Proceedings of the Hurricane Dean Impact Assessment

THE MARINE GEOLOGY UNIT
UWI, MONA

Prepared by the
Marine Geology Unit,
Department of Geography and Geology
University of the West Indies, Mona

Impact of Hurricanes on Jamaica’s Coastlines

November 6th, 2007

Summary of Workshop Presentations

Proceedings of the BEACHES end of Project Workshop

Funded by the Environmental Foundation of Jamaica
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## Workshop Program

**IMPACT OF HURRICANES ON JAMAICA'S COASTLINE**

*Beach Erosion And Coastal Hazards: Ensuring Safety (B.E.A.C.H.E.S.)*

Mona Visitor’s Lodge & Conference Center UWI, Mona Campus

November 6th, 2007

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</thead>
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<tr>
<td>8:30-9:00 am</td>
<td>WORKSHOP REGISTRATION</td>
<td></td>
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</tbody>
</table>
| 9:00 –9:20 am | Opening Remarks  
*Mrs. Eleanor Jones*                                                                                     |                                                                                                       |
| 9:20 –9:35 am | BEACHES –Project objective and methods used  
*Prof. Edward Robinson – Marine Geology Unit (MGU) UWI*                                                     |                                                                                                       |
| 9:35 –9:50 am | Coastal Hazard Maps - design and applications  
*Mr. Richard Coutou (MGU-UWI)*                                                                                 |                                                                                                       |
| 9:50 –10:05 am | Coastline assessment, documenting physical features  
*Prof. Edward Robinson (MGU-UWI)*                                                                                |                                                                                                       |
| 10:05 –10:30 am | COFFEE BREAK & POSTER VIEWING                                                                             |                                                                                                       |
| 10:30 –10:45 am | Hazards of our Coastline – Impacts on coastal communities  
*Shakira Khan (MGU-UWI)*                                                                                     |                                                                                                       |
| 10:45 –11:00 am | Characteristics of Hurricane Dean  
*Mr. Rafi Ahmad  
Unit for Disaster Studies (UWI)*                                                                              |                                                                                                       |
| 11:00 –11:15 am | Offshore sand deposits – South coast shelf: A preliminary appraisal  
*Prof. Edward Robinson (MGU-UWI)*                                                                             |                                                                                                       |
| 11:15 – 12:00 pm | **PARTICIPANTS REVIEW**                                                                                   |                                                                                                       |

**END OF MORNING WORKSHOP**
<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
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<tbody>
<tr>
<td>1:30 – 1:45 pm</td>
<td><strong>REGISTRATION</strong> – Hurricane Dean Impact assessment</td>
</tr>
<tr>
<td>1:45 – 2:00 pm</td>
<td>Opening Remarks</td>
</tr>
<tr>
<td>2:00 – 2:15 pm</td>
<td><strong>Impact of storm surge: implications for future development</strong>&lt;br&gt;Mr. Norman Harris and Ms. Georgette D’Aguilar&lt;br&gt;Mines &amp; Geology Division</td>
</tr>
<tr>
<td>2:15 – 2:30</td>
<td><strong>Impact of Hurricanes Dean and Felix on Manatee Bay, St. Catherine</strong>&lt;br&gt;Dr. David Miller¹ and Dr. Andrew Pearson&lt;br&gt;¹Department of Geography &amp; Geology (UWI)</td>
</tr>
<tr>
<td>2:30 – 2:45 pm</td>
<td><strong>Sectoral Damage Analyses of Hurricane Dean - Financial Sector and the Main Road Infrastructure</strong>&lt;br&gt;Dr. Parris Lyew-Ayee and Ms. Karen McIntyre&lt;br&gt;Mona Geoinformatix Ltd</td>
</tr>
<tr>
<td>2:45 – 3:00 pm</td>
<td><strong>Coastal Impact of Hurricane Dean</strong>&lt;br&gt;Mr. Ainsley Henry and Miss. Stacy Moses</td>
</tr>
<tr>
<td>3:00 – 3:15 pm</td>
<td>Damage assessment: A critical Pre and Post disaster impact decision making tool, the case of Hurricane Dean&lt;br&gt;Mrs. Karema Akins-Mitchell&lt;br&gt;Office of Disaster Preparedness and Emergency Management (ODPEM)</td>
</tr>
<tr>
<td>3:15 – 3:45 pm</td>
<td><strong>COFFEE BREAK &amp; POSTER VIEWING</strong></td>
</tr>
<tr>
<td>3:45 – 4:00 pm</td>
<td>Ms. Claire Bernard&lt;br&gt;Planning Institute of Jamaica (PIOJ)</td>
</tr>
<tr>
<td>4:00 – 4:15 pm</td>
<td><strong>Policy Implications of Hurricane Dean</strong>&lt;br&gt;Ms. Kim-Marie Spence&lt;br&gt;Caribbean Policy Research Institute</td>
</tr>
<tr>
<td>4:15 – 4:30 pm</td>
<td><strong>Hurricane Dean - Impacts and Issues in relation to coastal communities: Case of Portland Cottage and its environs</strong>&lt;br&gt;Dr. Balfour Spence and Miss Natainia Lummen&lt;br&gt;Department of Geography &amp; Geology (UWI)</td>
</tr>
<tr>
<td>4:30 – 4:45 pm</td>
<td><strong>Hurricane Dean – The Southwest coast of Jamaica</strong>&lt;br&gt;Ms. Deborah-Ann Rowe (University of Chester)</td>
</tr>
<tr>
<td>4:45 – 5:00 pm</td>
<td><strong>PARTICIPANTS REVIEW</strong></td>
</tr>
</tbody>
</table>
The project is designed to address and provide for improved measures of hazard susceptibility for problems of coastal erosion, which increasingly affects Jamaica’s primary tourist destination, the beaches and coastline, as well as smaller coastal communities. To achieve the objectives we carried out the following activities:

1. Acquisition of historical data
2. Field surveys, including bathymetric surveys
3. Community interaction
4. Preparation of hazard maps

Data acquired included current and old aerial photographs; current and old topographic and other maps; reports from newspapers, journals and as electronic data. These were used to provide qualitative and quantitative data on rates of erosion/accretion and incidence of hazards along selected stretches of the coast.

Historical analysis of the change in position of the coastline, particularly the rate of change, is widely accepted as being the one geoindicator which is most useful in attempting to predict the scale and direction of future erosion events. To this end historical data were used to identify changes in shoreline position and physiography; changes in vegetation; changes in human settlements; changes in road systems.

While it is possible to follow many physical and cultural changes through time using aerial photographs, field visits are needed to carry out ground truthing, or verification of photographic images; update data. Air photos are snapshots of the surface, valid for the moment of acquisition. Even the latest set of photos will not be up to date. For example, the passage of Hurricane Ivan left a trail of destruction, including coastal flooding and landslides, but there was no immediate post-Ivan photographic or satellite cover, to allow a regional assessment of damage. Local air photography has shown samples of the changes that occurred. Field visits also serve to identify specific beach and other coastal characteristics, such as the geology of the bedrock and the composition of the beach sediments. The geology of the bedrock underlying unconsolidated coastal sediments influences the availability and distribution of sediment in the coastal system, and controls the basic shape of the coastline.

Field methods used include geological mapping, constructing and monitoring beach profiles, measuring beach width and beach composition, mapping boulder strews and measuring individual clasts. Bathymetric surveys were carried out where there was no previous data. Knowledge of the shelf morphology is important for modelling the nature
of waves, surge and tsunami impacts on the coast. For example a storm surge can build up water over a broad island shelf if the coastline geometry is such as to inhibit the dispersal of surge water, and where the coast itself is very low-lying, as is the case at Portland Cottage.

Hazard maps, perhaps more properly called inventory maps, serve to highlight those features that might be vulnerable to future hazardous events. Preliminary hazard maps have been prepared for the six communities involved in the study. These were displayed in the poster area. We are asking for your comments, criticisms and suggestions for improvement.

The coastal hazard maps have been prepared as the database for the second main objective of our programme, to develop interaction and training with selected coastal communities, based on site-specific knowledge of the hazards apparent for each community location. The ultimate objective is to provide such maps for the entire coastline of Jamaica, but this would entail extension of the present project.

In defining the coastal hazard zone we used factors depending primarily on physiographic/ geological settings. On the landward side the 7 meter contour was used as a guide to delineate the coastal area at most risk to hazardous events. This area could be affected by rare, extreme storm events. This contour also marks the likely position of sea-level in 200 to 1000 years time, suggested by global warming modeling. Where the coastline is backed by hilly terrain, the boundary enclosing coastal gully systems was used as a guide to focus on those coastal areas most at risk from extreme precipitation events, causing flash flooding and debris flows. The catchment for each gully was defined.

On the seaward side normally the edge of the island shelf was used. As the width and nature of the shelf varies from place to place we undertook bathymetric surveys of the shelf opposite the communities selected for closer interaction. Where the shelf is extensive, as opposite Farquhars Beach, Clarendon, no specific boundary was defined.

