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US Army Corps
Of Engineers

HURRICANE MITCH

PRELIMINARY DAMAGE ASSESSMENT REPORT

EL SALVADOR, GUATAMALA
HONDURAS, AND NICARAGUA

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EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) conducted this report at the request of the United States Agency for International Development (USAID). This preliminary damage assessment report quantifies the repair and rehabilitation costs associated with the long-term recovery efforts for the regions effected by Hurricane Mitch, which included El Salvador, Guatemala, Honduras, and Nicaragua. USACE and USAID agreed that preliminary damage assessments would be performed on four categories, which included: (1) transportation infrastructure, (2) public utilities, (3) social infrastructure, and (4) housing and shelter. The transportation infrastructure assessments were on roads and bridges, railways, seaports, and airports. The public utilities assessments included water systems, wastewater systems, power and telecommunications systems. The social infrastructure assessments included hospitals, public buildings and schools. The housing and shelter assessments included estimates on the number of homes that need to be rebuilt in each country.

This report's global assumption is that the infrastructure will be replaced or repaired to the same quality that existed immediately prior to the devastation of Hurricane Mitch, and is referred to throughout this report as the "Like in Kind" assumption. The only exception to this "Like in Kind" assumption was when the pre-existing facilities did not meet the current acceptable international standards, such as water treatment and wastewater treatment facilities. This report employed a deliberate assessment methodology divided into three phases: (1) raw data collection on damaged structures/facilities, (2) development of cost factors for each country, and (3) production of a comprehensive cost estimate reflecting the collective reconstruction efforts. This report reflects data obtained from: USACE forces in Central America, U.S. SOUTHCOM situation reports, United Nations, U.S State Department, Central Intelligence Agency, Housing and Urban Development, news reports, and Internet sources.

The assessments show that Honduras sustained the greatest overall total damage in all categories as shown in Table 1, but not necessarily in all subcategories.

	El Salvador	Guatemala	Honduras	Nicaragua
Transportation	227,000,000	402,000,000	450,000,000	145,000,000
Public Utilities	1,413,000,000	1,488,000,000	1,697,000,000	630,000,000
Social Infrastructure	28,000,000	180,000,000	338,000,000	39,000,000
Housing & Shelter	35,000,000	49,000,000	945,000,000	482,000,000
Total for Country	**1,703,000,000**	**2,119,000,000**	**3,430,000,000**	**1,296,000,000**

TABLE 1 – Preliminary Damage Assessments

In the Transportation Infrastructure category, Honduras received the greatest damage in the Roads and Bridges subcategory with damages estimated at $281 Million, and in the Seaport subcategory with damages estimated at $49 Million. Guatemala received the greatest damage in the Railways subcategory with damages estimated at $185 Million. Nicaragua had the only currently quantifiable damage in the Airport subcategory with damages estimated at $5 Million.

In the Public Utilities category, El Salvador received the greatest damage in the Water Utilities subcategory with damages of $693 Million, and in the Wastewater Utilities subcategory with damages of

$520 Million. Guatemala received the greatest damage in the Power Utilities subcategory with damages of $379 Million. Honduras received the greatest damage in both the Telecommunications and Petroleum Utilities subcategory with damages estimated at $36 Million and $200 Million respectively.

In the Social Infrastructure category Honduras sustained the greatest damage in both the Hospital subcategory with damages at $338 Million, and in the School subcategory with damages of $50 Million. At the time of this report USACE had not received any damage assessments for the Public Building subcategory (police stations, firehouses, government buildings, etc.).

The assessments in the Housing and Shelter category showed that Honduras sustained the greatest damage at $945 Million, Nicaragua sustained $482 Million in damages, Guatemala received $49 Million, and El Salvador received $35 Million in damages.

