PD-ABW-482

Coastal Infrastructure Design, Construction and Maintenance Training Program

Final Program Performance Report

November 2000–December 2001

Prepared For:

Cooperative Agreement No. 532-A-00-00-00025-00

Issued By:

Organization of American States
Unit for Sustainable Development and Environment

1889 F Street N.W.
Washington, DC 20006

http://www.oas.org/cdcm_train

February 2002

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DESCRIPTION OF PROGRAM AND PROJECT ACCOMPLISHMENTS

Hurricane Lenny was a late season storm that began as a tropical depression in the Western Caribbean on 13 November 1999. It moved in an unusual easterly/northeasterly direction. By 17 November, it had become a Category IV hurricane with sustained winds of over 150 mph. The storm caused high waves, which pounded the usually sheltered west coasts of the leeward Caribbean Islands.

The Eastern Caribbean countries of Antigua and Barbuda, Dominica, St. Lucia and Grenada sustained significant damages from hurricane Lenny. Physical damage estimates to coastal infrastructure, coastal communities and businesses in these four countries were estimated to be US$268 million. The cost of restoring the infrastructure alone back to its pre-disaster condition has been estimated by the Caribbean Disaster Emergency Response Agency (CDERA) to be US$51.3 million for Antigua and Barbuda, US$21.5 million for Dominica, US$94.3 million for Grenada and US$6.6 million for St. Lucia.[1] In response to the damages suffered, the Caribbean Regional Program of the U.S. Agency for International Development-Jamaica (USAID/J-CAR) implemented a 'Special Objective' project to assist these countries in their recovery and in reducing their vulnerability to future disasters. The *OAS/UWI Coastal Infrastructure Design, Construction and Maintenance Training Project* was one part of this broader USAID/J-CAR Special Objective project.

The Coastal Infrastructure Design, Construction and Maintenance (CDCM) Training Program

The aim of the Coastal Infrastructure Design, Construction and Maintenance (CDCM) Training Program was to reduce the long-term vulnerability of coastal infrastructure in the project countries and in the broader Caribbean region by expanding the capacity for appropriate design, construction and maintenance of coastal infrastructure works, through a series of training courses that were designed and implemented under the project. The target audience for the training included public- and private-sector engineers, planners, architects and environmental officials. The objectives of the CDCM training program were:

- Reduced reliance on external design and construction assistance for coastal infrastructure by building capacity within the participating countries' governments and private sector for the design and construction of coastal defense works.
- Increased emphasis on the proper maintenance of coastal infrastructure and coastal defense works to ensure longevity of investments in sea defenses.
- Increased knowledge of beach and coastal processes that result in damage to coastal infrastructure and/or shorelines.

The CDCM training program was executed by the Unit for Sustainable Development and Environment of the Organization of American States (OAS/USDE), in close collaboration with the Engineering Department of the University of the West Indies (UWI) in St. Augustine, Trinidad. Furthermore, a strong link was established between UWI and Old Dominion University, a US-based university with expertise in coastal processes and design, and with the Coastal Hydrology Laboratory (CHL) of the US Army Corps of Engineers.

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[1] *Hurricane Lenny Recovery in the Eastern Caribbean: Special Objective Document.* USAID/J-CAR, 17 April 2000.

Project Management and Administration Functions

Project Timeline

- November 1999—Hurricane Lenny
- April 2000—USAID Special Objective finalized
- October 2000—USAID-OAS agreement signed
- November 2000—Project activities began.
- January 2001—OAS received the letter of credit with project funds
- June–September 2001—Training courses conducted
- December 2001—Project close

Coordination Mechanisms

UWI Engineering Institute

The Engineering Institute of the University of the West Indies (UWI/EI) implemented the project's training program activities. To provide a framework for this role, a Memorandum of Understanding between the OAS and UWI/EI was developed. Under this MOU, UWI/EI had the following responsibilities within the project:

a. Prepare course materials for the identified short courses within the Project training program, including the identification and engagement of appropriate resource people and review of course materials.
b. Coordinate the administration of the Project's short courses. This included contracting of teachers; identification and notification of participants; arranging course venues and travel for participants and teachers; preparation and distribution of course materials; and provision of administrative support during courses.
c. Facilitate plans for integrating course material into the ongoing curriculum of the University of the West Indies.

To provide expert guidance in program design and review, the OAS sought the assistance of Mr. Compton Deane, a recognized authority on coastal engineering in the Caribean, for the following tasks:

a. Prepare a brief report on the deficiencies in the Caribbean region in regards to coastal infrastructure design, construction and maintenance and the challenges involved in organizing a training program to address these deficiencies. This report is available on the 'documents' page of the project web site (http://www.oas.org/cdcm_train.)
b. Assist UWI/EI with the refinement of course outlines, identification and selection of appropriate presenters and preparation of course materials.
c. Develop recommendations for integrating the course material developed under the CDCM Training project into engineering curriculum at the University of the West Indies, St. Augustine.

For course preparation and logistical support, UWI established a project secretariat, with an events manager and clerical assistant. The secretariat arranged participants' registration, travel and accommodations, established venue arrangements and coordinated travel and logistical support for course coordinators, lecturers and presenters.

US-Based University Support

In accordance with the stipulation contained in the document *USAID/J-CAR Hurricane Lenny Recovery in the Eastern Caribbean* and consistent with the recommendations from the *Coastal Infrastructure Design, Construction and Maintenance: Needs Assessment* report (see below), four US universities were invited to submit a proposal for participation in the development of course material and the delivery of courses under this project: University of Florida, Texas A&M, the Massachusetts Institute of Technology and Old Dominion University. Proposals were received from the University of Florida and from Old Dominion University (ODU), in collaboration with the US Army Corps of Engineers' Coastal Hydrology Lab (CHL). After a review of the proposals by UWI/EI, Compton Deane and OAS, ODU/CHL was selected to participate in the CDCM Training project.

In May 2001, a memorandum of understanding was established between the OAS and the Old Dominion University Research Foundation, to provide course development and teaching assistance for the USAID/OAS/UWI Coastal Infrastructure Design, Construction and Maintenance (CDCM) training program. Under this MOU, ODU undertook the following tasks:

a. Preparation of course materials for components of the short courses within the Project training program. In support of this, ODU identified appropriate roles for and engaged the assistance of the US Army Corps of Engineers' Coastal Hydrology Laboratory (CHL) in course preparation and delivery. All course material was prepared in coordination with the University of the West Indies' Engineering Institute (UWI/EI).
b. Participation in the CDCM short courses to deliver of the materials prepared by ODU/CHL.

Involvement in this course, through ODU, of the personnel the USACOE Coastal Hydrology Laboratory was significant. The CHL is one of the world's preeminent coastal engineering agencies. The CHL is currently developing the *Coastal Engineering Manual (CEM)*, which will replace the Corps' existing *Shore Protection Manual.* Through the CHL, participants in the USAID/OAS/UWI CDCM training program were trained using the newest materials developed by the CHL for US courses on the concepts and cases included in the CEM.

CDCM training course participants received a limited-license version (for use during courses) of the interactive CEM and the Coastal Engineering Design and Analysis System (CEDAS) software, courtesy of Veri-Tech, Inc., Vicksburg, MS, USA. Access to the interactive version of the CEM was facilitated by ODU and the CHL.

Project Information Dissemination

The project web site, http://www.oas.org/cdcm_train, serves as a repository for information and materials developed under the project, including the initial needs assessment; course descriptions, materials and syllabi for all courses; and a link to the *Hurricane Hazard Information for Coastal Engineers* (see description in the following section).

Project Activities

Coastal Infrastructure Design, Construction and Maintenance Needs Assessment

During the period November 2000–January 2001, the project supported a needs assessment of coastal engineering design, construction and maintenance capacity within the Caribbean region. This needs assessment was conducted by a team comprising Selpelco/Westmar Consultants (Kirkland WA USA) and Smith Warner International (Kingston Jamaica). The terms of reference for this activity were:

1. Obtain input on the existing and desired capacity of coastal infrastructure design, maintenance and construction (CDMC), through interviews with key personnel in the four participating countries and at regional institutions such as the CDB, UWI and private engineering firms.
2. Provide input into the content and execution of a series of short courses in CDMC. Propose criteria for selecting a suitable US-based University to partner with UWI-St. Augustine and develop a list of potential partner universities.
3. Present findings in a two-day technical meeting with the OAS and UWI/EI.
4. Prepare a final report, which addresses the gaps in the region in understanding of coastal engineering processes in the general engineering and CDCM communities. Also included in this report were recommendations for the content, structure and target participants in the training courses and a short list of potential US-based University partners.