The coastline on the 1:12 500 topographic maps was taken as the line of reference for the hazard maps. The historical analysis using aerial photographs may indicate that the coast has changed over time. In those areas where coastline change has occurred a coastline layer for each air photo series is being added as a layer on the base map. As analysis proceeds, distinctive symbols/colours for different kinds of coastline environments will be added.
PROJECT OBJECTIVES AND METHODS

The Marine Geology Unit
Department of Geography & Geology
UWI Mona

The project is designed to address and provide for improved measures of hazard susceptibility for problems of coastal erosion, which increasingly affects Jamaica’s primary tourist destination, the beaches and coastline, as well as smaller coastal communities.
Implementation

To achieve the objectives we carried out the following activities:

- 1. Acquisition of historical data
- 2. Field surveys, including bathymetric surveys
- 3. Community interaction
- 4. Preparation of hazard maps

1. Acquisition of Historical Data

a) Current and old aerial photographs
b) Current and old topographic and other maps
c) Reports from newspapers, journals and as electronic data

These were used to provide qualitative and quantitative data on rates of erosion/ accretion and incidence of hazards along selected stretches of the coast.
**AERIAL PHOTO ACQUISITION**

<table>
<thead>
<tr>
<th>Aerial Surveys</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1941/42 Keystone Aviation</td>
<td>Mines and Geology Division</td>
</tr>
<tr>
<td>1949/53/54 Hunting Aerosurveys</td>
<td>Mines and Geology Division</td>
</tr>
<tr>
<td>1961 Hunting Aerosurveys</td>
<td>Department of Geography and Geology, University of the West</td>
</tr>
<tr>
<td>1968 Spartan Air Services</td>
<td>Indies</td>
</tr>
<tr>
<td>1980 BKS Services Ltd.</td>
<td>Mines and Geology Division</td>
</tr>
<tr>
<td>1991 colour photos CIDA project</td>
<td>NEPA</td>
</tr>
<tr>
<td>2002 IKONOS satellite imagery</td>
<td>Ministry of Land &amp; Environment</td>
</tr>
</tbody>
</table>

**Geoindicators**

Historical analysis of the change in position of the coastline, particularly the rate of change, is widely accepted as being the one geoindicator which is most useful in attempting to predict the scale and direction of future erosion events.
Air Photo Time Series

- Changes in shoreline position and physiography
- Changes in vegetation
- Changes in human settlements
- Changes in road systems

2. Field Visits

Ground Truthing

- While it is possible to follow many physical and cultural changes through time using aerial photographs, field visits are needed to:
  - carry out ground truthing, or verification of photographic images
  - Update data; air photos are snapshots of the surface, valid for the moment of acquisition. Even the latest set of photos will not be up to date.
  - For example, the passage of Hurricane Ivan left a trail of destruction, including coastal flooding and landslides, but there was no immediate post-Ivan photographic or satellite cover, to allow a regional assessment of damage. Local air photography has shown samples of the changes that occurred
53 localities have been visited along Jamaica’s coastline.
Field visits also serve to identify specific beach and other coastal characteristics, such as the geology of the bedrock and the composition of the beach sediments.

The geology of the bedrock underlying unconsolidated coastal sediments influences the availability and distribution of sediment in the coastal system, and controls the basic shape of the coastline.

Field methods

- These include
  - Geological mapping
  - Constructing and monitoring beach profiles
  - Measuring beach width and beach composition
  - Carrying out bathymetric surveys where there is no previous data
  - Mapping boulder strews and measuring individual clasts
Field methods

- These include
  - Geological mapping
  - Constructing and monitoring beach profiles
  - Measuring beach width and beach composition
  - Carrying out bathymetric surveys where there is no previous data
  - Mapping boulder strews and measuring individual clasts
Measuring current direction and velocity using coconuts
Knowledge of the shelf morphology is important for modelling the nature of wave, surge and tsunami impacts on the coast.

A storm surge can build up water over a broad island shelf if the coastal geometry is such as to limit the ejection of surge water and where the local bed geometry will lead to the erosion of Portland Cottages.

Therefore bathymetric surveys were carried out in some areas.
NEARSHORE BATHYMETRY
3. Community Visits

- To augment the data collection and analysis programme through interaction with selected coastal communities.
- To develop and/or improve site-specific, community-based programmes of hazard awareness and mitigation planning.
4. Preparation of Hazard Maps

- Hazard maps, perhaps more properly called inventory maps, serve to highlight those features that might be vulnerable to future hazardous events.
- Preliminary hazard maps have been prepared for the six communities involved in the study.
- These are displayed in the poster area.
- We are asking for your comments, criticisms and suggestions for improvement.

COASTAL HAZARD MAPS

- The coastal hazard maps have been prepared as the database for the second main objective of our programme, to develop interaction and training with selected coastal communities, based on site-specific knowledge of the hazards apparent for each community location.
- The ultimate objective is to provide such maps for the entire coastline of Jamaica, but this would entail extension of the present project.
Defining the Coastal Zone

We used factors depending primarily on physiographic/geological settings.

- On the landward side,
  - the 7 metre contour was used as a guide to delineate the coastal area at most risk to hazardous events.
  - Where the coastline is backed by hilly terrain, the boundary enclosing coastal gully systems was used as a guide to focus on those coastal areas most at risk from extreme precipitation events, causing flash flooding and debris flows.

- On the seaward side,
  - Normally the edge of the island shelf was used. As the width and nature of the shelf varies from place to place we undertook bathymetric surveys of the shelf opposite the communities selected for closer interaction.
  - Where the shelf is extensive, as opposite Farquhars Beach, Clarendon, no specific boundary was defined.

COASTAL DRAINAGE

- Miscellaneous small valleys drain the back coast region. Some valleys may contain intermittent streams while others are normally dry, especially valleys carved into limestone.
- With intense rainfall these valleys discharge storm water into the coastal area (they would not be valleys if this did not happen from time to time).
- Such flows may be very intense, if infrequent, even developing into debris flows, and giving rise to life-threatening situations.
- For this reason all local coastal catchments, as defined by the surface topography, are being delineated on the hazard maps.
THE COASTLINE

- The coastline on the 1:12 500 topographic maps has been taken as the line of reference for the hazard maps.
- The historical analysis using aerial photographs may indicate that the coast has changed over time.
- In those areas where coastline change has occurred a coastline layer for each air photo series is being added as a layer on the base map.
- As analysis proceeds, distinctive symbols/colours for different kinds of coastline environments will be added.

THE YELLOW ZONE

- The area between the coastline and the 25 ft (about 7 m) contour has been emphasised on the hazard maps in yellow.
- The yellow zone marks those areas near the coast that could be affected by unusually large inundations caused by hurricane storm surge or tsunami.
- It also marks the likely future inundation when sea-level rise reaches its expected full height in 200 to 1000 years time.
- Although it is not expected that, normally, such flooding will be frequent or extensive, the yellow zone provides a focus for examining features that may be vulnerable to varying degrees.
Post Presentation Discussion

In the discussion recorded after the presentation the points raised included the fact that every event, i.e. storm surge, high winds etc., leaves a signature on the ground. The imprints related to these events are usually in terms of sediments, boulders, changes in the coastline and it is up to us now how we interpret these changes and how to utilize them. The point was raised that we must have some mechanism or means of collecting the evidence. One method suggested was to review snapshots of the ground for particular instances in time. The BEACHES project has utilized aerial photographs dating back to 1940’s and coming to present time, also remote sensing imagery. Such historical sources are very important to have but recent post event vertical imagery is also needed. It was felt that one of the greatest drawbacks at a national level was the unavailability of recent post event vertical imagery. In the case of the most recent event, Hurricane Dean, acquisition of vertical images is hindered due to the high cost. The multidisciplinary use of such imagery should justify the allocating of funds to obtain such images. The recommended solution was to acquire these images months after the event when the cost was reduced.
The Marine Geology Unit has set out an objective to provide residents with information on the range of possible damages and the disaster prevention activities associated with coastal hazards. By combining geology, geomorphology, coastline change, housing and population, MGU has been able to construct a series of coastal hazard maps which can be used and adapted both for resident education and for administrative and technical information in the mitigation and prevention of disasters. The base map for the hazard map is usually a Jamaica 1:12,500 topographic map, for technical and administrative information and an aerial photograph for more resident educational information. The area below 40m elevation has been defined as the coastal zone by NEPA (Coastal Atlas, XXXX). The area below the 7m elevation has also been outlined and is the MGU limit for storm surge and expected sea level rise within the next 200 – 600 years. Data for storm surge and inundation from previous storms and hurricanes are then analyzed and overlain on the base map along with geology and geomorphology. Critical facilities and communities are then added to outline the hazards which are present and the degree of damage and inundation that can be incurred with future events.