The overall preliminary damage assessment totals show that the Public Utilities Infrastructure received the greatest damage with total repair/rehabilitation cost estimates at $5.2 Billion, followed by the Housing Infrastructure at $1.5 Billion, then the Transportation Infrastructure at $1.2 Billion, and last, the Social Infrastructure at $585 Million. The total preliminary damage assessment total for all four countries is $8.5 Billion. The Public Utilities Infrastructure cost estimates were by far the most costly infrastructure category due to the repair/rehabilitation to currently accepted international standards.

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1. BACKGROUND

1.1 - Assessment Authority and Scope

Under authority of the Economy Act (31 U.S.C. 1535) and Section 632 of the Foreign Assistance Act (22 U.S.C. 2357), the U.S. Agency for International Development (USAID) requested the Department of Army (DA), acting through the U.S. Army Corps of Engineers (USACE); prepare a damage assessment for repair and rehabilitation cost estimates in El Salvador, Guatemala, Honduras and Nicaragua.

1.2 - Assessment Area Description

This assessment covers the Latin American countries affected by Hurricane Mitch. The affected area is the following four countries: El Salvador, Guatemala, Honduras and Nicaragua. USACE and USAID agreed that USACE would perform preliminary damage assessments on transportation infrastructure, public utilities, social infrastructure, and housing and shelter. For the purpose of assessment, USACE subdivided these categories into the subcategories. For transportation infrastructure, USACE assessed roads and bridges, railways, seaports and airports. The public utilities category includes water systems, wastewater systems, power and telecommunications systems. The social infrastructure category includes hospitals, public buildings and schools. The housing and shelter category estimates the number of homes that need to be rebuilt in each countries. Each country has an assessment for each category.

1.3 - Nature of Hurricane Mitch Disaster

Hurricane Mitch, a one-time category 5 tropical cyclone on the Saffir-Simpson Scale (maximum sustained winds estimated at 260 + kilometers per hour) and the strongest October hurricane ever recorded in the greater Atlantic basin, was the most damaging storm on record in the Western Hemisphere. Hurricane Mitch affected the four countries of El Salvador, Guatemala, Honduras, and Nicaragua starting on October 27, 1998 for over seven days, leaving an overall average of 70 centimeters of rain and in some isolated locations up to 750 or more centimeters. The massive rain caused extensive damage from river flooding and land and debris slides. In fact, relatively little damage in the region occurred due to the strong winds which quickly dissipated when the storm made landfall. Mitch was responsible for thousands of deaths, displaced people throughout the region, and destroyed infrastructure, transportation routes, villages, and crops to the extent that recovery will most likely take years.

1.4 - Extent of Damage

Hurricane Mitch caused extensive damage to roads, bridges, and infrastructure. There were 3 million people displaced, 13,000 people missing and over 9,000 confirmed deaths.

2. REGIONAL SETTING AND ASSESSMENT METHODOLOGY

2.1 - Introduction:

This report uses various assessment and engineering data to provide a preliminary damage assessment that quantifies costs associated primarily with long-term recovery efforts for the region affected by Hurricane Mitch -- El Salvador, Guatemala, Honduras, and Nicaragua

2.2 - Key Assumption

This report's basic assumption is that the infrastructure will be replaced to the same quality as what existed before the devastation of Hurricane Mitch -- referred to as "Like in Kind." Where applicable, some sections comment on the limitations of the "Like in Kind" assumption. Examples are as follows:

- "Like in Kind" assumes that existing structure characteristics are sufficiently understood to produce a cost estimate for a facsimile of the original structure. The estimate is for a structure similar in scale and type of construction.

- "Like in Kind" repair and replacement was not used where pre-existing facilities did not meet currently accepted international standards. For example, water purification and primary wastewater treatment were estimated based on currently accepted international standards rather than pre-existing facilities.

- If recovery efforts exceed local engineering and supply capabilities, importing of equipment, supplies, and some engineering support would add to the estimates in this report. These costs are not included into this assessment, but a discussion of the impact of transportation and other logistical considerations is included in the data analysis section (Section 4).