The results of the needs assessment were used to guide the development of the training courses.

Hurricane Hazard Information for Coastal Engineers

To design buildings and infrastructure that are able to withstand the effects of natural hazards, it is critical to estimate the magnitude of the effects that can be expected at the building site during the life of the structure. Under the USAID/OAS Caribbean Disaster Mitigation Project, a Tropical Cyclone Hazard database was developed for the Caribbean basin. The information contained in this database is of use to engineers designing infrastructure and buildings in the Caribbean region, but was not accessible in a format appropriate for use in design work.

To provide participants in the CDCM training program—and coastal engineers and designers throughout the region—with access to the full breadth and depth of this database, the project supported the development of an application entitled *Hurricane Hazard Information for Coastal Construction*. This application is accessible through the internet via servers at UWI and Old Dominion University. Important features of this application include:

- User-generated report on wind, wave and surge information for 10-, 25-, 50- and 100-year return periods for locations in the Caribbean covered by the existing hazard database. For each hazard and return period combination, values are reported for the maximum likelihood estimate (MLE) as well as the 75%, 90%, 95% and 99% prediction limits.
- Users can specify the location of interest for a report by selecting a point on a map or by entering the latitude and longitude coordinates of the location, through a graphical user interface. For the map selection, the application allows the user to pan and zoom the map to select the location of interest.
- The application converts the data into formats commonly used by engineers.

- The application also includes significant background and descriptive information on the hazard database and storm hazard modeling:
  - A detailed description of the methodology used to develop the Tropical Cyclone hazard database;
  - Information on validations of the TAOS model and verifications of the hazard estimates in the database;
  - A discussion of return periods and prediction limits, as applied in the database; and
  - Individual discussions and sample applications of the wind, wave and surge data contained in the database.

The *Hurricane Hazard Information for Coastal Construction* application was first presented at course 3, Maintenance and Monitoring of Coastal Infrastructure, held in Grenada in September 2001 and is accessible on the web at http://cdcm.eng.uwi.tt.

CDCM Training Course Offerings

Course 1: Coastal Zone Management

Antigua and Barbuda, 16–22 June 2001, and St. Lucia, 2–6 July 2001. This course introduced the concepts and configuration of coastal zone management and exposed the participants to broad approaches to addressing problems in the coastal zone. The Barbados coastal zone management initiatives were used as a case study to emphasize the organizational, functional and legislative imperatives of coastal zone management. The climatic, hazards, vulnerability and environmental/biological aspects of the coastal zone were introduced. Overviews of coastal processes, beach management and the impact of inland activities on coastal waters were provided. Case studies were used throughout this course.

A total of 38 representatives of the CDCM training project countries (31), the broader OECS (6) and CARICOM (1) participated in these two offerings of the coastal management course and were from the fields of engineering (18), planning (10), fisheries (7) and surveying (3).

Course 2: Coastal Defense Systems

Part 1: St. Lucia, 19–22 July 2001. This course was designed as an introduction to coastal defenses and introduced the participants to coastal elements, coastal processes, hazards and vulnerability and sea defenses. Best practices for coastal monitoring and data collection were presented. The fundamental concepts of failure and design were introduced and the types of available sea defense designs were discussed in detail. A few of the participants had difficulties with some of the deep engineering concepts, such as design wave estimation and design reliability, but generally the course was quite well received. Midway through the course, participants worked in small groups on open-ended design assignments on actual situations in the Caribbean. Participants reported that these exercises were useful and effective in clarifying the course material. This interactive approach was supplemented by a field trip to Soufriere on the last day of the course, which afforded an opportunity to view the coastal elements and processes that had been presented and discussed in the first three days of the training course.

Part 2: Dominica, 30 July–3 August 2001. This course was originally planned as a five day course, but was shortened to four days after bad weather delayed the arrival of the majority of the course participants. The course was designed as a continuation of course 2.1. It covered the details of procedures for estimating design storms and wave conditions and methods to apply them to the design of various types of sea defenses. One module of this course focused on the appropriate design of coastal roads. Case studies and practical examples were used throughout the course. A field trip to sea defense construction works in progress at Cabrits provided a tangible example of the course concepts. At the end of this two course series, participants were well aware of what it takes to select and design an appropriate sea defense system for tropical storms, knew what questions to ask of design consultants in review and approval of plans for coastal infrastructure and were capable of running quick checks on designs.

Thirty people participated in each section of this course (parts 1 and 2). Of this number, 24 were from the project countries, 5 from the broader OECS and 1 from CARICOM. The majority of participants were engineers.

Course 3: Monitoring and Maintenance of Coastal Infrastructure

Grenada, 10–13 September 2001. This course began with an overview of the Coastal Engineering Manual, which is under development by the US Army Corps of Engineers. This was followed by modules on materials in the marine environment, infrastructure monitoring activities and vulnerability assessment. Availability and use of appropriate hazard risk information is critical to successful design and maintenance programs. Under the heading of data acquisition and remote sensing, a range of appropriate models, tools and collection methods were introduced. These included the TAOS storm hazard model, a storm hazard assessment model developed by Charles Watson, the SHOALS data collection system, developed by the US Army Corps of Engineers, and on-site beach monitoring methodologies. The course concepts were reinforced during field visits to three sea defense construction sites along the Western Main Road. The workshop concluded with a presentation of replacement analysis and an interactive discussion period. There were 23 participants in the course.

Course 4: Design of Marine Structures

Trinidad, 24–28 September 2001. The course began with a detailed, design-oriented hazard assessment, with an introduction to approaches and procedures for geotechnical assessments in the coastal zone, highlighted with appropriate case studies from the region. A presentation on beach nourishment design built upon related discussions in previous courses in this series. General marine structure design principles were introduced, followed by practical exercises on the design and protection of rubble structures. Finally, the topic of hazard mapping was introduced, using a coastal hazard mapping project in Belize as a case study. The course also included a full-day field trip along the north, east and west coasts of Trinidad and included visits to pocket and strip beaches, sea walls and causeways. 31 individuals participated in this course.

Incorporation of Course Materials into UWI Curriculum

The Civil Engineering department at the UWI is currently working on incorporating the courses developed under this project into its graduate. As these courses were been developed for professional development program, they cover more of the applied technologies, and professional issues and practices. For the graduate program, the Department is currently deepening the treatment of theory so that they qualify as top level graduate courses, with

relevance to similar coastal environments around the world. The graduate program will commence in January 2003. In the interim, the Department is looking to a second regional delivery of two to three of the courses sometime in August 2002.

Caribbean Coastal Engineering Issues

Throughout the courses, participants were surveyed on the principal coastal management issues in the participating countries and the region. The following issues have been consistently identified as the major impediments to proper coastal zone management generally, and with regard to coastal infrastructure in particular, in the Caribbean:

- Piecemeal environmental legislation;
- Lack of enforcement of existing laws and regulations;
- Absence of land use policies;
- Absence of a central coastal zone management unit;
- Lack of political will;
- Inadequate resources for data collection and monitoring;
- Destructive exploitation practices, including sand mining;
- Sea level rise;
- Vulnerability to natural hazards;
- Political interference;
- Need for continuous training programmes (at UWI and on a regional basis);
- Lack of appropriate design support tools;
- Need for improved networking and communications through a regional network;
- Need for updated and better access to bathymetric data; and
- Need for a framework for development of national implementation plans.

Recommendations

The CDCM Training program has successfully sensitized and trained selected individuals in the target countries to issues related to coastal infrastructure design, construction and maintenance. The activities and lessons of the project must now be expanded to a larger audience within the region and must be institutionalized within appropriate institutions in the region. A three-pronged strategy is recommended, consisting in further training to build critical expertise, the provision of coastal information management and dissemination tools, and the preparation of island-specific implementation plans for coastal zone management (CZM). These activities could be carried out under a two-year institutional capacity building project, resulting in the consolidation of a coastal engineering program at the UWI.