To date, MGU has produced several hazard maps for key communities around the Island and has completed a “Community Hazard Awareness Program.” At the community meetings awareness was achieved through presentations and posters. Key places in each community, such as parish councils, emergency shelters and schools were presented with posters and hazard maps outlining the dangers they face. Brochures were also produced and were handed out to the community; this included a coloured water proof copy of the hazard map, hazards which their community faced and mitigations to help prevent disasters. The 7 communities included were Homers Cove and Little Bay, Farquhars Beach, Wickie Wackie & Copacabana, St Margaret’s Bay, Galina and Annotto Bay. The MGU is dedicated to reducing the effects of coastal hazards and in so doing is producing more hazard maps for other coastal communities for the island of Jamaica.
Impact of Hurricanes & Storms on Jamaica’s Coastline

Coastal Hazard Maps
Design and Applications

The Marine Geology Unit
Mr. Richard Coutou

6th November, 2007

Natural Phenomena and Disasters

• A disaster occurs at the point of contact between social activities and a natural phenomenon of unusual scale.

• Although it is difficult to avoid natural phenomena such as rain, earthquakes and volcanoes, it is essential to understand their behavior and how we can live with them by reducing their impacts and to strengthen our ability to deal with their effects. Thus, we need to take measures for disaster prevention.

• One of the basic solutions to reduce the loss of life and damages is to remove the disaster phenomenon or the point of contact with the social activities. But it is often very difficult and expensive.

• However, it is possible to moderate a phenomenon by taking measures to reducing the effect of a phenomena. For example, construction of levees to prevent flooding and sea walls to prevent coastal erosion.

• Even if the phenomenon does occur, it should not affect social activities.

• Thus, it is important to understand where these phenomena occur and how it affects social activities. This can be done through a hazard inventory and hazard mapping.
Information Necessary for Reducing and Preventing Disasters

What: What kind of phenomenon occurs?

Where: Where does such a phenomenon appear?

When: When does a phenomenon occur or when is it likely to occur? What is the frequency or probability of occurrence?

Who: Who suffers from a disaster?

How: How large is the scale of phenomenon and the how extensive is the damage?

Functions of a Hazard Map

Hazard maps are basically a map showing areas that are affected by a particular hazard such as flooding, landslide or storm surge.

The function of a hazard map is to identify a specific phenomenon and to make it known how this phenomenon may affect social activities.

The hazard maps cannot stop a disastrous phenomenon. But the effective use of hazard maps can decrease the magnitude of a disasters.
Contents of a Hazard Map

- Disaster prevention information is the most important information that should be provided. Mainly, the forecast area of disaster should be included and the past disaster records may be included as needed. In some cases, the map can be divided into both types.

  Inundation areas, areas of erosion, flood prone areas, earthquake prone areas, etc.

- The location of refuges and evacuation routes to be used in case of a disaster and places of refuge can be identified from the hazard map (shelters).

  Shelters, police stations, fire stations, hospitals, health centres, communication installations, airports, etc.

Types of Hazard Maps

- Different types of phenomena:

  Landslide, flood, earthquake, storm surge,

- There are two types of hazard maps:

  (1) Resident-educating type: This type of map has the main objective to inform the residents living within the damage forecast area of the risk of danger. The information on areas of danger or places of safety and the basic knowledge on disaster prevention are given to residents. Therefore, it is important that such information is represented in an understandable form.

  (2) Administrative information type: This type of map is used as the basic materials that the administrative agencies utilize to provide disaster prevention services. These hazard maps can be used to establish a warning system and the evacuation system, as well as evidence for land use regulations. They may also be used in preventive works.
Objective of an MGU Hazard Map

- To provide residents with the information on the range of possible damage and the disaster prevention activities associated with coastal hazards. It is important point to provide residents with clear and understandable information.

Simple Hazard Map for Homers Cove and Little Bay

MGU Coastal Hazard Mapping

- Long term Coastline Change
- Bathymetry
- Geology and Geomorphology
- Historical data
- Sediment

Hazard Map

Recommendations, Mitigation, Planning and Protection
Constructing an

MGU Coastal Hazard Map

Basic Equipment

Theodolite and Measuring Staff
Global Positioning System
Hand-held depth sounder

Software

Microsoft Excel
Gartrip (Garmin)
Google Earth
ArcMap
Canvas (Deneba)

Constructing an

MGU Coastal Hazard Map

A base map is required. As the base map, a topographic map or a photographic map (auto-rectified photos) can be used.

Over-layered with:

- Geological and geomorphological data.
- Historical data of past hazards.
- Results from field research and beach/coastal monitoring.
- Critical Facilities: Police Stations, Fire Stations, Storm Shelters, Communication Installations, etc.
Constructing an

MGU Coastal Hazard Map

Geological and geomorphological data.

Constructing an

MGU Coastal Hazard Map

Historical data of past hazards

Inundation from Hurricane Allen (C. Whitten-Simpson)
Constructing an

MGU Coastal Hazard Map

Results from field research and beach/coastal monitoring

Constructing an

MGU Coastal Hazard Map

Critical Facilities
Constructing an MGU Coastal Hazard Map

Producing a hazard map is not the final goal.
Application of Hazard Maps

- A hazard map is significant only when it is publicly released to residents.
- They can be used by residents in evacuation planning and when their lives are in danger.
- This requires dissemination and education in the use of the hazard maps.
- Hazard maps are not directly related to preventive works, but using hazard maps, it is possible to estimate the cost of damages due to a disaster. Further, hazard maps can be used for the economic evaluation of a preventive work and for Benefit Cost (B/C) analysis.
- As a result, the priority order of preventive works can be determined.

Table 1 – Hazard Mapping in Jamaica

<table>
<thead>
<tr>
<th>Type</th>
<th>Purpose</th>
<th>Coverage</th>
<th>Scale</th>
<th>Date produced</th>
<th>Primary sources</th>
<th>Author</th>
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<tbody>
<tr>
<td>Landslide</td>
<td>To highlight degrees of landslide susceptibility</td>
<td>Rio Minho Watershed, Central</td>
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<td>Main Library, The University of the West Indies [UWI], Mona</td>
<td>McCarper CDMP/USAID</td>
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<td>Landslide</td>
<td>Landslide susceptibility investigation</td>
<td>Upper St. Andrew Area</td>
<td>1:10,000</td>
<td>1992</td>
<td>UWI Mona</td>
<td>Aedan Earle</td>
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<td>Landslide and Flood</td>
<td>Identifying critical hazard areas</td>
<td>Buff Bay-Pencair Watershed</td>
<td>1:25,000</td>
<td>2001</td>
<td>Foresty Department</td>
<td>Russel Maharaj</td>
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<td>Landslide</td>
<td>Provide information for planners, developers, local authorities</td>
<td>Rio Grande Watershed</td>
<td>1:50,000</td>
<td>2001</td>
<td>Mines and Geology Division</td>
<td>N. Harris, S. Miller &amp; I Williams</td>
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<td>Flood</td>
<td>Planning, insurance, disaster mitigation</td>
<td>Rio Firth (Gordon Pen-Hunts Bay)</td>
<td>1:40,000</td>
<td>1994</td>
<td>Water Resources Authority</td>
<td>Herbert Thomas</td>
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<td>Flood</td>
<td>Planning, insurance, disaster mitigation</td>
<td>Hope River</td>
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<td>Water Resources Authority</td>
<td>Herbert Thomas</td>
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<td>Flood</td>
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<td>Yallahs River Valley</td>
<td>1:10,000</td>
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<td>Flood &amp; Landslide</td>
<td>Minimum</td>
<td>Hope River Valley</td>
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<td>1997</td>
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<td>M. Rammelike</td>
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Cedera review: status of hazard maps vulnerability assessments and digital maps in the Caribbean: Jamaica
<table>
<thead>
<tr>
<th>Event Type</th>
<th>Event Description</th>
<th>Area</th>
<th>Duration</th>
<th>Organizing Body</th>
<th>Additional Details</th>
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<tbody>
<tr>
<td>Earthquake</td>
<td>To identify areas prone to earthquake</td>
<td>Kingston Metropolitan Area</td>
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<td>The University of the West Indies, Mona.</td>
<td>Natural Disaster Research Inc., UNI</td>
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<tr>
<td>Flood</td>
<td>To identify evacuation routes &amp; traffic control points for flood-prone areas</td>
<td>Portmore</td>
<td>122,040</td>
<td>Office of Disaster Preparedness and Emergency Management [ODPEN]</td>
<td>Newco Productions Limited</td>
</tr>
<tr>
<td>Flood</td>
<td>Disaster education &amp; emergency</td>
<td>Rio Grande, Portland</td>
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<td>Storm surge</td>
<td>To show wave heights 100 yr return period</td>
<td>Kingston</td>
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<td>Natural Resources Conservation Authority (NRCA)</td>
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<th>Area</th>
<th>Duration</th>
<th>Organizing Body</th>
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<td>Flood and Storm</td>
<td>Preliminary hazard assessment</td>
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<td>O’Hara</td>
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<td>Preliminary hazard assessment</td>
<td>National</td>
<td>From 1,250,00</td>
<td>Mines and Geology Division</td>
<td>O’Hara</td>
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### Hazard map