2.3 - Assessment Methodology

This assessment employs a deliberate methodology to identify and quantify the condition of the infrastructure effected by Hurricane Mitch. Specifically, the methodology included three phases: (1) raw data collection reflecting damage to existing structures and facilities, (2) development of cost factors for each country covering areas of reconstruction pertinent to this report, and (3) production of a comprehensive cost estimate reflecting the collective reconstruction efforts for the effected regions. Information research focussed on four specific areas of transportation systems, public utilities, social infrastructure, and housing. This assessment cultivated multiple sources of data including U.S. Army Corps of Engineers forces in country, U.S. Southern Command situation reports, the United Nations, U.S. Departments of State and Housing and Urban Development, Central Intelligence Agency, news reports, and the Internet.

2.3.1 - Transportation Infrastructure.

2.3.1.1 - Roads and Bridges:

USACE received reports of either kilometers of impassable roadway or a percentage of all roads in a nation that were impassable. (In the latter case, USACE converted the percentage to kilometers of impassable roadway using a known total of national roadways.) USACE assumed only 5% of the length of any impassable roads would actually require replacement. This value was used to calculate the total road repair cost for each country.

Cost factors were generated for "Like in Kind" replacement or reconstruction based on established road structures types and conditions existing before Hurricane Mitch. The cost factors are listed in Table 2-1.

ROAD TYPE	REPAIR COST($ / km)
2 Lanes (Paved, 4m/lane)	520,000
2 Lanes (Unpaved, 4m/lane)	500,000
1 Lane (Paved, 4m/lane)	260,000
1 Lane (Unpaved, 4m/lane)	250,000

Table 2-1. "Like in Kind" Cost Factors

Similarly, USACE received various damage assessments listing the number of damaged and destroyed bridges. Due to the magnitude of damage, USACE assumed all of the destroyed bridges and half of the damaged bridges would need to be replaced completely.

Due to the unique styles and types of bridges in each of the four countries, USACE determined unique cost factors for each country. These costs are listed in Table 2-2. Using available data for existing bridges in the region, an average bridge span was estimated at 90 meters. The span for bridge repair was assumed to be an average of 64 meters.

Host Country	Bridge Cost Factor ($ / m for a 8m wide bridge)
El Salvador	6,800
Guatemala	6,800
Honduras	8,000
Nicaragua	7,200

Table 2-2. Bridge Reconstruction Cost Factors

2.3.1.2 - Railways

The railway assessment includes values for standard track construction. The railway damage estimates are based on hydrologic assessments of where destruction or damage would most likely have occurred from Hurricane Mitch, resulting in line breakage. The estimated line breakage was assessed in kilometers.

Where main line rail is to be replaced, the cost estimate is based on reconstruction of the rail using U.S. standard gauge and indigenous treated timber. It is assumed that 50% of the rail is reusable, but some will have to be imported from the U.S. because it cannot be manufactured in-country. It is assumed that the base course is 30 cm in depth, and roadbed drainage is not included. Rail reconstruction cost is calculated as a single track (Ballast, rails, and ties) at $600,000 per kilometer.

2.3.1.3 - Seaports

The seaport assessment includes channel and harbor dredging only. Preliminary assessments show all seaports still operational with no reported equipment damage. USACE navigation experts assumed the typical amount of shoaling (deposit of sedimentation) associated with a strong hurricane.

Baseline cost figure of using a USACE dredge assumes like costs for any dredge operation using a "Western" country's ocean-going dredge. Ports requiring dredges are prioritized by economic significance to the country -- imports first and export second. Cost estimates for dredging are based on estimates using USACE dredge operation figures as a guideline. Baseline figures are estimated on a daily operation rate cost. The basic dredge cost was determined applying the following rate:

(1) For use of a hopper dredge similar to the *Essayons* or *Yaquina*, cost was calculated at $40,000 per day.

(2) For use of a deep-water port dredge such as the *Wheeler* or the *McFarland*, the cost was calculated at $70,000 per day.

(3) Survey cost is calculated at $2,500 per day

2.3.1.4 - Airports

With the exception of one paved airfield in Nicaragua, USACE has not received any assessments of airfield damage.

