CARIBBEAN Safe School Initiative CSSI

IMPLEMENTATION OF THE MODEL SAFE SCHOOL PROGRAMME IN THE CARIBBEAN

HAZARD RISK ASSESSMENT REPORT AND COSTED ACTION PLAN

ELLERSLIE SCHOOL
BARBADOS

NDRM Natural Disaster Risk Management in the CARIFORUM

An initiative of the African, Caribbean and Pacific Group, funded by the European Union, and implemented by:

CDEMA Caribbean Disaster Emergency Management Agency

SUBMITTED BY:
Environmental Solutions Limited

TO:
The Caribbean Disaster Emergency Management Agency Coordinating Unit

Hazard Risk Assessment Report and Costed Action Plan – Ellerslie School, Barbados for the Consultancy to Develop National Safe School Policies, Assess School Vulnerability to Hazards and Develop School Costed Action Plans in Six Borrowing Member Countries

CARIBBEAN DISASTER EMERGENCY MANAGEMENT AGENCY COORDINATING UNIT
Resilience Way, Lower Estate
St. Michael
Barbados, W.I.

REPORT PREPARED BY ENVIRONMENTAL SOLUTIONS LIMITED

ENVIRONMENTAL SOLUTIONS LIMITED
7 Hillview Avenue
Kingston 10, Jamaica, W.I
Tel : (876) 978-9519, 978-6297, 978-5902
Fax : (876) 946-3745
E-Mail : envirsol@cwjamaica.com
Website : www.eslcaribbean.com

Original Submission Date: November 12, 2019
Revision Date: June 22, 2020

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

Environmental Solutions Ltd. (ESL) has been contracted by the Caribbean Disaster Emergency Management Agency (CDEMA) to develop/enhance National Safe School Polices in four Borrowing Member Countries (BMCs), conduct hazard assessments of 33 schools across six BMCs, and prepare costed action plans for each of the schools based on the results of the assessments.

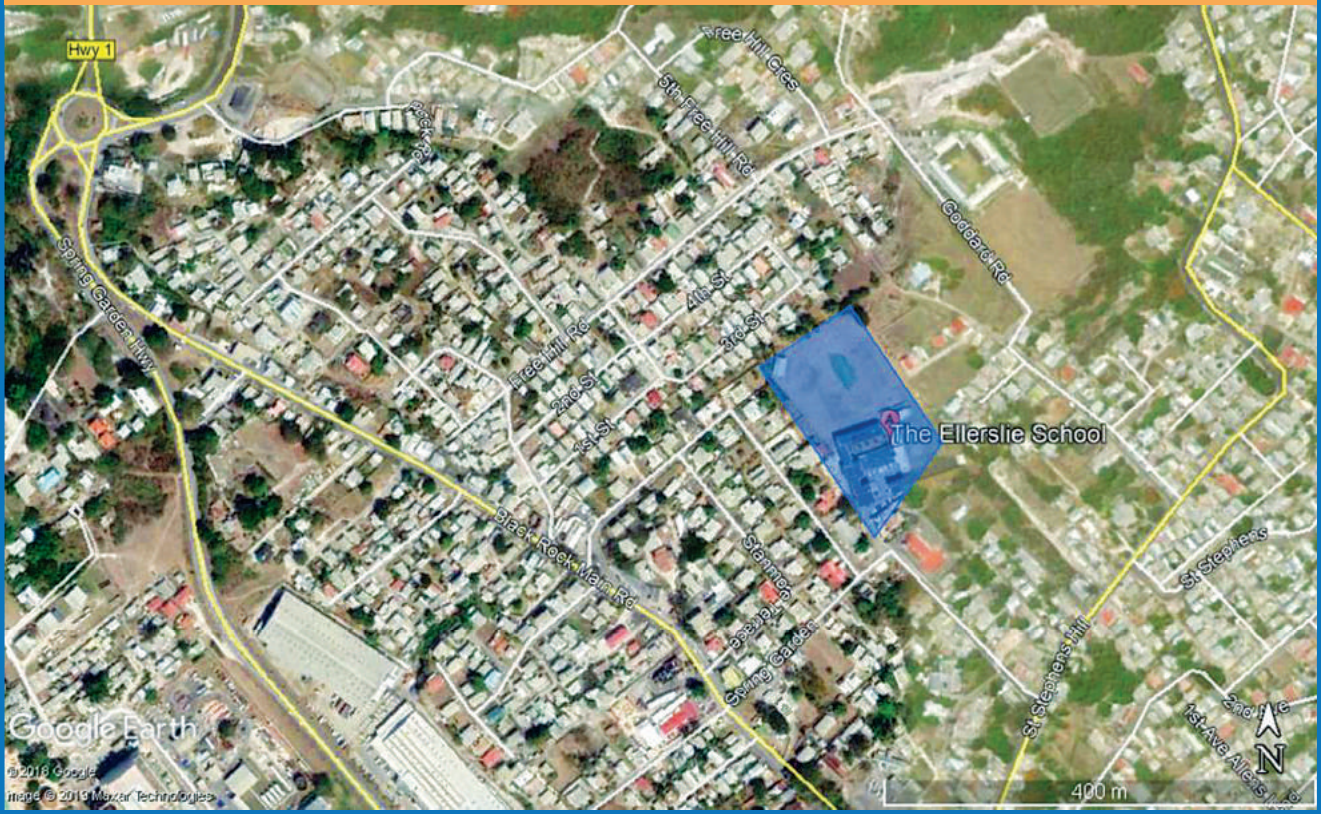
This document presents the Hazard Risk Assessment Report and Costed Action Plan for one (1) school in Barbados. The report has been divided into six main sections. Section 1 describes the method and approach the consultants used to undertake the assessment. Section 2 outlines the Country Risk Profile which presents the natural hazards that the country is exposed to which may impact the school. Sections 3 to 6 summarize the vulnerability assessment of the identified hazards and Section 7 presents the proposed recommendations. The results of the school safety and green assessments are presented in the Appendices.