Expand the Building of Expertise and Institutional Capacity

a) *Building of academic capacity in coastal engineering at UWI.* This would entail establishing formal arrangements with universities and specialized institutions such as ODU and the Coastal Hydrology Lab of the U.S. Army Corps of Engineers, to facilitate exchanges of personnel for short working visits, including students and young professionals; collaboration in the use of laboratory services; assistance with coastal data collection and research addressing critical coastal management issues in the Caribbean; and collaboration in the preparation of academic and technical publications.

b) *Design and implementation of a follow-on training program.* This program would address the needs and gaps identified by the participant and teachers involved in the recently

completed training program. It would be implemented by the same institutional partnership, and would be structured so that it would maximize opportunities for further capacity building at UWI.

c) *Organizing an annual Caribbean Coastal Management Workshop/Conference.* The conference would offer an opportunity for coastal engineers in the islands to present lessons learned and to exchange experiences in the implementation of island specific plans and projects. In addition, the conference would offer a forum to address development policy issues involved in coastal zone management, and would make a significant contribution to creating awareness of coastal issues among policy makers in the region.

d) *Developing a web-based network linking academic and specialized institutions with practicing coastal engineers and managers.* The purpose of this web site is to support and facilitate the exchange of information and access to expertise relevant to coastal engineering and coastal zone management in the region and outside. This would include making available the U.S. Army Corps of Engineers Coastal Engineering Manual, a powerful tool for planning and engineering of coastal projects.

Develop Regional Tools for Data Management and Analysis

a) *Promote the full utilization of the Coastal Resources Inventory System (CRIS),* developed under the CPACC project and installed in 12 English speaking Caribbean countries. CPACC (Caribbean Planning for Adaptation to Global Climate Change) is a four-year project funded by the Global Environment Facility. Identifying and reducing coastal vulnerability through capacity building in coastal management is an important component of the project.

b) *Support the development of regional scale advanced coastal processes modeling.* Such modeling is essential to improve the understanding of coastal processes typical to Caribbean islands. Included in this activity will be the validation of the TAOS tropical storm modeling system with actual observations from the region. The TAOS modeling system is being used by various institutions in the Caribbean to produce coastal hazard assessments and information of relevance to coastal design and coastal zone management. The potential to expand to the Caribbean U.S. government regional hurricane water level and wave models (developed for the Gulf of Mexico) will also be explored.

c) *Contribute to the maintenance and improvement of the coastal climate, sea-level and beach monitoring networks installed by CPACC and COSALC (Coast and Beach Stability in the Caribbean Project).* These two projects, and several others, have produced information and introduced practices aimed at improving coastal zone management and engineering. The UWI program, with its focus on networking and capacity building, could play an essential role in linking and integrating the various ongoing initiatives in climate observation and beach monitoring.

d) *Facilitate the production of and access to bathymetric survey data.* The region needs a mechanism that maintains a current inventory of bathymetric data for critical coastal areas and that coordinates further investments in obtaining such data. The application of SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) will be explored.

Assist in the Development of National Implementation Plans

a) *Update the CRIS and the national GIS systems with recent coastal information.* Relevant information is being collected sporadically in the context of ongoing coastal development projects. For various reasons (lack of a designated coastal zone authority, tendency on the part of private contractors not to share results of studies), little of that information is presently captured and entered into a national data base that can be used by all agencies operating in the coastal area.

b) *Identify* critical *and at risk locations, develop monitoring strategies.* Each island has known coastal problem spots that need priority attention due to their importance in the nation's development.

c) *Develop and implement, on a pilot basis, an Island Coastal Management Plan.* The formulation of these plans should be coordinated by the institution or mechanism entrusted by government with the mandate for coastal zone management. Partnering with the private sector (tourism, fisheries, etc.) is essential for sustaining implementation.

d) *Disseminate the* methodology *and results of the pilot through training workshops.*

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Coastal Infrastructure Design, Construction and Maintenance Training
Implemented by the Organization of American States, Unit for Sustainable Development and Environment
and the Engineering Institute of the University of the West Indies, St. Augustine Trinidad
for USAID-Jamaica/Caribbean Regional Program

Coastal Infrastructure Design, Construction and Maintenance Training

Participating Countries: Antigua & Barbuda, Dominica, Grenada and St. Lucia

This project aimed to reduce the long-term vulnerability of coastal infrastructure in the project countries and in the broader Caribbean region by expanding the capacity for appropriate design, construction and maintenance of coastal infrastructure works, through series of training courses that were designed and implemented under the project. The target audience for the training included public- and private-sector engineers, planners, architects and environmental officials.
[CDCM Project Background] | [CDCM Issues and Recommendations]

Training Courses: Descriptions, Schedules and Materials
The centerpiece of the project was a series of training courses developed and delivered under the project:
- *Course 1: Coastal Zone Management*
- *Course 2: Coastal Defense Systems*
- *Course 3: Monitoring and Maintenance of Coastal Infrastructure*
- *Course 4: Design of Marine Structures*

[CDCM Training Course Page]

Hurricane Hazard Information for Caribbean Coastal Construction
The *Hurricane Hazard Information for Caribbean Coastal Construction* system is designed to provide storm hazard data useful for practicing engineers, architects, and planners in the Caribbean. Technical documents on storm hazards and storm hazard modeling are also available.
[UWI Hazard Data Server Page] | [Mirror Site]

Documents
Needs Assessment: To provide a baseline for planning the training program, a assessment of existing coastal infrastructure design, construction and maintenance resources, expertise and issues in the Eastern Caribbean was conducted November 2000-January 2001.
Deficiencies of the Caribbean Region in Terms of Coastal Design, Construction and Maintenance: A separate review of CDCM deficiencies in the Caribbean and the challenges facing the development and institutionalization of CDCM training in the region was also undertaken. March 2000.
Solutions to Coastal Disasters Conference Paper: A paper on the CDCM Training project was presented by Jan Vermeiren and Raymond Charles at the ASCE's *Solutions to Coastal Disasters 2002* conference.
[CDCM Training Documents Page]

This project is funded by the USAID-Jamaica/Caribbean Regional Program under a special objective for *Hurricane Lenny Recovery in the Eastern Caribbean.* [USAID/J-CAR Special Objective Document]

Organization of American States

Conditions and Disclaimer

Coastal Infrastructure Design, Construction and Maintenance Training: Project Overview

Background

Hurricanes and tropical storms are annual occurrences in the Caribbean. These storms can, and have, caused extensive damage to vulnerable buildings and infrastructure. The capacity of small island states to resume normal economic activity following hurricane-induced setbacks depends on several factors, including the initial level of hazard vulnerability, the size of the internal reserves and the speed with which normal trade patterns can be reestablished.

Hurricane Lenny was a late season storm that began as a tropical depression in the Western Caribbean on 13 November 1999. It moved in an unusual easterly/northeasterly direction. By 17 November, it had become a Category IV hurricane with sustained winds of over 150 mph. The storm caused high waves, which pounded the usually sheltered west coasts of the leeward Caribbean Islands.

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1. *Hurricane Lenny Recovery in the Eastern Caribbean: Special Objective Document.* USAID/J-CAR, 17 April 2000.

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Course 1: Coastal Zone Management

Antigua and Barbuda, 16–22 June 2001, and St. Lucia, 2–6 July 2001. This course introduced the concepts and configuration of coastal zone management and exposed the participants to broad approaches to addressing problems in the coastal zone. The Barbados coastal zone management initiatives were used as a case study to emphasize the organizational, functional and legislative imperatives of coastal zone management. The climatic, hazards, vulnerability and environmental/biological aspects of the coastal zone were introduced. Overviews of coastal processes, beach management and the impact of inland activities on coastal waters were provided. Case studies were used throughout this course.