USACE assumed the entire surface of that airstrip would need repaving and estimated the cost thereof.

2.3.2 - Public Utilities

2.3.2.1 - Water System

USACE estimated that the water supply systems in those metropolitan areas affected by Hurricane Mitch would need major renovation or complete replacement. The serviced population was that portion of the indigenous population currently being supplied by those municipal water services.

Estimates for water supply treatment facilities were based upon standard consumption and cost factors associated with water purification.

USACE estimates are for facilities that meet currently accepted international standards, which most likely exceed those that existed prior to Hurricane Mitch.

2.3.2.2 - Wastewater System

There is no evidence of any significant municipal wastewater treatment in most of the affected countries. The proposed serviced population is the same portion of the indigenous population currently being supplied by municipal water services.

Estimates for wastewater treatment facilities were based upon standard consumption and cost factors associated with primary wastewater treatment.

USACE estimates are for facilities that meet currently accepted international standards, which most likely exceed those that existed prior to Hurricane Mitch.

2.3.2.3 - Power System

Power damage assessments were based upon replacing a percentage of these systems based on the storm's intensity and duration, and the vulnerability of each nation's power systems. USACE's estimated losses of power supply and distribution systems are listed in Table 2-3.

Country	Estimated Loss
El Salvador	10%
Guatemala	15%
Honduras	20%

Nicaragua	10%

Table 2-3 - Estimated Power System Losses

USACE electrical estimators calculated the value of the entire electrical production and distribution system in each of the affected countries, and then calculated the cost to replace the appropriate estimated portion that was lost due to Hurricane Mitch.

2.3.2.4 - Telecommunications

Preliminary in-country reports show telephone services are quickly being brought back online. USACE estimators did a flood-based risk assessment determining the location of major urban phone switches in respect to areas of known flood and mudslide damage. Estimators determined the most likely types and quantities of equipment and overhead lines that would need to be replaced.

Since most telephone equipment and supplies are produced from outside the affected areas, estimators used standard US replacement costs. The planning costs are summarized in the table below.

EQUIPMENT	TYPE	COST
Switch Replacement		$1,000 per line
Aerial Phone Lines	300 pair	$ 35,000 per mile
	900 pair	$ 68,000 per mile
	2100 pair	$168,000 per mile
Buried Cables	300 pair	$ 28,000 per mile
	900 pair	$ 69,000 per mile
	2100 pair	$169,000 per mile
Underground (Duct Systems)	300 pair	$190,000 per mile
	900 pair	$280,000 per mile
	2100 pair	$413,000 per mile

Table 2-4 - Telecommunications Reconstruction Cost Factors

2.3.2.5 - Petroleum

USACE estimators used hydrological data from the current storm event and previous flood risk models to determine, by location, which petroleum refineries, storage facilities, and distributions systems were most likely damaged.

USACE then applied industry planning factors for the repair and replacement of those facilities most likely damaged or destroyed by Hurricane Mitch.

2.3.3 - Social Infrastructure

2.3.3.1 - Hospitals

USACE received reports on damaged and destroyed medical facilities in each of the affected countries.

For planning purposes, USACE used an estimate of $36 million as the replacement cost based upon a United States "standard" 100-bed hospital, complete with equipment.

2.3.3.2 - Public Buildings

The USACE recognizes the need to repair and reconstruct facilities dedicated to "public works" such as police stations, firehouses, post offices, courthouses, public works facilities and government buildings.

At the time of this report, USACE has not received damage assessments of these facilities or determined construction costs for these buildings.

2.3.3.3 - Schools

USACE received preliminary reports of the number of damaged schools in El Salvador, Honduras, and Nicaragua from various sources.

From construction experience in the region, USACE assigned a base cost of $20,000 to replace or significantly renovate each damaged school.

2.3.4 - Housing and Shelter

In order to determine the number of housing units required; USACE started with the published numbers of displaced personnel. USACE then divided the number of displaced people by the mean family size of each country to determine the number of units required.