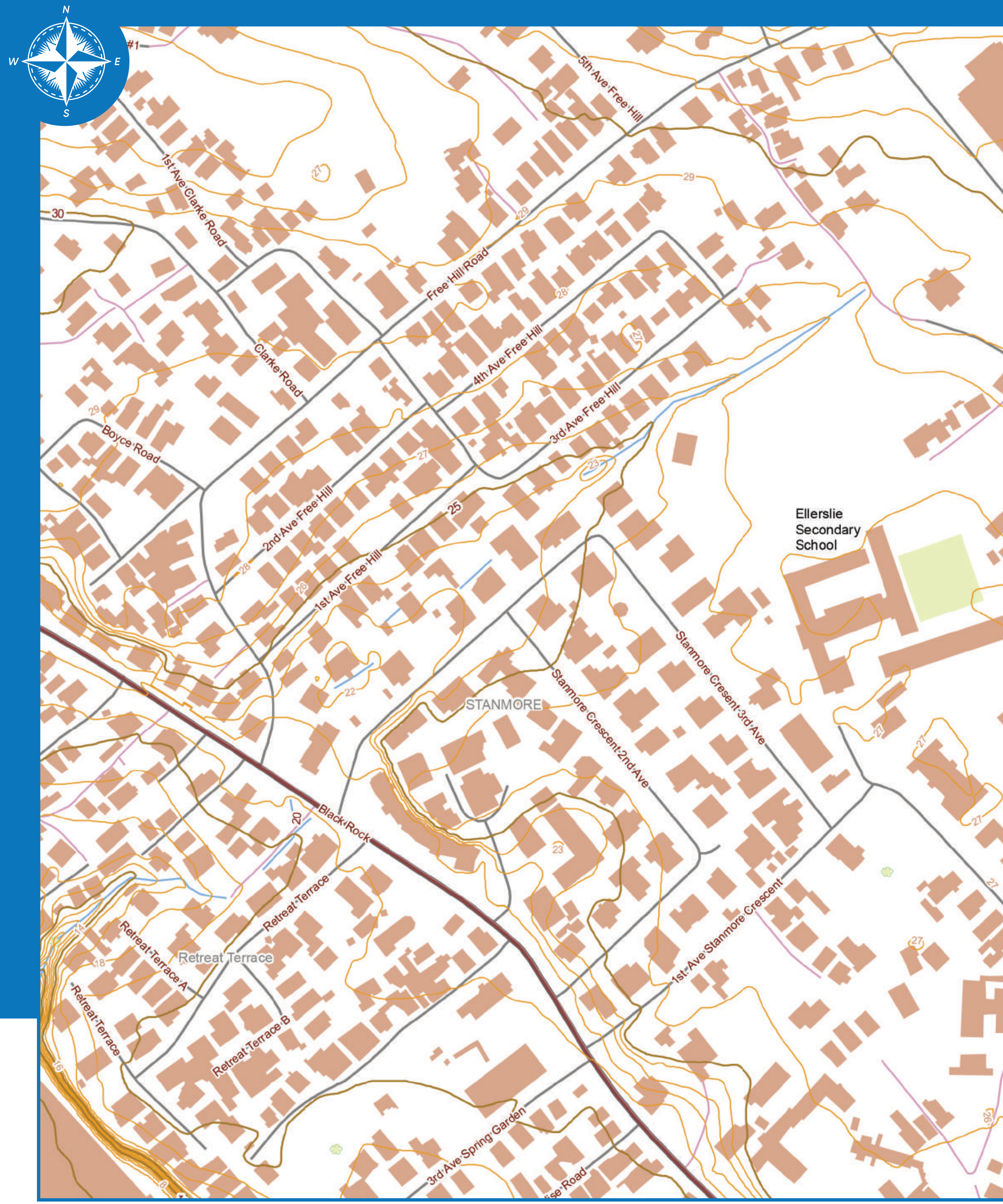
The assessments were conducted on May 21 and 24, 2019 (regular school days) at the Ellerslie School in the parish of St. Michael, Barbados (Figure 1-1). The school is located on the west coast, in the capital city of Bridgetown, one of the country's four major urban centres. The school is found in the community of Black Rock, which is largely residential, and in close proximity to the Spring Garden Highway (Figure 1-2).