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Materials

Note: all materials are in Adobe Acrobat .pdf format

- Cover, Table of Contents, Preamble: text (277k)
- Chapter 1 - Elements of Coastal Management: text (325k)
- Chapter 2 - Land Use Planning: text (300k)
- Chapter 3 - Coastal Processes: text (525k) | additional slides (900k)
- Chapter 4 - Coastal Hazards and Vulnerability: text (325k) | slides (1,450k) | Figure 1 (30k) | Figure 2 (25k)
- Chapter 5 - Mitigation Alternatives: text (6,600k)
- Chapter 6 - Beach Management: text (1,050k)
- Chapter 7 - Marine Biology Issues: text (335k)
- Chapter 8 - Climate Change: text (310k) | slides (2,475k) | figures (2,060k)
- Chapter 9 - Integrated Watershed Management: text (555k)
- Chapter 10 - Environmental Impact Assessment: text (315k)
- Chapter 11 - Monitoring and Measurement: text (980k)
- Chapter 12 - Legislative Environment: text (315k)

Schedule

Day	Session	Topic	Presenter*
1	Morning 8:30am - 12 noon	• Opening Ceremony • Elements of Coastal Management	USAID/OAS/Government UWI
	Afternoon 1:30 - 4pm	• Land Use Planning	UWI
2	Morning 8:30am - 12 noon	• Coastal Processes • Coastal Hazards and Vulnerability	UWI & ODU/CHL
	Afternoon 1:30 - 4pm	• Coastal Hazard Mitigation Alternatives • Beach Management	ODU/CHL
3	Morning 8:30am - 12 noon	• Marine Biological Issues	UWI
	Afternoon 1:30 - 4pm	• Climate Change	CHL

4	Morning 8:30am - 12 noon	• Watershed Management and Coastal Quality • EIA	UWI
	Afternoon 1:30 - 4pm	• Data Collection and Analysis • Legislative Environment & Policy	CHL UWI
5	Morning 8:30am - 12 noon	• Clinic	Panel
	Lunch	• Closure & Presentation of Certificates	Coordinator

20 minute coffee breaks provided at 10:30am and 3pm. Lunch provided from 12 noon to 1:30pm.

*Presenters

- University of the West Indies (UWI)
- Old Dominion University (ODU)
- US Army Corps of Engineers' Coastal Hydraulics Laboratory (CHL)

USAID/OAS/UWI Coastal Infrastructure Design, Construction and Maintenance Training:
http://www.oas.org/CDCM_Train

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Course 2.1: Coastal Defense Systems I

St. Lucia, 19–22 July 2001. This course was designed as an introduction to coastal defenses and introduced the participants to coastal elements, coastal processes, hazards and vulnerability and sea defenses. Best practices for coastal monitoring and data collection were presented. The fundamental concepts of failure and design were introduced and the types of available sea defense designs were discussed in detail. A few of the participants had difficulties with some of the deep engineering concepts, such as design wave estimation and design reliability, but generally the course was quite well received. Midway through the course, participants worked in small groups on open-ended design assignments on actual situations in the Caribbean. Participants reported that these exercises were useful and effective in clarifying the course material. This interactive approach was supplemented by a field trip to Soufriere on the last day of the course, which afforded an opportunity to view the coastal elements and processes that had been presented and discussed in the first three days of the training course.

Materials

Note: all materials are in Adobe Acrobat .pdf format

- Cover, table of contents: text (290k)

- Chapter 1 - Coastal hazards and vulnerability: text (320k)
- Chapter 2 - Cross shore sediment process: slides (2,850k)
- Chapter 3 - Introduction to coastal engineering: text and slides (317k)
- Chapter 4 - Coastal processes—tides and tidal flows: text (315k)
- Chapter 5 - Coastal processes—waves: text (390k)
- Chapter 6 - Longshore sediment transport processes: slides (1,760k)
- Chapter 7 - Coastal mapping: slides
  - Introduction (2,065k)
  - Coastal project assessment (6,185k)
  - Nearshore surveying (5,050k)
  - Beach surveying (5,570k)
  - Monitoring and measurements (1,175k)
- Chapter 8 - Sediment budgets and modeling: text (335k)
- Chapter 9 - Alternatives for coastal storm damage mitigation and functional design of coastal structures: slides
  - Alternatives for coastal storm damage mitigation (5,820k)
  - Functional design of coastal structures (2,470k)
  - Structure hydraulic response (1,420k)
- Chapter 10 - Coastal and offshore structures: text (320k)
- Chapter 11 - Structural design: slides (1,870k)

Schedule

Day	Session	Topic	Presenter*
1	Whole Day	• Opening Ceremony • Coastal Hazards and Vulnerability	UWI
2	Whole Day	• Coastal Processes	UWI & ODU/CHL
3	Morning	• Coastal Mapping and Data Collection	ODU/CHL
	Afternoon	• Sources and Uses of Coastal Hazard Information	UWI
4	Whole Day	• Introduction to Coastal Defense Systems	UWI
5	Morning	• Clinic (Case Studies)	Panel

	Lunch	• Closure & Presentation of Certificates	Coordinator

20 minute coffee breaks provided at 10:30am and 3pm. Lunch provided from 12 noon to 1:30pm.

Course 2.2: Coastal Defense Systems II

Dominica, 30 July–3 August 2001. This course was originally planned as a five day course, but was shortened to four days after bad weather delayed the arrival of the majority of the course participants. The course was designed as a continuation of course 2.1. It covered the details of procedures for estimating design storms and wave conditions and methods to apply them to the design of various types of sea defenses. One module of this course focused on the appropriate design of coastal roads. Case studies and practical examples were used throughout the course. A field trip to sea defense construction works in progress at Cabrits provided a tangible example of the course concepts. At the end of this two course series, participants were well aware of what it takes to select and design an appropriate sea defense system for tropical storms, knew what questions to ask of design consultants in review and approval of plans for coastal infrastructure and were capable of running quick checks on designs.

Thirty people participated in each of the sections of this course (2.1 and 2.2). Of this number, 24 were from the project countries, 5 from the broader OECS and 1 from CARICOM. The majority of participants were engineers.

Materials

Note: all materials are in Adobe Acrobat .pdf format

- Cover, table of contents: text (275k)
- Chapter 1 - Life cycle designs: slides (2,770k)
- Chapter 2 - Design of coastal structures: slides (3,510k)
- Chapter 3 - Design of coastal roads: text (1,235k)
- Chapter 4 - Design of coastal defense works: text (340k)

Schedule

Day	Session	Topic	Presenter*
1	Whole Day	• Opening Ceremony • Life Cycle Design	ODU/CHL
2	Whole Day	• Design of Coastal Roads	UWI & ODU/CHL
3	Whole Day	• Design of Coastal Defense Works	UWI & ODU/CHL
4	Whole Day	• Drawings, Specifications and Contract Documents	UWI & ODU
5	Morning	• Field Visit	UWI
	Lunch	• Closure & Presentation of Certificates	Panel Coordinator

20 minute coffee breaks provided at 10:30am and 3pm. Lunch provided from 12 noon to 1:30pm.

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*Presenters

- University of the West Indies (UWI)
- Old Dominion University (ODU)
- US Army Corps of Engineers' Coastal Hydraulics Laboratory (CHL)

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Course 3: Monitoring and Maintenance of Coastal Infrastructure

Grenada, 10–13 September 2001. This course began with an overview of the Coastal Engineering Manual, which is under development by the US Army Corps of Engineers. This was followed by modules on materials in the marine environment, infrastructure monitoring activities and vulnerability assessment. Availability and use of appropriate hazard risk information is critical to successful design and maintenance programs. Under the heading of data acquisition and remote sensing, a range of appropriate models, tools and collection methods were introduced. These included the TAOS storm hazard model, a storm hazard assessment model developed by Charles Watson, the SHOALS data collection system, developed by the US Army Corps of Engineers, and on-site beach monitoring methodologies. The course concepts were reinforced during field visits to three sea defense construction sites along the Western Main Road. The workshop concluded with a presentation of replacement analysis and an interactive discussion period. There were 23 participants in the course.