<table>
<thead>
<tr>
<th>Hazard map</th>
<th>Users</th>
<th>Uses</th>
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</table>
| Landslide Susceptibility Study for the Kingston Metropolitan Area          | ODEP, Mines and Geology, UWI, and National Environmental and Planning Agency (NEPA) | • to identify the possibility of future landslides and landuse constraints  
  • to assess the scale of landslide problems  
  • to plan controls and development regulation. |
| Landslide Susceptibility Map of Upper Rio Grande Watershed                 | Students, researchers and geologists                                    | Educational                                                         |
| Landslide Susceptibility Map of Rio Grande Valley, Portland               | The Planning Institute of Jamaica, ODEP, and Parish Councils          | • development planning, disaster planning coordination and mitigation and the enforcement of laws  
  • disaster management, part of the process of building bridges and road works, and disaster mitigation planning. |
| Rio Cobre Flood Plain Map                                                 | ODEP, National Works Agency and Water Resource Authority               | • disaster management, part of the process of building bridges and road works, and disaster mitigation planning. |
| Hope River Flood Plain Map                                                | ODEP, National Works Agency and Water Resource Authority               | • disaster management, part of the process of building bridges and road works, and disaster mitigation planning. |
| Landslide Susceptibility Map of Rio Grande                               | Planners and the Local Planning Authority                              | Educational and development planning                                |
| Kingston Metropolitan Area Seismic Hazard Zonation hazard map              | Students and planners                                                   | Disaster management                                                 |
| Portmore Evacuation Map                                                   | Developers, planners, and citizens                                     | to increase the awareness disaster preparedness techniques          |
| Rio Grande Flood Plain Map                                                | Water Resources Authority, National Works Agency, the Parish Council and ODEP | • Planning, roads and bridges planning, disaster management and disaster mitigation purposes |
| Rio Minho Floodplain Map                                                  | Water Resources Authority, National Works Agency, the Parish Council and ODEP | • Planning, roads and bridges planning, disaster management and disaster mitigation purposes |
| Flood and Landslide Prone Areas Map                                       | Planners and developers, and geographers                               | Increasing knowledge of flooding, to show areas which are vulnerable to flooding and landslides |
Community-based Coastal Hazard Awareness Programmes

Other uses of these Coastal Hazard Maps

Vulnerability Assessment of the Coastline

Hazard maps are not directly related to preventive works, but using hazard maps, it is possible to estimate the cost of damages due to a disaster. Further, hazard maps can be used for the economic evaluation of a preventive work and for Benefit Cost (B/C) analysis.

As a result, the priority order of preventive works can be determined.

Evidence based Policy (EBP)
EBP is an approach that "helps people make well informed decisions about policies, programmes and projects by putting the best available evidence from research at the heart of policy development and implementation" (Davies, 2004: 3).
Post Presentation Discussion
In the discussion recorded after the presentation the points raised included the fact that one of the main products of this presentation is that the hazard maps are presented in a way to identify hazardous processes related to hurricanes which in this case focuses on the storm surge part largely. Inclusion of the return periods for the events/hazards identified would have been ideal. It was pointed out that hazard maps are dynamic documents and need to be continuously updated or they will become obsolete. Hazard maps should be used to properly site Critical facilities. Suggestions were made to use a photograph as the base for the hazard map to allow for easy identification of buildings. A consensus was reached that hazard maps designed for “popular” use could utilize this approach however for use by technical personnel a topographic base map would be most suited. It was pointed out that this data should be made available to planning and development agencies.
Other points highlighted were the usefulness of the map as it relates to development and planning in key areas such as selection of sites, identification of mitigation measures in place etc. The hazard maps cover small fishing and coastal communities.
Coastline assessment, Documenting Physical features
Prof. Edward Robinson
Marine Geology Unit
Department of Geography and Geology
University of the West Indies

The principal methods available are either laboratory-based or field-based and the main objective is to measure changes in the actual shoreline. The main lab-based method involves analysis of satellite and aerial survey images. By comparing aerial photographs and high resolution satellite imagery of a locality, acquired on different occasions, it is possible to measure beach losses and gains over time. The specific periods of time depend on the dates when successive photos were taken.

Defining the shoreline is very much dependent on image quality, the type of shoreline being investigated and the detail features, particularly of beaches, that enable an accurate assessment to be made. Among these are:

- **The wet/dry line** – the high point on the beach wetted by waves; this is a proxy for the high-water line of any one tidal cycle
- **The swash terminus** – marked by debris washed up to high tide level; also a proxy for the high-water line
- **The berm top** (if there is a berm) may be used to define the high point reached by recent high tides
- **The beach toe** marks the foot of the beach face, where waves break in calm seas. On sheltered carbonate beaches it is commonly well-defined, as at Long Bay Negril. It marks the seaward extent of the beach
- **The vegetation line** is most easily recognized on aerial photos and so easily mapped. However it can be heavily compromised where human activity has cut back the natural vegetation to widen the beach.
- **The beach width** – distance of beach toe to vegetation line where human activity has cut back vegetation it may merely measure an artificially widened beach.
- **The cliff base** on a coast with a cliff but no beach (but on steep to vertical cliffs, the cliff top is more easily identified)
- **Seawalls, riprap etc** on hardened, beachless coasts.

Jamaica’s coastlines can be divided into those with beaches and those that are cliffed. Mangrove-backed coasts may or may not be lined with beaches. Cliffered coastlines may be fronted by beaches, but usually fall off directly into the sea. There are two main kinds of beach. White sand beaches are formed from organic remains derived, usually, from reefs and sea-grass beds to seaward. Black or dark sand and cobble beaches derive their sediments mainly from material brought to the
coast by rivers. Both kinds require a more or less continuously available supply of beach materials.

Natural cycles of beach erosion and accretion occur in Jamaica, as elsewhere. In Jamaica a typical annual cycle is one in which the summer tends to be associated with calm conditions on the north coast, whereas the winter is associated with more active erosive waves, quite often very active if it is a bad season for northers. The opposite set of conditions tends to operate on the south coast, which is relatively sheltered from northers but is more open to the swells, even surges, generated by the Trade Winds.

Longer period trends of both erosion and deposition are also apparent and evaluation of these forms a major part of the Marine Geology Unit’s investigations in the BEACHES project, and in which aerial photo and satellite images prove most useful, as in quantifying the extent of beach erosion at such places as Palisadoes, the Vere coast and at St. Margaret’s Bay. Most significant changes in beach morphology associated with erosion take place during times of bad weather and stormy seas, particularly winter northers and tropical storms or hurricanes, but trends extending over tens, perhaps hundreds of years have been identified.

On rocky or cliffed shorelines the deposition of debris hurled ashore by storms provides an indication of the width of coast that is susceptible to giant wave events and thus should not be developed. The indicators include the absence of debris and vegetation close to the top of a cliffed coast; the presence of debris (sand, cobbles, coral blocks and fragments, large boulders) scattered over the coastal platform, derived from the offshore area, or torn from the cliffs; the presence of one or more debris ridges inland from the shoreline.

Mapping of such deposits demarcates the worst case scenario for potential damage for at least the past 4000 years (the time when sea-level reached more or less its present position after the post-ice age rise). It therefore provides direct evidence of danger zones as a guide for administering setbacks and taking adaptive measures, and provides a useful baseline for implementing integrated coastal management procedures. Additionally, with climate change models predicting further sea-level rise and the possibility of more frequent intense storms, the 4000 year worst-case scenario will become increasingly important as a model for what lies in the future.
DOCUMENTING PHYSICAL FEATURES

The Marine Geology Unit
Department of Geography & Geology
UWI Mona

Some results from activities and visits carried out:

• 1. Using historical data
• 2. Field surveys, including bathymetric surveys
• 3. Community interaction
• 4. Preparation of hazard maps
Some localities visited during the programme

Using Air Photo Time Series

- By comparing aerial photographs and high resolution satellite imagery of a locality, acquired on different occasions, it is possible to measure beach losses and gains over time.

- The specific periods of time depend on the dates when successive photos were taken.
Some Features of Jamaican Beaches

On Aerial Photos, Identifying Shoreline Indicators through Time

- **Wet/dry line** – a proxy for the high-water line
- **Swash terminus** – a proxy for the high-water line
- **Berm top** (if there is a berm)
- **Beach toe** (commonly well-defined on carbonate beaches, e.g. Negril)
- **Vegetation line** (heavily compromised by human activity)
- **Beach width** – distance of beach toe to vegetation line
- **Cliff base** on a coast with a cliff but no beach (but on steep to vertical cliffs, the cliff top is more easily identified)
- **Seawalls, riprap etc** on hardened beachless coasts.
St. Margaret’s Bay
using vegetation line


RIO GRANDE

West bank of Rio Grande estuary

Coast between Rio Grande and groyne beach

CARIBBEAN
SEA

Beach with groynes

500 metres

Example using wet/dry line

Coastline changes at Port Royal between 1961 and 1991.

