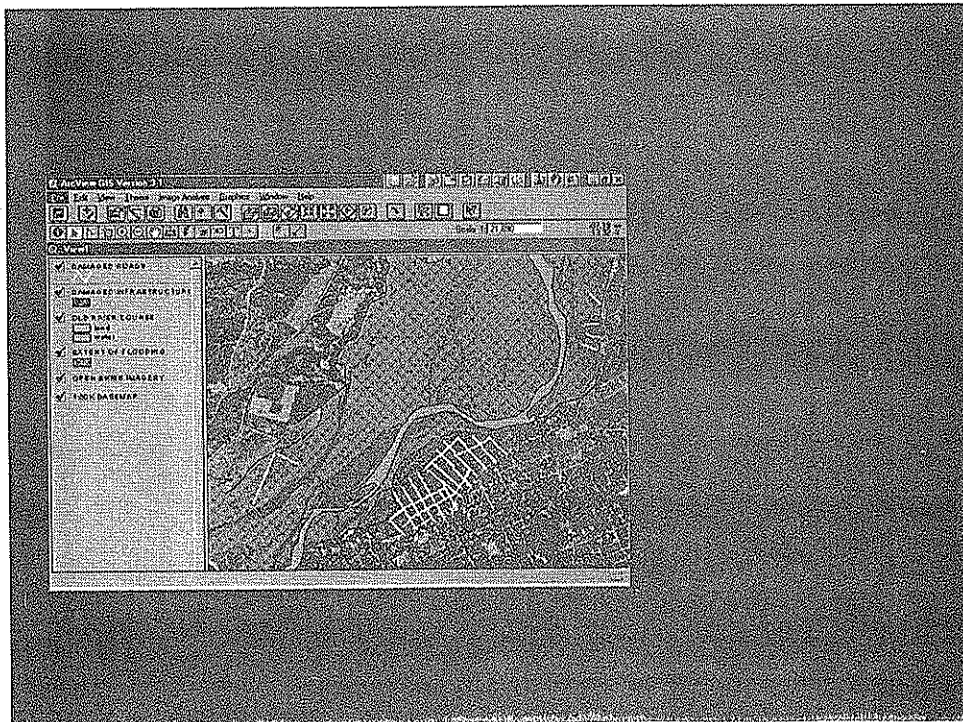


Figure 4: Integration of Imagery into GIS Data Base

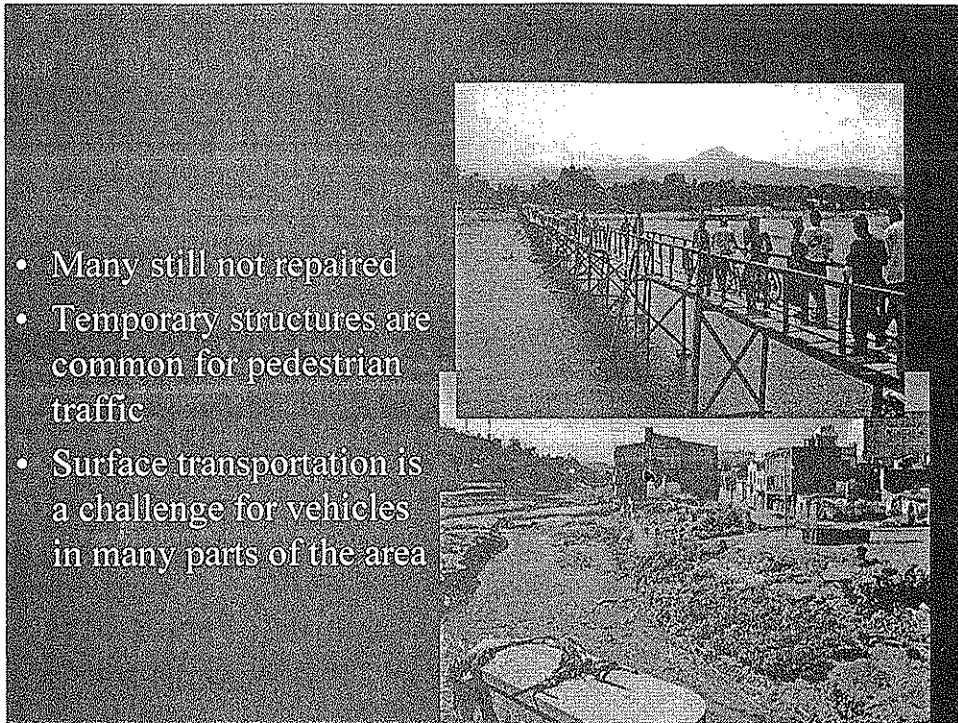


Figure 5: Temporary foot bridges and Damaged Bridge Infrastructure