Materials

Note: all materials are in Adobe Acrobat .pdf format (except for the presentations in Chapters 2 and 4)

- Course title page, table of contents: text (355k)
- Chapter 1 - Materials in a marine environment: title page (260k), slides part 1 (1,250k) and part 2 (550k)
- Chapter 2 - Monitoring of coastal erosion: title page (265k), *Coastal Engineering Manual* presentation (4,800k)
- Chapter 3 - Vulnerability of coastal infrastructure [files too large to post]
- Chapter 4 - TAOS (The Arbiter of Storms) model: text (300k)
    - Presentation on the *Hurricane Hazard Information for Coastal Engineers:* presentation (1,400k)
- Chapter 5 - Data acquisition and remote sensing I [files too large to post]
- Chapter 6 - Data acquisition and remote sensing II: text (450k)
- Chapter 7 - Maintenance management: title page (265k)
    - Structure failure modes: slides (1,030k)
    - Overview of maintenance and monitoring: slides (1,550k)
- Chapter 8 - Replacement analysis: title page (265k)
    - Evaluating coastal structures: condition index system: slides (885k)
    - Repair and rehabilitation of coastal structures: slides (900k)

Schedule

Day	Session	Topic	Presenter*
1	Morning	• Opening Ceremony • Materials in a Marine Environment	CHL
	Afternoon	• Monitoring of Coastal Erosion • Vulnerability	CHL
2	Whole Day	• Maintenance Management Systems • Replacement Analysis	CHL
3.	Morning	• Introduction to Data Acquisition and Remote Sensing	UWI, CHL, CPACC
	Afternoon	• Clinic	Panel
4.	Morning	• Workshop • Closure & Presentation of Certificates	Panel Coordinator

20 minute coffee breaks provided at 10:30am and 3pm. Lunch provided from 12 noon to 1:30pm.

*Presenters

- University of the West Indies (UWI)
- Old Dominion University (ODU)
- US Army Corps of Engineers' Coastal Hydraulics Laboratory (CHL)

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Course 4: Design of Marine Structures

Trinidad, 24–28 September 2001. The course began with a detailed, design-oriented hazard assessment, with an introduction to approaches and procedures for geotechnical assessments in the coastal zone, highlighted with appropriate case studies the region. A presentation on beach nourishment design built upon related discussions in previous courses in this series. General marine structure design principles were introduced, followed by practical exercises on the design and protection of rubble structures. Finally, the topic of hazard mapping was introduced, using a coastal hazard mapping project in Belize as a case study. The course also included a full-day field trip along the north, east and west coasts of Trinidad and included visits to pocket and strip beaches, sea walls and causeways. 31 individuals participated in this course.

Materials

Note: all materials are in Adobe Acrobat .pdf format

- Course title and table of contents: text (270k)
- Chapter 1 - Hazard Assessments: slides (340k)
- Chapter 2 - Geotechnical Investigations: text (340k) | slides and figures [too large to post'
- Chapter 3 - Beach Nourishment Design: slides [too large to post]
- Chapter 4 - Rubble Mound Stability: slides (685k)
- Chapter 5 - Foundation Design: slides (655k)
    - Orinco River Drainage: slides (475k)
- Chapter 6 - Design Principles
- Chapter 7 - Coastal Structure Foundations: slides (375k)
- Chapter 8 - Scour and Scour Protection: slides (955k)
- Chapter 9 - Case Studies: slides (1,075k)

Schedule

Day	Session	Topic	Presenter*
1	Whole Day	• Hazard Assessment • Risk Analysis	Smith, Watson, Stere
2	Morning	• Life Cycle Design	Basco, Smith
	Afternoon	• Design of Marine Structures	Basco
3	Whole Day	• Design of Marine Structures	Basco
4	Whole Day	• Case Studies; Failures and Successes	Basco, Smith
5	Morning	• Case Studies; Failures and Successes	Smith, Basco, Allyn
	Lunch	• Closure & Presentation of Certificates	Coordinator

20 minute coffee breaks provided at 10:30am and 3pm. Lunch provided from 12 noon to 1:30pm.

*Presenters

- University of the West Indies (UWI)
- Old Dominion University (ODU)
- US Army Corps of Engineers' Coastal Hydraulics Laboratory (CHL)

CDCM Training: Project Issues and Recommendations

Caribbean Coastal Engineering Issues

Throughout the courses, participants were surveyed on the principal coastal management issues in the participating countries and the region. The following issues have been consistently identified as the major impediments to proper coastal zone management generally, and with regard to coastal infrastructure in particular, in the Caribbean:

- Piecemeal environmental legislation;
- Lack of enforcement of existing laws and regulations;
- Absence of land use policies;
- Absence of a central coastal zone management unit;
- Lack of political will;
- Inadequate resources for data collection and monitoring;
- Destructive exploitation practices, including sand mining;
- Sea level rise;
- Vulnerability to natural hazards;
- Political interference;
- Need for continuous training programmes (at UWI and on a regional basis);
- Lack of appropriate design support tools;
- Need for improved networking and communications through a regional network;
- Need for updated and better access to bathymetric data; and
- Need for a framework for development of national implementation plans.

Recommendations

The CDCM Training program has successfully sensitized and trained selected individuals in the target countries to issues related to coastal infrastructure design, construction and maintenance. The activities and lessons of the project must now be expanded to a larger audience within the region and must be institutionalized within appropriate institutions in the region. A three-pronged strategy is recommended, consisting in further training to build critical expertise, the provision of coastal information management and dissemination tools, and the preparation of island-specific implementation plans for coastal zone management (CZM). These activities could be carried out under a two-year institutional capacity building project, resulting in the consolidation of a coastal engineering program at the UWI.

Expand the Building of Expertise and Institutional Capacity

a. *Building of academic capacity in coastal engineering at UWI.* This would entail establishing formal arrangements with universities and specialized institutions such as ODU and the Coastal Hydrology Lab of the U.S. Army Corps of Engineers, to facilitate exchanges of personnel for short working visits, including students and young professionals; collaboration in the use of laboratory services; assistance with coastal data collection and research addressing critical coastal management issues in the Caribbean; and collaboration in the preparation of academic and technical publications.
b. *Design and implementation of a follow-on training program.* This program would address the needs and gaps identified by the participant and teachers involved in the recently completed training program. It would be implemented by the same institutional partnership, and would be structured so that it would maximize opportunities for further capacity building at UWI.
c. *Organizing an annual Caribbean Coastal Management Workshop/Conference.* The conference would offer an opportunity for coastal engineers in the islands to present lessons learned and to exchange experiences in the implementation of island specific plans and projects. In addition, the conference would offer a forum to address development policy issues involved in coastal zone management, and would make a significant contribution to creating awareness of coastal issues among policy makers in the region.
d. *Developing a web-based network linking academic and specialized institutions with practicing coastal engineers and managers.* The purpose of this web site is to support and facilitate the exchange of information and access to expertise relevant to coastal engineering and coastal zone management in the region and outside. This would include making available the U.S. Army Corps of Engineers Coastal Engineering Manual, a powerful tool for planning and engineering of coastal projects.

Develop Regional Tools for Data Management and Analysis

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a. *Promote the full utilization of the Coastal Resources Inventory System (CRIS),* developed under the CPACC project and installed in 12 English speaking Caribbean countries. CPACC (Caribbean Planning for Adaptation to Global Climate Change) is a four-year project funded by the Global Environment Facility. Identifying and reducing coastal vulnerability through capacity building in coastal management is an important component of the project.
b. *Support the development of regional scale advanced coastal processes modeling.* Such modeling is essential to improve the understanding of coastal processes typical to Caribbean islands. Included in this activity will be the validation of the TAOS tropical storm modeling system with actual observations from the region. The TAOS modeling system is being used by various institutions in the Caribbean to produce coastal hazard assessments and information of relevance to coastal design and coastal zone management. The potential to expand to the Caribbean U.S. government regional hurricane water level and wave models (developed for the Gulf of Mexico) will also be explored.
c. *Contribute to the maintenance and improvement of the coastal climate, sea-level and beach monitoring networks installed by CPACC and COSALC (Coast and Beach Stability in the Caribbean Project).* These two projects, and several others, have produced information and introduced practices aimed at improving coastal zone management and engineering. The UWI program, with its focus on networking and capacity building, could play an essential role in linking and integrating the various ongoing initiatives in climate observation and beach monitoring.
d. *Facilitate the production of and access to bathymetric survey data.* The region needs a mechanism that maintains a current inventory of bathymetric data for critical coastal areas and that coordinates further investments in obtaining such data. The application of SHOALS (Scanning Hydrographic Operational Airborne Lidar Survey) will be explored.