The greatest loss occurred east of Port Royal with up to 110 m of coastal recession. This was partly balanced by gains along the southeastern shoreline and at the extreme western tip of Palisadoes.
COASTLINE TYPES

- Jamaica’s coastlines can be divided into those with beaches and those that are cliffed.
- Mangrove-backed coasts may or may not be lined with beaches.
- Cliffed coastlines may be fronted by beaches, but usually fall off into deep water.

There are two main kinds of beach:
- White sand beaches are formed from organic remains derived, usually, from reefs to seaward.
- Black or dark sand and cobble beaches derive their sediments from material brought to the coast by rivers.
- Both kinds require a continuously available supply of beach materials.
Some Beach Features

Beach backed by Dunes
Beachrock present in foreshore
Beach backed by mangroves

BEACHROCK EXPOSED AFTER IVAN
EROSION OF VEGETATION LINE

SHORELINE RETREAT
SWASH TERMINUS MARKED BY TRASH
- Beach Erosion - Non-carbonate (siliciclastic) beaches

January 12, 2007

...and April 19, 2007
• In Jamaica a typical annual cycle is one in which the summer tends to be associated with calm conditions on the north coast, whereas the winter is associated with more active erosive waves, quite often very active if it is a bad season for northers.

• The opposite set of conditions tends to operate on the south coast, which is relatively sheltered from northers but is more open to the swells, even surges, generated by the Trade Winds.
• Longer period trends of both erosion and deposition are also apparent
• Evaluation of these forms a part of the Marine Geology Unit’s activities.

• Most significant changes in beach morphology associated with erosion take place during times of bad weather and stormy seas, particularly winter northerners and tropical storms or hurricanes.
A winter Norther, 2004

Hurricane Emily, 2005
COASTS WITH CLIFFS
Cliffed coastlines

Some rock falls occur where cliffs are made of geologically weak materials.

On the other hand some cliffs are made of really solid rock. These may seem to be safe....

...unless they are weakened by extensive development of joints, or undercut by sea caves when sudden collapse may occur...
Cliff recession of 20 metres reported over 40 years

Lateral spreading of soil and mud sediments onto the beach and sea

SOIL SLUMP ONTO BEACH AT ROCKY POINT ST. THOMAS

DECEMBER 2, 2003
Features of many cliffed coastlines

The absence of debris and vegetation in a **barren zone** near the shoreline at Galina Point is a sure indicator of frequent storm impacts. The **green treeless zone** behind the barren zone is less frequently impacted.

Typical geological evidence of major storm or tsunami events on clifftops

- The absence of debris and vegetation near the shoreline of a cliffed coast.

- The presence of debris (sand, cobbles, coral blocks and fragments, large boulders) scattered over the coastal platform, derived from the offshore area, or torn from the cliffs.

- The presence of one or more debris ridges inland from the shoreline.
Geoindicators of Giant Waves

- Very large boulders deposited inland from the shoreline; up to 100 tonnes and up to 180 m inland at Galina
Debris ridge at Discovery Bay

Galina debris ridge
WHAT MAPPING OF THE GEOLOGICAL FEATURES OF CLIFFED COASTS ACHIEVES

- Demarcates worst case damage areas for at least the past 4000 years

- Therefore provides direct evidence of danger zones as a guide for administering setbacks and taking adaptive measures

- Provides useful baseline data for implementation of integrated coastal management procedures

- With climate change models projecting sea-level rise and the likelihood of more frequent intense hurricanes, the 4000-year worst case scenario will be increasingly important as a model for what may lie in the future

HOW DO WE KNOW THAT 4000 YEARS OF EVIDENCE IS THERE?

Constraints on time periods over which debris may accumulate are governed by

- Position of sea level

- Depths of suitable buried deposits

- Cutoff elevation for surface accumulations, beyond which waves do not reach
DEFINING THE CONSTRAINTS ON TIME PERIODS IN JAMAICA OVER WHICH EVIDENCE MAY ACCUMULATE

For surface evidence: We assume that impacts on shore would be much reduced if sea level was 2 m or more lower than present.

For buried evidence: The deepest sub-recent deposits that could include sand layers are at 13 m depth in the Negril Morass.

St. Margaret’s Bay Bathymetry: XL plot of gps depth points and shore control

offshore bathymetry
Part of Annotto Bay Survey

Using ACD Canvas

Bathymetry at St. Margaret’s Bay
The Communities

• These will be the subject of the next presentation

Acknowledgements

• To the Environmental Foundation of Jamaica for funding the programme
• To the current and past personnel of the Marine Geology Unit
• To the members of the project’s Advisory Committee
• To all the persons in the communities who helped in putting together the information for the project
Was this year’s hurricane season unusually active?

Yes, but by no means unique.

- In 1933 fifteen tropical storms and hurricanes traversed the Caribbean, six of them close to Jamaica and one crossing the western part of the island.
- Between 1812 and 1815, and again between 1915 and 1917 four hurricanes seriously affected the island.
Some Features of the Jamaican Island Shelf in areas without significant reefs

- Island Shelf
- Island Slope
- Upper Shoreface
- Lower Shoreface
- Surf zone
- Slope break?
- Wave base
- Shelf edge depth 12 - 30 m
Hazards of our coastline: impacts on coastal communities

Shakira Khan
Marine Geology Unit
UWI, Mona

The data presented was collected by as part of a three year study conducted by members of the Marine Geology Unit entitled Beach Erosion and Coastal Hazards: Ensuring Safety (B.E.A.C.H.E.S) and funded by the Environmental Foundation of Jamaica. The aim of the project was to identify hazards that impact Jamaica’s coastline and measure implemented at both the community and management levels. Specifically the project identified the various storm induced hazards (i.e. flooding, storm surge and damage caused by boulders) that affect six communities; three on the North coast (Galina, Annotto Bay and St. Margaret’s Bay) and three on the South Coast (Homers Cove, Farquhar Beach and Wickie Wackie/Copacabanna). These communities’ represent two different Physical settings; Galina and Homers Cove are situated on an elevated Late Pleistocene limestone platform which is relatively flat at the seaward edge of the platform and backed in several places by vegetated ridges. These platforms form cliffs at the water’s edge, up to 10m above sea level in some places, and lack beaches of any kind. The other four communities; Farquhars Beach, St. Margaret’s Bay, Annotto Bay and Wickie Wackie/Copacabanna are located on narrow strips land fronted by a sandy shoreline and typically backed by swamps and/or mangroves. This difference in physical setting exposes these communities to different types of hazards.

Methodologies
Coastal Hazard identification and mapping of hazards in the selected communities was carried out though field identification, community questionnaires and reviews of historical records. Individual boulders were measure with a tape and positioned by GPS. Extent of maximum inundation the study areas were determined though community interviews, identification of landward extent of storm debris and/or damage and comparison with historical hazard maps if they exist for the areas investigated. Beach position over time was measured over the short term through beach profile monitoring and over the long term using satellite imagery and aerial photographs to map the coastline position. All field data was plotted on the appropriate sheet of the 1:12500 topographic map series of Jamaica.

Findings
Four types of storm induced hazards were identified in these communities. Storm surge was identified as a common hazard at all sites affecting both elevated cliffed coastlines and low lying areas. Common to all areas however beach erosion existed in low lying sand fronted areas while boulder emplacement and transport were the major hazards in cliffed areas. The two elevated cliffed coastlines investigated showed that inundation from storm surge and the landward extent of boulder and debris transport has affected areas up to 500m from the coast. Beach erosion affected the low lying areas fronted by sand. Long term coastline retreat was identified to be occurring along the sections of coastline fronted by sand. Monitoring of the beaches during the life of the project showed that currently beach erosion was cyclical but exacerbated by storms and hurricanes. This however still poses a threat to communities since long term retreat has place homes and businesses in close proximity to the variable zone.
Using this data hazard maps were generated that identified areas affected by storm surge, coastal erosion and mobile boulders. These maps also indicate location of the nearest shelters and evacuation routes. Increased hazard awareness at the community level was facilitated through seminars and presentations of the coastal hazard maps to residents and included mechanisms of formation, extent of impacts of these hazards and suggestions for improve evacuation planning and community development were out discussed.

Ways forward

Coordination with government agencies and stakeholders responsible for ensuring safety in the coastal zone through mitigation, planning and emergency management is required. Informed decisions related to adaptation and/or mitigation strategies can be developed using hazard maps to identify areas affect and through understanding the mechanisms generating these events.