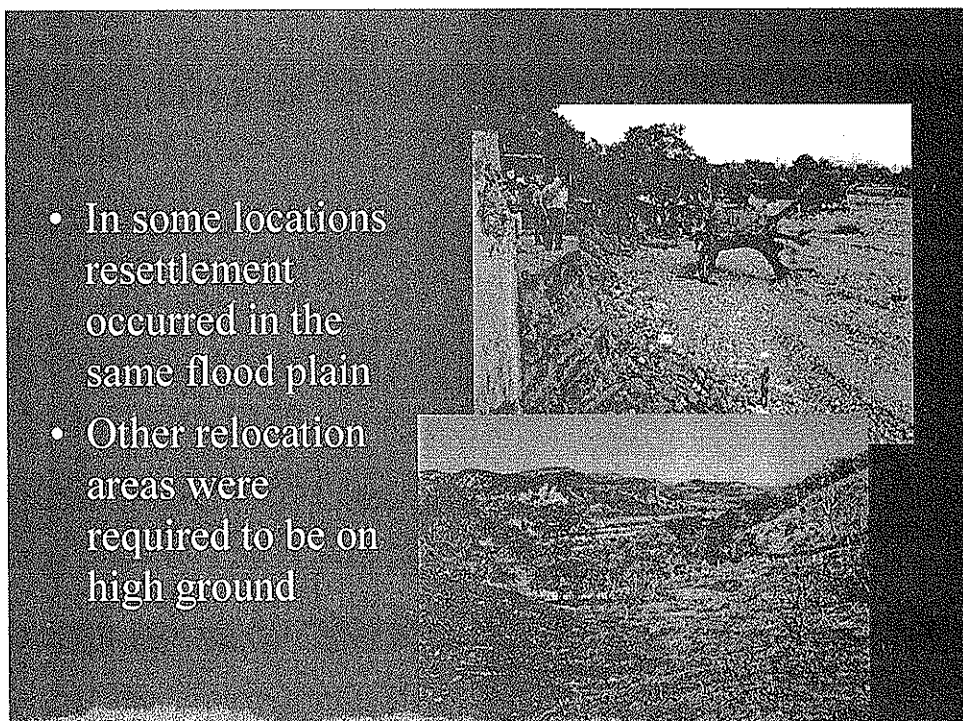


Figure 6: Policy Variations in Resettlement and Relocation Practices



Figure 7: Preparation for Future Flood Protection Through Channel Clearing and Construction