From construction experience in the region, USACE realized the cost differential between an urban and rural home. USACE assigned values of $2500 to replace a rural home and $4000 to replace an urban home. To determine the mix of urban and rural

homes, USACE used the percentages of the population living in rural and urban areas, assuming the displaced people were a cross section of the population as a whole.

3.3 - Honduras

Hurricane Mitch slammed into the east coast of Honduras late in October 1998 with extremely high winds and enormous quantities of rain causing extensive flooding, mudslides, and extensive infrastructure damage, knocking out roads, bridges, and washing away many homes.

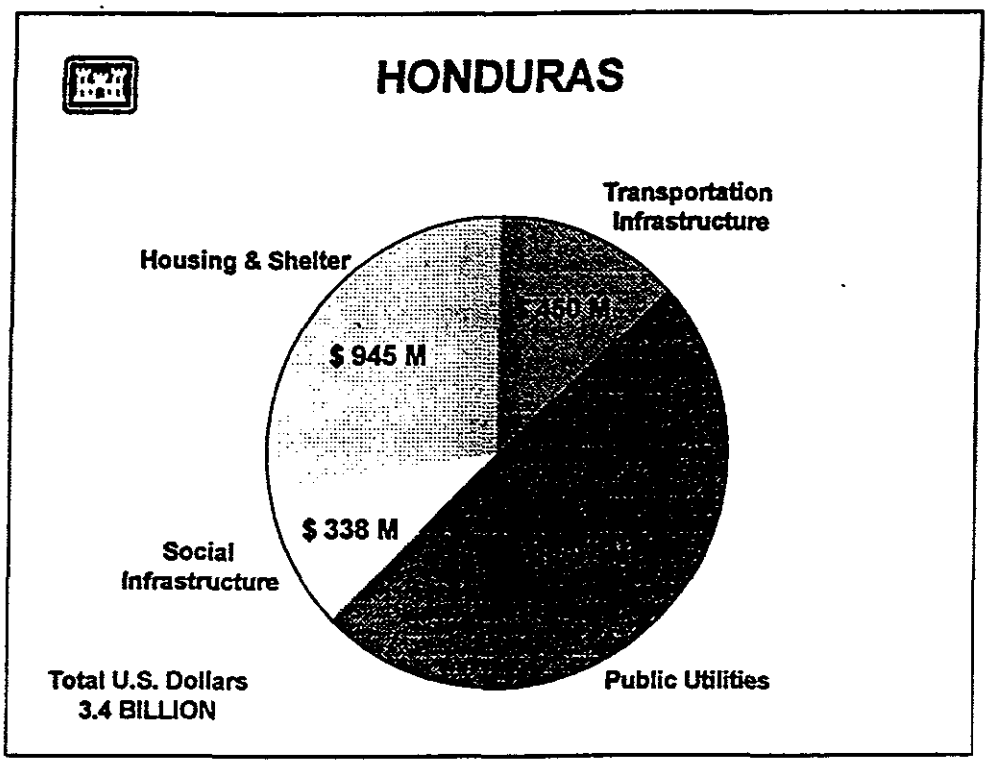

FIGURE 3 - HONDURAS

3.3.1 - Transportation Infrastructure

3.3.1.1 - Roads & Bridges

Heavy rainfall and mudslides damaged an estimated 70% of the road network in the varied terrain of Honduras. Using the standard cost per kilometer for single lane unpaved roads and double-lane paved roads, an estimated $161 million will be required for road reconstruction.

Hurricane Mitch severely impacted approximately one hundred seventy (170) bridges in Honduras -- ninety-five (95) bridges destroyed and seventy-five (75) heavily damaged. One hundred thirty-three (133) single span bridges, averaging 90 meters per bridge, require complete replacement; the thirty-seven (37) bridges remaining will be able to be fixed at a length of 64 meters per bridge. Using the costs for bridge repair, $120 million will be required to rebuild the bridges in Honduras.