Suggested steps in the way forward:

- Increase public awareness campaigns that explain the effects of coastal hazards on the community
- Revisit evacuation routes and emergency systems and review location of emergency shelters and critical facilities using hazard maps to identify areas not likely to be affected
- Utilize hazard maps in community planning, zoning and planning policy improvement
- Develop long term monitoring and assessment programs
Impacts of Hurricanes on our Coastline

Impacts on coastal communities

Introduction

BEACHES - Beach Erosion And Coastal Hazards: Ensuring Safety began in March 2004 with funding from the Environmental Foundation of Jamaica. The project was designed to identify and assess coastal hazards and the impact of these hazards on coastal communities.

Specifically the project identified the various storm induced hazards (i.e. flooding, storm surge, beach erosion and damage caused by boulders) that affect the communities of Galina and its environs.

The aim is to raise hazard awareness at the community level through interviews, meetings and workshops and to create a hazard map of for each community to be used as a tool for this and future hazard related programs in these communities.
Work done

- Analysis of Air Photographs and Satellite Images to determine coastline position over time.
- Assessment of physical setting and geomorphology of the area.
- Assessment of coastline type - beach monitoring and or characteristics of raised platform.
- Boulder mapping
- Storm surge inundation mapping
- Acquisition of Bathymetric Data
- Meetings with community members for collection of anecdotal evidence.

The Communities

Six communities were selected for more detail study:

- Galina, St. Mary
- Homers Cove, Westmoreland
- Annotto Bay, St. Mary
- Farquhers Beach, Clarendon
- St. Margaret’s Bay, Portland
- Copacabanna to Wickie Wackie coastline, St. Andrew

They represent different physical settings from cliffed to low lying sandy coasts.
Elevation of the platform

Approx. 7m ASL

Boulder on the platform
Mapping of the debris ridge

Identifying the debris ridge
The absence of debris and vegetation in a barren zone near the shoreline at Galina Point is a sure indicator of frequent storm impacts. The green treeless zone behind the barren zone is less frequently impacted.
### Characteristics of the boulders

<table>
<thead>
<tr>
<th>Boulder#</th>
<th>a (m)</th>
<th>b (m)</th>
<th>c (m)</th>
<th>Cuboidal Vol (a<em>b</em>c)</th>
<th>Bipyramidal Vol</th>
<th>Est vol</th>
<th>Est mass</th>
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Total = 180
BOULDER MAPPING WITH GPS

Maps were generated with the data the hazard maps previously presented were built on this basis.
Storm Surge Inundation

The light grey to white areas were swept clean by Hurricane Allen 1980.

POST-HURRICANE ALLEN PHOTO OF GALINA 1980

Inundation from Hurricane Allen 1980 (C. Whitout-Simpson)

Maximum inundation 2.5 km

Source: Mines and Geology Division
OFF SHORE BATHYMETERY

GALINA Hazard map

MAPPING THE EVIDENCE: Light grey is barren zone; yellow and green dots are boulders. Dark line is debris ridge; medium grey is extent of marine flooding from Hurricane Allen.
Community awareness Component

Homers Cove, Westmoreland
Platform at Homers Cove, Westmoreland

Hazards identified
Hazards

Boulders transported inland during Hurricane Ivan
Houses totally destroyed!

Hazards
Community meeting at Homers Cove & Little Bay, Westmoreland

Boulders and other debris identified on the platform

When severe wave events occur (hurricanes or tsunami) blocks of rock can be torn off the cliff face and hurled inland
Copacabana/ Wickie Wackie

Damaged Caused by Hurricane Ivan

Homes destroyed by storm surge at Copacabana 7 Caribbean Terrace during hurricane Ivan.

Photo: J. Tisdale and Bishop
Hurricane Ivan on the palisades

Courtesy of Franklyn McDonald

October 2005

September 2006
Beach Monitoring

Beach Monitoring – Done by beach profiling at specified locations every 2 to 3 months to monitor seasonal changes of the beach profile. Profiles are conducted using a scope and measuring staff.

3 profiles were set up by MGU. 1 in the community of Wickie Wackie and the other at Copacabana.
Long term changes of the coastline at Wickie Wackie and Copacabana shows erosion. Coastlines were for the years 1961, 1981, 2002 and 2007. From the years 1961 to 1981 shows the greatest change, while from 2002 to 2007 the coastline changes are very small.
The bathymetry shows a very narrow shelf off the coast of Wickie Wacky and Copacabana and even narrower shelf south of Caribbean Terrace. This means waves approaching are usually have large amplitudes and are usually very powerful.
Farquhars Beach, Clarendon
Short term beach changes observed at Farquhars beach

January 2006

March 18 2007

Short term beach changes observed at Farquhars beach

January 2007

March 18 2007
Summary profile

Farquhars Beach community meeting
Annotto Bay, St. Mary
Groynes are broken

Coastline North of the town of Annotto Bay, January 2006
Profiles established in September 2005
Storm Waves

August 2005

September 2005

November 2005
November 2005

Sand brought in by Hurricane Ivan Approximately 19 m from sea.
C. Willmott- Simpson Hurricane Allen 1980 storm surge map.

Map Courtesy of Mines & Geology Division

Legend:
- Landward extent of storm surge inundation associated with Hurricane Allen, 1980
- Landward extent of storm surge inundation associated with Hurricane Ivan, 2004
Community-based Coastal Hazard Awareness Programmes

Community Meetings

Annotto Bay

Community-based Coastal Hazard Awareness Programmes

Coastal Hazard Maps

Annotto Bay Coastal Hazard Map
St. Margaret’s Bay, Portland

June 10, 1969

J. Tyndale-Biscoe.

Collapsed house at St. Margaret’s Bay
March 2003.
Where some recovery does take place this is not significant or permanent enough to remove citizens for imminent danger.

November 2004

Jan 2006

June 2006
Profile established across from the Baptist Church

Mobile zone of 19 m

Profile established at Fisherman's Beach

Mobile zone of 11 m
MECHANISMS THAT MIGHT CAUSE BEACH LOSSES AT ST. MARGARET’S BAY

- Wave erosion by passing tropical storms and hurricanes

- Wave erosion by the onset of severe winter northers

- Interference in sediment supply to the beach from Rio Grande sand and gravel mining or due to marina construction at Port Antonio

- Interference in sediment supply for other reasons
Processes involved
Direction of net sediment transport

NW (WINTER) WAVE TRAIN

Beach with groynes in need of repair, March 2003
St. Margaret’s Bay hazard map

Common issues affecting communities
Cliffed comminutes

- Storm Surge
- Boulder Transport

Boulders and other debris identified on the platform

When severe wave events occur (hurricanes or tsunami) blocks of rock can be torn off the cliff face and hurled inland
Beach Front Communities

- Beach erosion
- Coastline retreat
- Storm surge
- Flooding
Storm Surge

House located behind dune crest
Recommendations

• Although we don’t propose to be engineers and know the solution to these problems we are able to identify the physical processes taking place and provide the basis on which technical solutions may be founded.

• However if structural mitigation is the option selected it should be pointed out that these are anthropogenic and by their very nature to not conform to natural processes therefore they must be revisited, maintained and their functionality periodical assessed

• Waves breaking on impromptu sea-wall, March 2003
Structures to Protect Coastal Land and Property

Sea Walls

March 2006
Structures to Protect Coastal Land and Property

**Bulkheads**

- Fill
- Tieback
- Anchor
- Filter cloth
- Weep hole

*Adapted from Cambie 1998*

---

Structures to Protect Coastal Land and Property

**Rock Revetments**

- High water mark
- Armour rocks
- Graded layers
- Filter cloth
- Toe reinforcements

*Adapted from Cambie 1998*
Gabion Channel Stabilization

Tent Bay, Barbados, 1987. Gabions are most successful in slope and river stabilization where they are not affected by wave action.

Slope Stabilization Using Gabions

The stones have to be closely packed in the wire baskets so as to reduce their movement.
Deterioration in Gabion Groynes

- Deteriorated gabion groynes, Speightstown, Barbados, 1980. The gabion baskets have spilled open, spreading the stones over the beach. Seawall behind.

Groynes

- Groynes are often constructed where longshore drift moves sand along the beach. In this example the beach has built up on the updrift side and eroded on the downdrift side.
Effect of a Groyne Field

- Sand eventually moves around the end of each groyne to feed downdrift sections of the beach.
Post Presentation Discussion

In the discussion recorded after the presentation Points were raised about the interconnectivity of hinterland drainage impacting low lying coastal areas and that assessments of coastal zone should also look at impacts to these areas from external pressure.
Characteristics of Hurricane Dean, August 19, 2007, Jamaica Area

CHARACTERISTICS OF HURRICANE DEAN, AUGUST 19, 2007, JAMAICAN AREA  
RAFI AHMAD & PARRIS LYEW-AYEE Jr.