Assist in the Development of National Implementation Plans

a. *Update the CRIS and the national GIS systems with recent coastal information.* Relevant information is being collected sporadically in the context of ongoing coastal development projects. For various reasons (lack of a designated coastal zone authority, tendency on the part of private contractors not to share results of studies), little of that information is presently captured and entered into a national data base that can be used by all agencies operating in the coastal area.
b. *Identify critical and at risk locations, develop monitoring strategies.* Each island has known coastal problem spots that need priority attention due to their importance in the nation's development.
c. *Develop and implement, on a pilot basis, an Island Coastal Management Plan.* The formulation of these plans should be coordinated by the institution or mechanism entrusted by government with the mandate for coastal zone management. Partnering with the private sector (tourism, fisheries, etc.) is essential for sustaining implementation.
d. *Disseminate the methodology and results of the pilot through training workshops.*

CDCM Training: Project Documents

Project Documents

Coastal Engineering Manual Project homepage. In each course, significant use was made of the new *Coastal Engineering Manual* (CEM), currently under development by the USACE/CHL. When completed, this document will serve as the primary reference for Coastal Engineering. The CEM is the replacement manual for the existing *Shore Protection Manual.* Participants received limited-license versions (for use during courses) of the interactive CEM and the *Coastal Engineering Design and Analysis System* (CEDAS) software, courtesy of Veri-Tech, Inc., Vicksburg, MS, USA.

Needs Assessments

Deficiencies of the Caribbean Region in Terms of Coastal Design, Construction and Maintenance (CDCM). March 2001. (HTML 8k)

Coastal Infrastructure Design, Construction and Maintenance: Needs Assessment. February 2001. Full report with appendices (PDF 4,235k) or individual sections:

- Main Report (PDF 175k)
- Appendix A: Figures (PDF 1,060k)
- Appendix B: Photographs (PDF 2,762k)
- Appendix C: Questionnaire (PDF 32k)
- Appendix D: List of Contacts (PDF 91k)
- Appendix E: Proposed Course Outline (PDF 18k)
- Appendix F: Letters to US-Based Universities (PDF 41k)
- Appendix G: Notes on Meetings with Engineering and Hydrographic Survey Companies (PDF 16k)

Background Documents

- *Hurricane Lenny Recovery in the Eastern Caribbean.* USAID/J-CAR Special Objective Document. Apr 2000. (MS Word 100k)
- Initial CDCM Training Course Announcement (PDF 360k)

Hurricane Lenny Reports

- *Report on TAOS/L Model Run for Hurricane Lenny.* Caribbean Institute for Meteorology and Hydrology, December 1999.
- TAOS Model Operational Simulations of Hurricane Lenny. Watson Technical Consulting. 1999.
- *Recommendations for the rehabilitation of Grand Anse, Grenada, following the erosion caused by Hurricane Lenny.* Cambers, Gillian, December 1999.
- Report from the US National Hurricane Center
- General Report Links: US AID/Office of US Foreign Disaster Assistance Report Archive | CDERA Situation Reports

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CDCM Training Links

Sponsoring Agencies: Organization of American States | US Agency for International Development | University of the West Indies

Related Projects: Caribbean Disaster Mitigation Project (CDMP) | Caribbean Project for Adaptation to Climate Change (CPACC) | Asian Urban Disaster Mitigation Program | OAS Natural Hazards Project | PAHO Emergency Preparedness and Disaster Relief Coordination Program

Related Agencies: Caribbean Disaster Emergency Response Agency (CDERA) | Organization of Eastern Caribbean States Natural Resource Management Unit (OECS/NRMU) | European Community Humanitarian Office (ECHO) for the Caribbean

Hazards-related Sites:

- General: Natural Hazards Center (Colorado) | Regional Disaster Information Centre (Costa Rica) | International Decade for Natural Disaster Reduction (IDNDR)
- Atmospheric: National Hurricane Center (Florida) | National Weather Service (Texas) | Gray's Predictions
- Earthquake: USGS Earthquake Information | IDNDR RADIUS | Structural Engineers Association of California
- Landslide: Unit of Disaster Studies (University of the West Indies, Mona)
- Volcanic: Government of Montserrat and Montserrat Volcano Observatory | USGS Volcano Site

Other: Caribbean Geology | NOAA Coastal Services Center

USAID: USAID's Hurricanes in Central America and the Caribbean page *Hurricane Georges Reconstruction and Recovery in the Eastern Caribbean: Special Objective Document*

USAID/OAS/UWI Coastal Infrastructure Design, Construction and Maintenance Training:
http://www.oas.org/CDCM_Train

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CDCM Training: Contact Information

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USAID/OAS/UWI Coastal Infrastructure Design, Construction and Maintenance Training:
http://www.oas.org/CDCM_Train

Page last updated on 10 Apr 2001

Towards a Solution for Coastal Disasters in the Caribbean

Note: This paper was prepared for presentation at the "Solutions to Coastal Disasters 2002" conference, organized by the American Society of Civil Engineers and held in San Diego 24-27 February 2002.

Raymond Charles, M.Phil.[1], and Jan C. Vermeiren, PhD[2], Member ASCE.

Abstract: Hurricane Lenny (November 1999) exposed significant weaknesses in the coastal infrastructure of islands in the Eastern Caribbean. With financial support from the U.S Agency for International Development, the Organization of American States and the University of the West Indies organized and implemented a five-course training program for coastal zone managers and engineers. This paper presents the structure and results of the training program, and also the elements of a medium term capacity building program presently under development.

INTRODUCTION

Hurricane Lenny was a late season storm that began as a tropical depression east of Central America on November 13, 1999. It moved in an unusual West to East direction and became a tropical storm by the evening of November 14th. The following day, the storm strengthened to a Category I hurricane (winds 74-95 mph) and on November 17th was at the Category IV level (winds reached 150 mph) pounding the Leeward Islands. It continued its easterly direction dropping to a Category III storm and subsequently dissipating over the Atlantic Ocean.

The hurricane demonstrated the vulnerability of the Small Island Developing States of the Caribbean Community. While there were relatively small humanitarian needs emanating from this event, the damage to coastal infrastructure, coastal communities and businesses was significant. Physical damage estimates were in the $269 million range with Antigua and Barbuda, Dominica, Grenada and St. Lucia being the hardest hit islands.

Much of the damage was caused not by the wind, but by high waves extending far south of the hurricane track, and affecting the usually sheltered western coastlines of the Eastern Caribbean islands.

The coastal damage included the removal of large quantities of sand from beaches, damages to hotels and other property sited on the coast, to sea walls, coastal roads, jetties and other port structures. Over the past decade, similar hurricane damage to coastal infrastructure has been experienced in most of the Caribbean territories. However there have been several cases of well-designed coastal structures surviving the onslaught of hurricane surge and wave attack. The recurrence of damage to coastal infrastructure by hurricanes, especially Hurricane Lenny, brought to the fore stark deficiencies in the Region's performance with respect to design, construction and maintenance of coastal infrastructure.

Coastal Engineering Training In The Caribbean

There are several institutions in the Caribbean charged with the responsibility for collecting and analysing information on disasters and marine conditions. However, there is a shortage of suitably qualified engineers in the region who have sufficient training and experience in the design of marine structures. The majority of the engineers practicing in this field in the Caribbean have first degrees from the Department of Civil Engineering of the University of the West Indies. In view of the increasing economic dependence of the Caribbean islands on activities in the coastal zone, the need for a program dedicated to the design, construction and maintenance of coastal structures at University of the West Indies is evident.

Recognising the need for a comprehensive solution for this regional issue, the US Government agreed to fund, through its Agency for International Development (USAID), an assistance program aimed at repairing critical infrastructure damaged by Lenny, and at helping the population to return to self-sustaining economic activities. Strengthening the ability of these countries to withstand and respond to future coastal disasters was the central objective of the assistance. The program therefore included a disaster mitigation component and a training program in coastal processes and design and construction of marine structures.

A cooperative agreement was established with the Organization of American States (OAS) to design and implement a short term training program aimed at laying the basis for sustainable and continuous improvement of the coastal engineering capacity in the Caribbean. The Engineering Institute and the Department of Civil Engineering, University of the West Indies were contracted by the OAS to organize and deliver a training program in coastal design, construction and maintenance (CDCM). This paper presents the structure and results of the training program, and also the elements of a medium term capacity building program presently under development.