3.3.1.2 - Railways

Railway estimates were based on hydrologic assessments of where destruction or damage would result in line breakage. The lines are all single track, narrow gage and non-electrified. Half of the line is 1.067-meter gage and the other half is 0.914-meter narrow gage. Because of the mountainous terrain, many bridges in low-lying areas have been effected by flooding and have been included in the reconstruction estimate. Assessments on the four main railway lines are as follows:

- The line from Puerto Cortes to El Llano has approximately 11-km of track and six (6) main river crossings destroyed or damaged. Repair costs are estimated at $25 million.

- The line from Baracoa to Bufalo has approximately 10-km of track and multiple river crossings destroyed or damaged. Repair costs are estimated at $8.6 million.

- The line from Tela to Santa Rita has approximately 12-km of track and 4 bridge structures destroyed or damaged. Repair costs are estimated at $18.8 million.

- The line from Tela to San Lorenzo has approximately 32-km of track and 14 bridges destroyed or damaged. Repair costs are estimated at $67 million.

The total estimated cost to repair and replace damaged railroad infrastructure for the country of Honduras is $120 million.

3.3.1.3 - Seaports

The Hurricane's excessive rainfall caused sediment from the rivers and streams to be poured into the seaports and deltas, causing shoaling and filling. The seaports represent a significant factor in Honduras' economy and in receiving supplies for infrastructure reconstruction. It is estimated that the major ports for Honduras will need dredging and surveying to clear channels. Using standard costs for surveying and dredging, $49 million will be required to open the seaports in Honduras.

3.3.1.4 - Airports

The major airports in Honduras did not suffer extensive damage. There is no cost for rebuilding airports in Honduras. The unit costs for runway repair are included in the assessment methodology section (Section 2.3.1.4).

3.3.2 - Public Utilities

3.3.2.1 - Water System

The water systems for the effected areas before Hurricane Mitch were rudimentary. This estimate provides water for the same percentage of population as before the storm. The cost to rebuild the water systems to serve approximately 1.6 million people throughout various cities in Honduras is $644 million.

3.3.2.2 - Wastewater System

The wastewater systems existed only in certain areas of heavily-populated cities. This estimate provides a wastewater system for approximately the same percentage of population that was in place before Hurricane Mitch. Repair of the wastewater systems serving 1.6 million people throughout various cities in Honduras will cost approximately $483 million.

3.3.2.3 - Power System

The power system in Honduras is estimated as being 20% is damaged or destroyed. A more detailed damage assessment should be performed. The total damage assessment and estimated repair costs are $334 million for Honduras.

3.3.2.4 - Telecommunications

Major portions of Honduras have been heavily damaged by Hurricane Mitch. Approximately 800-km of aerial cable and 18,000 phone switches would need to be replaced in Honduras at an estimated $36 million. The cost figures for switches and other telephone equipment are included in the assessment methodology section (Section 2.3.2.4).

3.3.2.5 - Petroleum

Most of the petroleum is used for fuel and petrochemical uses and does not provide a bulk of the country's energy requirements. The major refinery is located in one of the areas receiving heavy damage. The estimated cost to replace the existing refinery with an imported prefabricated unit from the United States, including installation of a new wharf handling facility, is $200 million. At the very minimum repairs to this facility will be about $100 million. The extent of damage to petroleum storage and distribution facilities. Total cost to repair petroleum infrastructure could be in excess of $200 million.

3.3.3 - Social Infrastructure

3.3.3.1 - Hospitals

Honduras hospitals have been assessed and eight (8) were reported heavily damaged or destroyed. The cost to repair and rebuild the hospitals in Honduras is $288 million.

3.3.3.2 - Schools

Honduran schools have been assessed and 2500 schools have been damaged or destroyed. The cost to repair and rebuild the schools in Honduras is $50 million.

3.3.4 - Housing and Shelter

The storm displaced an estimated 1.9 million people in Honduras. Honduran population statistics indicate a six person family average, with 68% rural and 32% urban. Estimating that approximately 317,000 homes need to be replaced, the total cost for rebuilding damaged homes is $945 million -- $539 million rural and $406 million urban.