The University of the West Indies at Mona

**Acknowledgement:**
Meteorological Service, Jamaica

Hurricane tracks within 100km of Jamaica
DEAN NEAR JAMAICA: HURRICANE WATCH

• On August 17, 2007, 2100 UTC, the National Meteorological Service of Jamaica issued a Hurricane Watch for Jamaica (Bulletin #3)

• Dean was located near latitude 15.0° North, longitude 64.5° West or some 1290 km (805 miles) east southeast of Morant Point

• The system was moving west at a forward speed of 33 km/h (21 mph).
On August 18 at 1200 UTC, National Hurricane Center classified Dean as a category 4 hurricane located some 920 km (575 miles) east-southeast of Morant Point with hurricane force winds extending outward approximately 95 km (60 miles), while tropical storm force winds extended as far as 335 km (205 miles) from the centre.

National Meteorological Service of Jamaica issued a Hurricane Warning for Jamaica (Bulletin #8), 1500 UTC on Saturday August 18.

At this time Dean was located near latitude 15.7° North, longitude 68 West or about 840 km (525 miles) east southeast of Morant Point.

The system was moving west northwest at a forward speed of 28 km/h (17 mph).
Dean in Jamaican waters

Hazardous Processes

- Wind
- Rainfall
- Landslides: debris Flows and Mud flows
- Storm surge
Wind Speeds: August 20, 2007

CUMULATIVE RAINFALL FROM DEAN:
August 18-20
Rainfall Rate (mm/hr), August 18-20, 2007

Simulation of Surge Impact on Caribbean Terrace pre-Hurricane Dean.
Storm surge at Caribbean Terrace, St Andrew

Section of the Palisadoes Tombolo, view northeast, showing accumulation of storm surge deposits.
Data limitations.
From: National Meteorological Service, Jamaica, 2007

• Data associated with the passage of Dean has been limited due to a number of challenges.

At the Norman Manley International Airport the weather station tower was blown down just after 1800 UTC (1300 local time) on Sunday August 19, which resulted in the loss of data.

Data from the station located at the Pedro Bank was limited due to communication difficulties.

At Folly Point (Portland), August 19, 2.28pm:
The Folly Point automatic weather station is located in north-eastern Portland.

Data recorded at this station recorded a gradual increase in wind speed and the resultant gradual decrease in the atmospheric pressure.

The maximum wind speed recorded were 43.6 knots or 80.7 km/h or 50.1 mph at 1928 UTC (1428 hours local time) on the 19th.

The minimum pressure recorded was at 1000.0 millibars at 2058 UTC and 2128 UTC (i.e. 1558 and 1628 hours local time) respectively

Tropical storm force winds were recorded at Folly Point between 1828 UTC and 2258 UTC (1328 and 1758 hours local time).
At Morant Point (St. Thomas), August 19, 2007:
The Morant Point automatic weather station is located in the parish of St. Thomas at the Morant Point Lighthouse.

- The average one hour winds at Morant Point increased gradually to a maximum of 54.5 knots or 100.8 km/h or 62.7 mph at 1747 UTC (1247 local time).
- There was a corresponding gradual decrease in atmospheric pressure to a minimum of 999.1 millibars at 2047 UTC (1547 local time).
- Tropical storm force winds were experienced at Morant Point between 1647 UTC and 2347 UTC (1147 and 1847 hours local time).

Rainfall intensity recorded at the Norman Manley International Airport

<table>
<thead>
<tr>
<th>Date</th>
<th>5 Min</th>
<th>10 Min</th>
<th>15 Min</th>
<th>30 Min</th>
<th>60 Min</th>
<th>2 Hrs</th>
<th>6 Hrs</th>
<th>12 Hrs</th>
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<td>31.8</td>
<td>49.6</td>
<td>93.6</td>
<td>120.2</td>
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<tr>
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<td>10.4</td>
<td>6.2</td>
<td>7.8</td>
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<td>8.4</td>
<td>8.6</td>
<td>8.6</td>
<td>9.8</td>
<td>16</td>
</tr>
<tr>
<td>21</td>
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<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
## Rainfall Data for some selected stations along the south coast:

Ingleside in Manchester reported the maximum 24 hour rainfall of 342.9 mm and this was followed by amounts of 256 mm recorded at the Sugar Industry Research Institute (S.I.R.I.) station also in Manchester. This amount represents 183% of the normal rainfall expected for that station for the month of August.

In St. Thomas, the amount rainfall recorded over the 2 days period August 19 and 20 for Morant Bay was 331.5 mm or 217% of the normal expected for that station for the month of August.

Norris followed with 24 hour rainfall amounts of 210 mm on the 19th.
Other stations reporting in excess of 100% of normal rainfall during the passage of Dean are:

In St. Catherine the Bernard lodge stations (Blair Pen 251% and Phoenix Park 211%) reported in excess of 200% of normal rainfall expected for the month of August.

In Kingston & St. Andrew; Norman Manley International Airport (130.2 mm or 161% of the normal for August),
In Clarendon; New Yarmouth 158% and Monymusk 117% of the normal rainfall amounts expected for those stations respectively for the month of August.

The maximum 24 hour rainfall amounts associated with the passage of Hurricane Dean was 133.4 mm.

At the Norman Manley International Airport the analysis of rainfall intensities associated with the passage of Hurricane Dean indicate the following:
Maximum 15 minutes rainfall was 12.6 mm,
• 30 minutes was 19.4 mm,
• 1 hour rainfall was 31.8 mm,
• 2 hour was 49.6 mm,
• 6 hour maximum of 93.6 mm and
• 12 hour accumulated maximum of 120.2 mm.
In general there was no significant flooding associated with the passage of Hurricane Dean and this may well be attributed to the fact that Dean was traveling quite quickly as the eye moved offshore the south coast.

Some level of flooding was, however, reported in eastern parishes which had possible saturated ground conditions resulting from heavy rainfall the previous week.
Meteorological Service, Jamaica
Pressure and Wind Data associated with the passage of Dean observed at Morant Point August 18-19, 2007
Date / Time (GMT-5) / Pressure (mb) / Wind speed (knots) / Wind speed (mph) / Wind speed (kmph)

- 18-Aug-07 22:47 1010.9 27.6 31.7 51.1
- 19-Aug-07 5:47 1007.1 23.2 26.7 42.9
- 19-Aug-07 10:47 1006.1 26 29.9 48.1
- 19-Aug-07 11:47 1004.7 33.6 38.6 62.2
- 19-Aug-07 12:47 1002.9 54.5 62.7 100.8
- 19-Aug-07 13:47 1000.6 53.6 61.6 99.2
- 19-Aug-07 14:47 999.4 44.2 50.8 81.8
- 19-Aug-07 15:47 999.1 48.8 56.1 90.3
- 19-Aug-07 16:47 1002.7 39.4 45.3 72.9
- 19-Aug-07 17:47 1004.4 40.3 46.3 74.6
- 19-Aug-07 18:47 1006.4 34.1 39.2 63.1
- 19-Aug-07 19:47 1007.7 21.5 24.7 39.8
- 19-Aug-07 20:47 1009.1 16 18.4 29.6
- 19-Aug-07 21:47 1009.8 24.3 27.9 45.0
- 19-Aug-07 22:47 1010.2 26.6 30.6 49.2

Thank You
Post Presentation Discussion

This presentation emphasizes the point that dissemination of information during hazardous events is critical. It highlights the importance of sharing information and working together, so that the information base that is present in one place is enriched by the information base that is present somewhere else.

The presentation also illustrated the use of the models to facilitate informed decisions through these predictions. It was felt that such an approach should be utilized by emergency and rescue agencies as this kind of approach would facilitate quick responses. Use of models based on this we should look into development of models for quick assistance, so that when people want to put up buildings they can get predictions as to what the consequences will be and develop mitigation measures if applicable.
OFFSHORE SAND AND GRAVEL: THE POSSIBILITIES

Physiographically the marine area around Jamaica can be divided into three main zones.

- the shallow shelves
- the island and bank slopes
- the deep sea areas.

The shelves and banks extend from the shoreline, if present, and terminate abruptly at depths of around 12 to 40 m. Reefs may be developed as more or less continuous systems, as on the north coast, or as patch reefs along the south coast. The island shelf is blanketed with mainly carbonate sand or mud, except where rivers drain from the interior, when fluvially derived, siliciclastic sediments may be dominant. In some places, such as at Long Bay, Negril, sediment cover may be sparse or absent, with bedrock at the surface. On the offshore banks, only carbonate sediments occur, diluted minimally by dust from volcanic eruptions, the Sahara desert, and space.

The transition from shelf to deep sea is abrupt, the resulting slopes being steep. Topographically the slopes are steep enough in places, that sediments fail to accumulate and the older bedrock is exposed at the surface, as north of Discovery Bay, where Miocene limestone outcrops. The slopes are extensively gullied. The gullies, or submarine valleys, act as drains, transporting fluvially-derived siliciclastic and biogenic carbonate sediments from the shallow shelves down to the deep sea floor. Local accumulations on these slopes may become unstable, and collapse, causing submarine slides, perhaps large enough, in some cases, to generate earthquakes and tsunamis.