PROGRAM ELEMENTS

A needs assessment was carried out to identify the principal gaps in the disaster resilience of the region's coastal infrastructure. Visits were

made to the four islands to observe the damage caused by hurricane Lenny, and to interview public works engineers and private sector engineers.

While the coastal infrastructure problems in the Caribbean are usually correctly identified, the nature and extent of the coastal damage observed after hurricanes points to deficiencies in available capacity for the following design elements:

a. Boundary condition definition in terms of risk of failure and site/natural hazard conditions;
b. Functional analysis and design concept generation, with regard to Environmental Impact Assessment, and Hydraulic behaviour and processes; and
c. Maintenance considerations with respect to monitoring, repair and rehabilitation.

Additionally, a lack of awareness of coastal processes and a failure to recognize the coastal zone as a national resource that requires an integrated approach to its management were evident in the aftermath of Hurricane Lenny.

In addressing these deficiencies, the CDCM program pursued two objectives: (a) make an impact in the short-term by improving knowledge and capacity among practicing engineers in the region, and (b) provide measures to ensure the sustenance and continuous improvement of coastal engineering education and training in the region. It was agreed that appropriate expert resources would need to be engaged from outside the region to provide professional support, and to collaborate with the Engineering Department UWI in organizing and delivering the training. After an extensive search, the Coastal Engineering Centre of the Old Dominion University (ODU), in Norfolk, Virginia, and the Coastal and Hydraulics Laboratory of the U.S. Army Corps of Engineers were selected as partners in this effort.

Short-term Solutions

Executed during 2001, the short-term program pursued a three-pronged approach. First, a professional development-training program in the Design Construction and Maintenance of Coastal Infrastructure (CDCM) was implemented. Second, a comprehensive database with information on tropical storm wind, wave and surge for the Caribbean was compiled and made available to participants. And third, the formation of a regional coastal zone management network was initiated.

The CDCM training program comprised 5 short courses in Coastal Engineering and Infrastructure, designed to address the deficiencies as given in Table 1. A total of 155 training opportunities were provided across the 5 courses, with 30 Engineers and Planners from Antigua & Barbuda, St. Lucia, Dominica, Grenada and Trinidad and Tobago forming the core of participation. The courses were delivered between June and September 2001, one in each of the core participating territories. Lecturers and presenters came from the ODU, the CHL, and the Department of Civil Engineering of UWI, along with practicing professionals in the Caribbean.

Table 1. CDCM Professional Development Course Configuration, 2001

Course Title	Deficiency Addressed	Duration
Coastal Zone Management	Coastal Zone Management; hydraulic processes, hurricane impact assessment, zone definition, beaches, setbacks, regulations, environmental & marine biological issues; organization and management issues	5 days
Design of Sea Defences I Design of Sea Defences II	Boundary Condition; Coastal processes, hazard assessment, beach monitoring, data collection, sea defences. Functional Analysis; Coastal processes, coastal roads, hazard assessment, reliability, design forces, design and construction of sea defences.	4 days
Maintenance of Coastal Infrastructure	Maintenance; Materials & maintenance, data collection and monitoring, beach and shore line management, inspection, management and life cycle/replacement analysis of coastal infrastructure.	4 days
Design of Marine Structures	Capstone; Geotechnical appraisal of the coastal zone, hazard assessment, design of coastal structures and sea defences.	5 days

coastal infrastructure, the project contracted the preparation of a comprehensive data base on the wind, wave and surge hazards from tropical storms affecting the Caribbean. The TAOS[3] storm modeiling system was used to analyse 115 years of tropical climatology in the Caribbean and to produce Maximum Likely Estimates (MLE) of wind, wave and surge values corresponding to 10, 25, 50 and 100 year return periods. A user can query the database by clicking on a site map, or by entering the latitude and longitude of the site for which the hazard information is required.

This information is accessible on a web site of the University of the West Indies, Faculty of Civil Engineering, at the IP address 196.3.139.41. It is an inter-active web site, using open source, and public domain software. The site also contains information on the methodology used, and on the interpretation of the model outputs and their use in conjunction with building codes.

Figure 1 shows the Data Access Screen, with the user definable options for selecting a map projection, and producing a particular output.

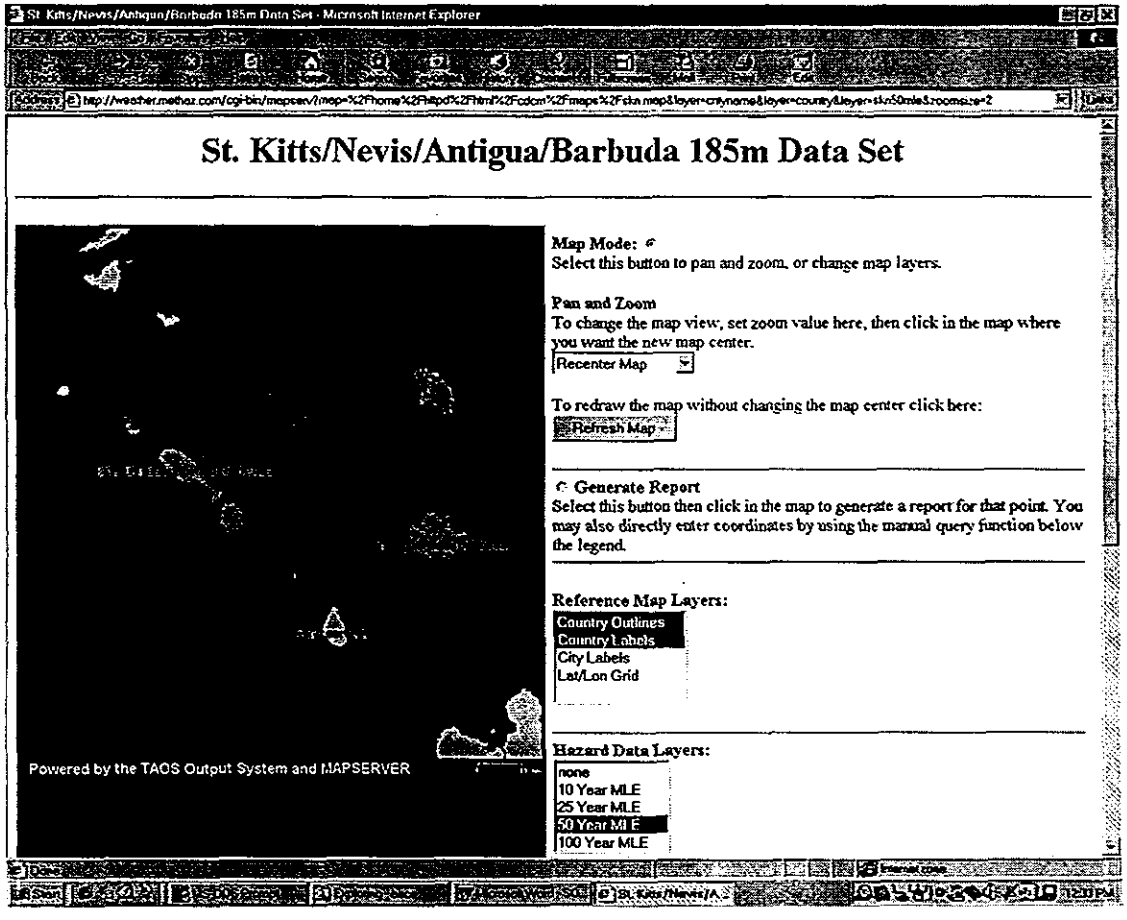
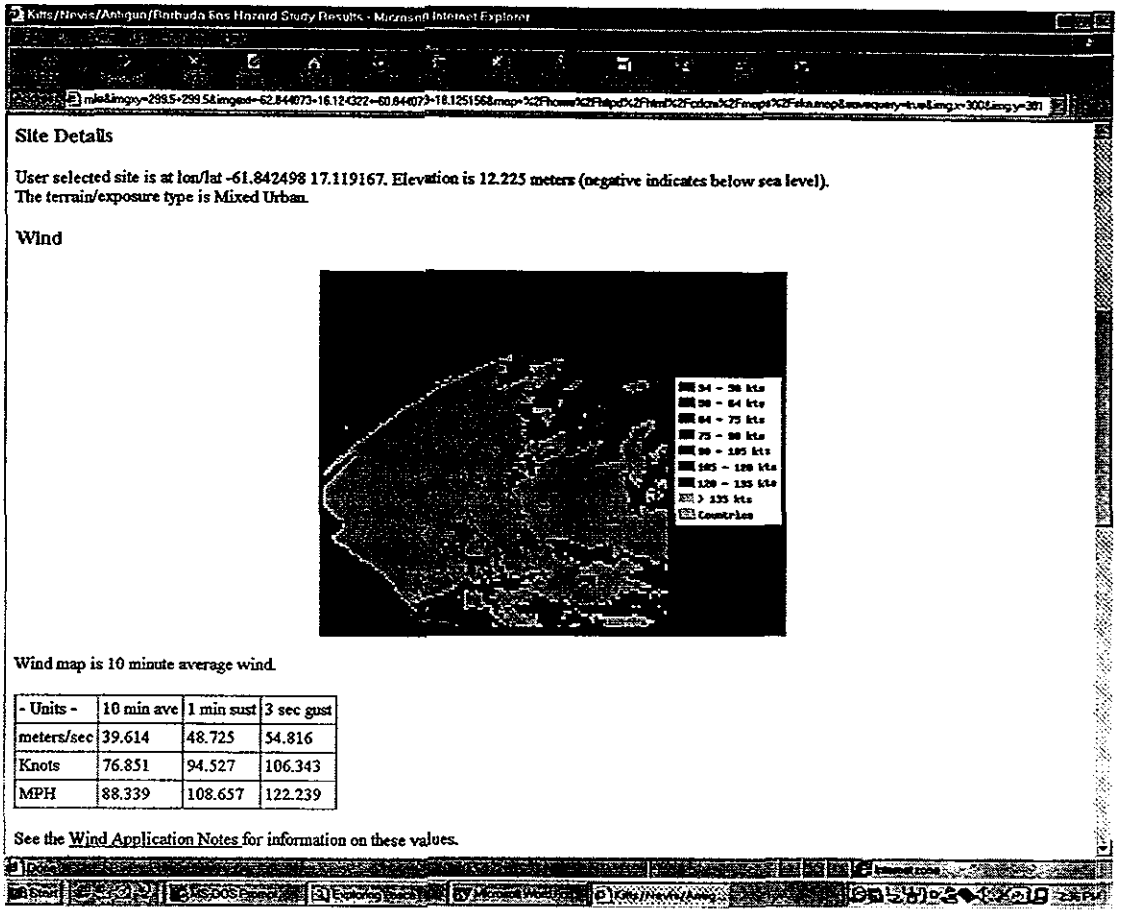