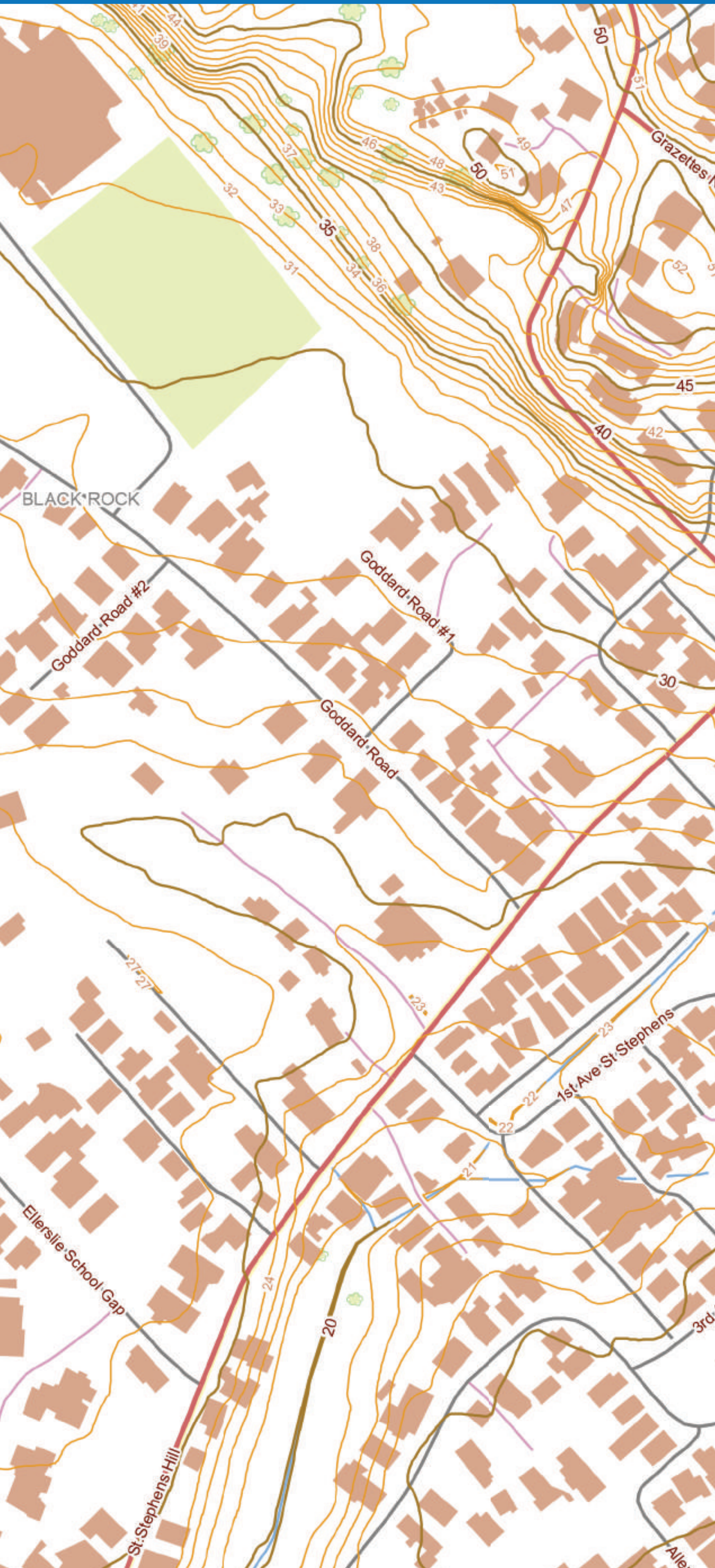
The Ellerslie School is a designated emergency shelter that may be used during a hurricane or other hazard event. Additional general information on the school can be found in Appendix 10.1, Table 10-1. The scores for the school based on the MSSP Assessment Toolkit Checklists can be found in Appendix 10.1.