The deep sea floor of Jamaica's Exclusive Economic Zone consists of an assemblage of basins and rises of various kinds. It is an area dominated by sediment accumulation, although there are regions where strong, deep sea currents keep the sea floor swept clean of sediment, and winnow out the fines. The main sediment sources are the material derived from the shallow shelves and rivers, deposited as broad fans between the topographic highs; the steady rain of pelagic sediment, consisting of tiny shells from minute animals and plants swimming or drifting in the waters of the ocean surface.

Early in 2004 surveys was carried out by diving and grab sampling of the bottom sediments on the south island shelf in the vicinity of Brune Bank to examine possible large sand dunes showing up on satellite images. Samples were collected from the bank and its flanks, and one or two samples were also obtained during the voyage back to shore. The characteristics of the samples are summarized here:
• mean grain size sorting
• sample phi units $\sigma$, descriptive

Samples of carbonate material

• grab 1 -0.54 (very coarse) 1.20 poorly sorted
• channel 7 -0.33 0.52 moderately well sorted
• dive 7 0.00 (coarse) 0.89 moderately sorted
• dive 1 0.32 1.23 poorly sorted
• dive 3 0.79 0.89 moderately sorted
• dive 2 0.85 1.13 poorly sorted
• grab 2 0.98 1.11 poorly sorted
• grab 3 1.20 (medium) 0.52 moderately well sorted
• grab 5 1.37 0.90 moderately sorted
• grab 6 1.53 0.82 moderately sorted

Samples of mixed carbonate and siliciclastic material

• grab 8 1.97 0.48 well sorted
• grab 9 2.12 (fine) 0.49 well sorted

These grain-size characteristics indicate possible commercial use, e.g. for beach nourishment and construction.

Sediments shed from the bank form a relatively extensive apron (at least 20 km$^2$), dominated by carbonate sand. On the bank itself coral and algal growth covered much of the terrain, with sand channels in between the coral growth. Assuming a very conservative thickness of one meter for the carbonate sand in the apron deposits, the volume available in the immediate vicinity of Brune Bank is of the order of twenty million m$^3$. There are several areas of the sea floor on adjacent parts of the shelf that show dune-like features, covering an area of some 150 km$^2$ indicated from satellite imagery, suggesting reserves of at least 150 million m$^3$. 
OFFSHORE SAND AND GRAVEL

The Possibilities

By

The Marine Geology Unit

JAMAICA'S EXCLUSIVE ECONOMIC ZONE (JEEZ)
Boundary provisional, subject to ratification
PHYSIOGRAPHY OF THE JEEZ

PHYSIOGRAPHICALLY THE MARINE AREA CAN BE DIVIDED INTO THREE MAIN ZONES.

- THE SHALLOW SHELVES
- THE ISLAND AND BANK SLOPES
- THE DEEP SEA AREAS.

ISLAND SHELF AND BANKS

- THE SHELVES AND BANKS EXTEND FROM THE SHORELINE, IF PRESENT, AND TERMINATE ABRUPTLY AT DEPTHS OF AROUND 15 TO 40 M.

- REEFS MAY BE DEVELOPED AS MORE OR LESS CONTINUOUS SYSTEMS, AS ON THE NORTH COAST, OR AS PATCH REEFS ALONG THE SOUTH COAST.

- THE ISLAND SHELF IS BLANKETED WITH MAINLY CARBONATE SAND OR MUD, EXCEPT WHERE RIVERS DRAIN FROM THE INTERIOR, WHEN FLUVIALLY DERIVED, SILICICLASTIC SEDIMENTS MAY BE DOMINANT.

- IN SOME PLACES, SUCH AS AT LONG BAY, NEGRIL, SEDIMENT COVER MAY BE SPARSE OR ABSENT, WITH BEDROCK AT THE SURFACE.

- ON THE OFFSHORE BANKS, ONLY CARBONATE SEDIMENTS OCCUR, DILUTED MINIMALLY BY DUST FROM VOLCANIC ERUPTIONS, THE SAHARA DESERT, AND SPACE.
THE ISLAND AND BANK SLOPES

- The transition from shelf to deep sea is abrupt, the resulting slopes being steep, many of the order of 30° or more.

- Topographically the slopes are steep enough in places, that sediments fail to accumulate and the older bedrock is exposed at the surface, as north of Discovery Bay, where Miocene limestone outcrops.

- Where bathymetric surveys have been detailed enough it is seen that the slopes are extensively gullied.

- The gullies, or submarine valleys, act as drains, transporting fluviolally-derived siliciclastic and biogenic carbonate sediments from the shallow shelves down to the deep sea floor.

- Local accumulations on these slopes may become unstable, and collapse, causing submarine slides, perhaps large enough, in some cases, to generate earthquakes and tsunamis.

THE DEEP SEA FLOOR

- An assemblage of basins and rises of various kinds, it is an area dominated by sediment accumulation, although there are regions where strong, deep sea currents keep the sea floor swept clean of sediment, and winnow out the fines.

- The main sediment sources are:
  - The material derived from the shallow shelves and rivers, brought down across the slopes, and deposited as broad fans between the topographic highs.
  - The steady rain of pelagic sediment, consisting of tiny shells from minute animals and plants swimming or drifting in the waters of the ocean surface.
  - On bathymetric maps the turbidite-covered areas show up as more or less flat plains. The intervening rises are usually covered by ocean-sourced (pelagic) sediment, or by outcrops of bedrock. These features are largely fault-controlled.
SOUTH ISLAND SHELF AND BRUNE BANK

POSSIBLE OFFSHORE SAND DEPOSITS

SATELLITE IMAGERY REVEALS THAT AT LEAST PART OF THIS REGION DISPLAYS DUNE-LIKE OR SAND WAVE-LIKE TOPOGRAPHY (early 1990s image)
THE 12 METRE "UNREEL"
DIVING FOR SAND

GRAB SAMPLING
MARINE SURVEY AT BRUNE BANK 2004

Brune Bank position from gps survey
Drume Bank (old chart position)

Red spots, sample stations; depths in metres
BRUNE BANK SAMPLES RANKED FOR MEAN GRAIN SIZE AND SORTING

<table>
<thead>
<tr>
<th>Sample</th>
<th>phi units</th>
<th>$\sigma_1$</th>
<th>Descriptive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grab 1</td>
<td>-0.54 (very coarse)</td>
<td>1.20</td>
<td>poorly sorted</td>
</tr>
<tr>
<td>Channel 7</td>
<td>-0.33</td>
<td>0.52</td>
<td>moderately well sorted</td>
</tr>
<tr>
<td>Dive 7</td>
<td>0.00 (coarse)</td>
<td>0.89</td>
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</tbody>
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Samples of mixed carbonate and siliciclastic material

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<tbody>
<tr>
<td>Grab 8</td>
<td>1.97</td>
<td>0.46</td>
<td>well sorted</td>
</tr>
<tr>
<td>Grab 9</td>
<td>2.12 (fine)</td>
<td>0.49</td>
<td>well sorted</td>
</tr>
</tbody>
</table>
SEDIMENT QUANTITIES POTENTIALLY AVAILABLE

Sediments shed from the bank form a relatively extensive apron (at least 20 km$^2$), dominated by carbonate sand.

• On the bank itself coral and algal growth covered much of the terrain, with sand channels in between the coral growth.

• Assuming a very conservative thickness of one metre for the carbonate sand in the apron deposits, the volume available in the immediate vicinity of Brune Bank is of the order of twenty million m$^3$.

• There are several areas of the sea floor on adjacent parts of the shelf that show dune-like features, covering an area of some 150 km$^2$ indicated from satellite imagery, suggesting reserves of at least 150 million m$^3$.

• Grain-size characteristics indicate possible commercial use, e.g. for beach nourishment and construction
ACKNOWLEDGEMENTS

• The original survey was funded and carried out under contract 03/09/433 – PL480 with the Environmental Foundation of Jamaica.

• Participating scientists included personnel from NEPA, CMS, Mines & Geology and MGU.

• Thanks are due to Roy Lankester and his crew for providing the boat and making the trip a success, and to Graeme Fulton for arranging the visit.

• The underwater pictures were taken by Peter Edwards.

• Xavier Moonan assisted with sample preparation.
REFERENCES


Post Presentation Discussion

The availability of offshore deposits is of great economic importance. The erosion of north coast beaches has placed a demand on sand for beach nourishment programs. However the location of this deposit off the south coast was felt to be too far to be used for project on the north coast. Research of this kind is needed off the north coast to identify source areas for the estimated 200 thousand to 300 thousand cubic meters a year to meet the needs of the expanding beach front hotel industry. Such a demand will probably place stresses on the offshore ecosystem and recommendations that deposits be identified and mapped and licensing of these blocks or more sustainable reaping of these blocks be approved for nourishment the projects.