Figure 1. Data Access Screen

Figure 2 shows statistical an output report for a particular query, with information on the selected location, and estimates for the wind, wave and surge values for that site and return period.



Site Details

User selected site is at lon/lat -61.842498 17.119167. Elevation is 12.225 meters (negative indicates below sea level).
The terrain/exposure type is Mixed Urban.

Wind

Wind map is 10 minute average wind.

- Units -	10 min ave	1 min sust	3 sec gust
meters/sec	39.614	48.725	54.816
Knots	76.851	94.527	106.343
MPH	88.339	108.657	122.239

See the Wind Application Notes for information on these values.

Figure 2: Wind section of Output Report, St. Johns, Antigua

The establishment of the CZM network would improve communication on the subject and provide opportunities for the sharing/optimisation of Island expertise existing in the region.

Lastly, the project has encouraged participants in the course to establish a coastal zone management network for the region, starting with four island states, Antigua and Barbuda, Dominica, St. Lucia and Grenada. The network will be supported by the UWI Faculty of Engineering, and will use a mailing list on the web site described above as a forum to exchange experiences and discuss coastal design and engineering issues and techniques. The network will facilitate:

- Promotion of awareness of the importance of coastal zone management, and its institutionalisation;
- Collaboration with the Caribbean Planning for Adaptation to Global Climate Change (CPACC) project on standardization of coastal zone inventories, legislation and regulations, and data collection procedures.
- Standardization of design techniques and procedures;
- Improved communication between practitioners in coastal zone management and coastal engineering in the participating territories;
- Sharing of expertise developed and resident in the respective territories;
- Advise on industry requirements of professional development and academic training courses and programs; and
- Liaison with other regional and international initiatives and agencies involved in coastal zone engineering and management.

Already, the initiative taken during the training program has borne fruit; each of the four territories have established working groups on coastal zone management, with St. Lucia already into formal implementation of its Coastal Zone Management Unit (CZMU), and Grenada is about to do so before the year's end. The remaining Island States are expected to establish formal CZMUs by March 2002. At that time the regional network will be formally launched and a dedicated web site would have been installed at the UWI. It is expected that the remaining Island States in the Caribbean will be integrated into the network by the summer of 2002.

Medium and Long Term Solutions

To ensure a sustainable and continuous provision of reliable capacity to deal with coastal zone and coastal engineering problems, the following initiatives are being developed to address the associated medium and long-term requirements.

a. Infusion of the Undergraduate B.Sc. Degree program at the Department of Civil Engineering, UWI with the fundamental elements of

coastal zone management and coastal engineering;

b. Introduction of graduate courses and programs in Coastal Engineering through link with the ODU coastal engineering program;
c. Establishment of a (summer) working visitor program with the CHL for young professionals and graduate students involved in coastal engineering and coastal zone management;
d. Hosting of an annual regional meeting/conference in coastal zone and coastal engineering issues, where the regional network can present their experiences in the development and implementation of related solutions; and
e. Participation by representatives of the regional network in International Conferences on coastal zone management and coastal engineering.

CONCLUSION

The training program in coastal design, construction and maintenance financed by U.S.AID for four islands in the Eastern Caribbean represents a promising start in addressing shortcomings in technical skills and expertise in this field. It also was successful in laying the groundwork for a network that will link practising engineers and coastal zone managers with technical resources and expertise available outside of these countries and needed to improve the region's capacity to reduce coastal disasters. The magnitude of the challenge is such, however, that a much broader and longer-term effort is needed. As the pre-eminent educational institution in the region, the University of the West Indies is prepared to play a central role in this effort, and to coordinate the resources and technical expertise that needs to be mobilized to continue to support coastal vulnerability reduction.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the valuable contributions made to this project by Messrs. David Smith of Smith Warner International Ltd., and Norm Allyn of Selpeco Westmar Consultants L.L.C. who undertook the needs assessment; Mr. Vincent Cooper, Dr. Gyan Shrivastava, and Dr. Derek Gay of the University of the West Indies who were coordinators for the different course sessions; Professor David Basco, Director of the Coastal Engineering Centre of Old Dominion University, and Mrs. Joan Pope, Associate Technical Director of the Coastal Hydraulics Laboratory of the U.S. Army Corps of Engineers who taught various subjects in the courses and coordinated the inputs of their respective institutions; Mr. Compton Deane, coastal engineer, former professor at the Faculty of Engineering at UWI and principal advisor to the project; and Steven Stichter, technical coordinator of the project for the Organization of American States.

END NOTES

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3. The Arbiter of Storms (TAOS), a parametric storm hazard modeling platform, integrating selectable wind, wave and storm surge models and linked with a statistical analysis package. Developed by Watson Technical Consulting, Savannah GA. http://www.methaz.com

Coastal Infrastructure Design, Construction and Maintenance Training
Implemented by the Organization of American States, Unit for Sustainable Development and Environment
and the Engineering Institute of the University of the West Indies, St. Augustine Trinidad
for USAID-Jamaica/Caribbean Regional Program

CDCM Training Administrative Information

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Reporting

- January-March 2001 Progress Report
- April-August 2001 Progress Report
- Final Project Report

Contracts

- Needs Assessment: Terms of Reference
- Assistance with Course Development: Terms of Reference
- Development of a CD-ROM: *Hurricane Hazard Information for Coastal Construction:* Terms of Reference

Memoranda of Understanding between the OAS and

- the Engineering Institute of the University of the West Indies: MOU Activities
- the Old Dominion University Research Foundation: MOU Activities

This project is funded by the USAID-Jamaica/Caribbean Regional Program under a special objective for *Hurricane Lenny Recovery in the Eastern Caribbean.* [USAID/J-CAR Special Objective Document]

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