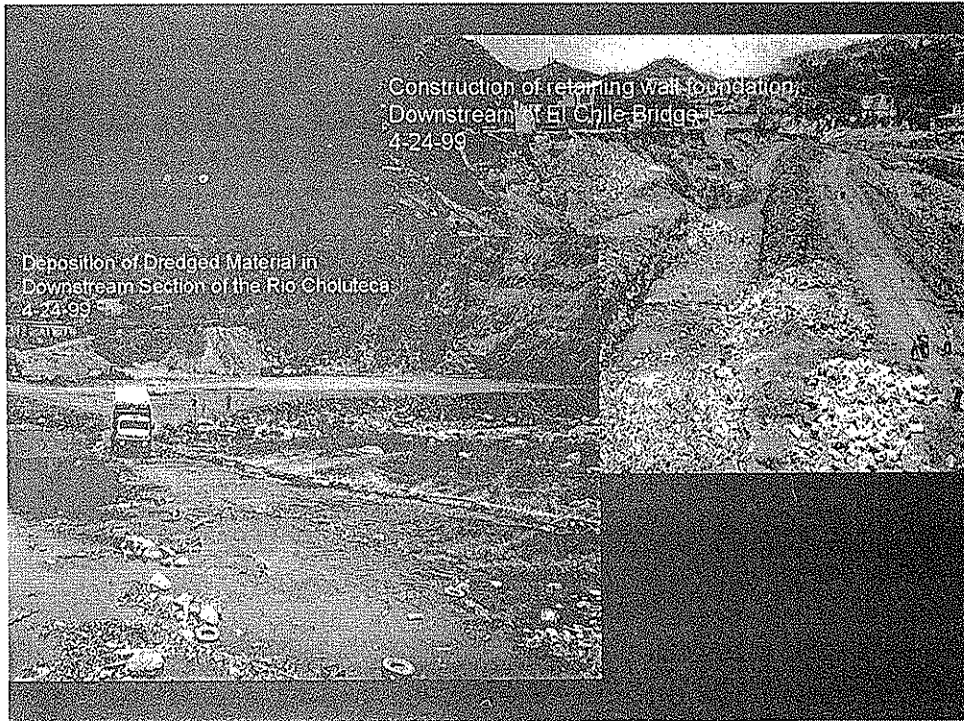


Figure 8: Stream Bank Stabilization Projects

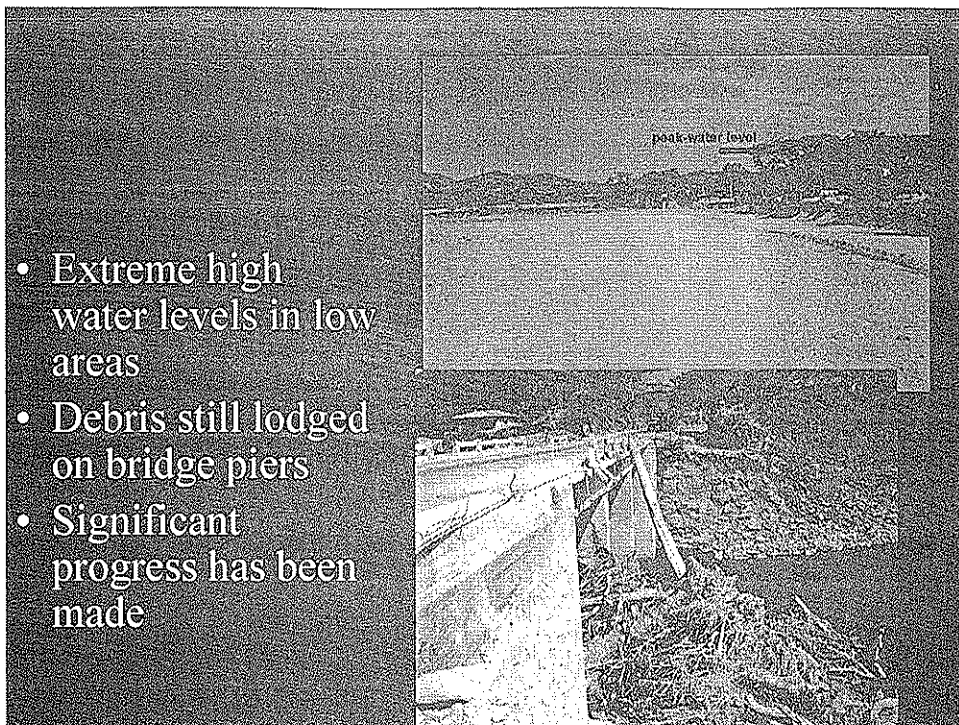


Figure 9: Debris and Sediment Management Challenges Along the Choluteca River

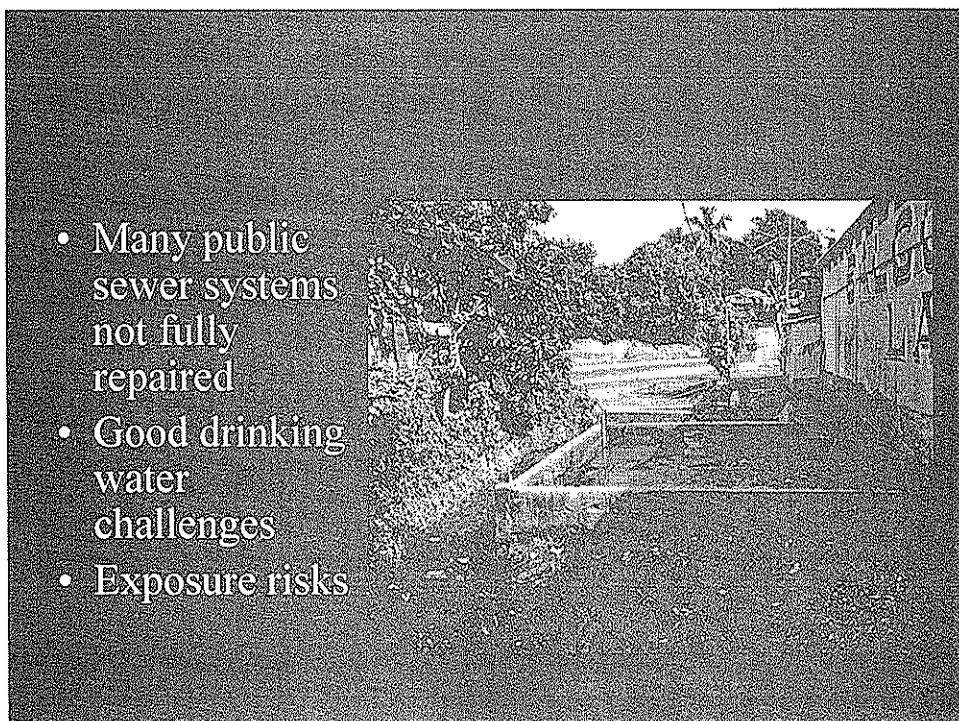


Figure 10: Sanitation and Drinking Water Exposure Risks