FIGURE 1.1: LOCATION OF ELLERSLIE SCHOOL IN BARBADOS (SOURCE: GOOGLE EARTH 2019)

FIGURE 1.2: LOCATION OF ELLERSLIE SCHOOL IN BARBADOS. AERIAL IMAGE SHOWING SURROUNDING ROAD NETWORK




N
S
E
W
1st Ave Clarke Road
Clarke Road
5th Ave Free Hill
Free Hill Road
4th Ave Free Hill
3rd Ave Free Hill
2nd Ave Free Hill
1st Ave Free Hill
Boyce Road
Ellerslie Secondary School
STANMORE
Stanmore Crescent 2nd Ave
Stanmore Crescent 3rd Ave
1st Ave Stanmore Crescent
Black Rock
Retreat Terrace
Retreat Terrace A
Retreat Terrace B
3rd Ave Spring Garden



ELLERSLIE SCHOOL

Extract from the Topographical Map of
BARBADOS

Scale: 1:2,500

Legend

- Road (main, class 1)
- Road (secondary, class 2)
- Track (other road, class 3)
- Footpath
- Named Building
- Other Building
- Trees
- Trees & Bush
- Recreational
- Sand
- Cultivation
- Sugar
- 100 Index Contour (V.I. 1m)
- Rock
- Tower
- Windmill
- Quarry
- Pond
- Well/Sink Hole
- Stream
- Cliff Or Steep Slope
- Parish
- 100m S25 100m Bench mark, Trig station
  Height in metres — Station Height in metres

Metres: 0 25 50 75 100 125
Feet: 0 100 200 300 400

Published by the Lands and Surveys Department
Ground Floor East Wing
Warrens Office Complex
Warrens, St. Michael
Tel: [246] 310 2000
Lsdept@barbados.gov.bb

1.1 PURPOSE

The Model Safe School Programme (MSSP) Toolkit states that "in a region that is prone to various hazards, many schools may be located in hazardous locations. Wherever possible, Hazard and Vulnerability Assessments should be performed for schools to guide the inclusion of preparedness and mitigation measures in the design, construction and operational phases. Disaster and emergency planning should be founded on a thorough understanding of the specific hazards faced by the education sector in general and at the individual institutions."

The purpose of this hazard risk assessment report is to identify and analyse the hazard vulnerability of the **Ellerslie School** in Black Rock, Barbados and to make recommendations to inform decision-making.

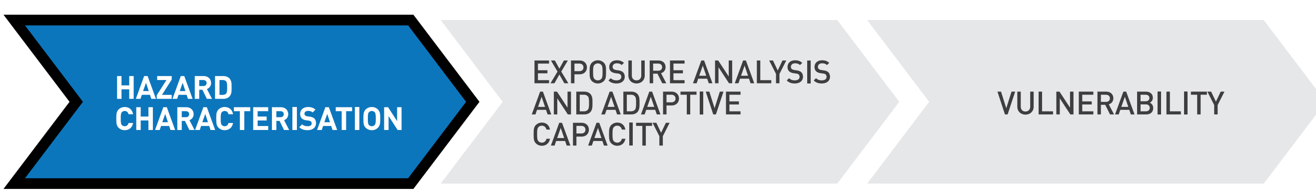
1.2 METHODOLOGY

The vulnerability assessment tool (VAT) used draws on the methodology developed by the National Oceanic and Atmospheric Association (NOAA). Some adaptations were made to consider the local situation as well as data quality and availability.

1.2.1 HAZARD RISK ASSESSMENT

The consultants undertook the hazard risk assessments through a 3-step process elaborated below.

1.2.1.1 STEP 1 - CHARACTERIZING HAZARDS

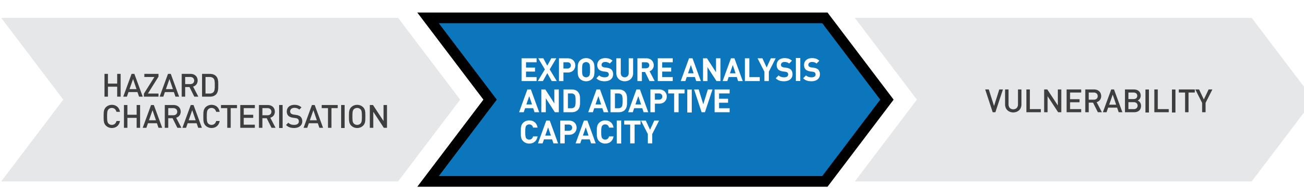


The first step involved the identification of the hazards (hydro-meteorological, geological, etc.) to which each of the countries, and by extension each school, may be exposed. To characterise hazards for each country, the Consultants conducted comprehensive desk research and stakeholder consultations with key agencies and various stakeholder groups to acquire the necessary information, which included but was not limited to:

- Existing spatial data from local and regional Geographic Information Systems (GIS) databases e.g. Caribbean Risk Information System, CHARIM Handbook & Geo-node, PITCA, CARDIN etc.
- Multi-hazard maps, including:
  - Wind and cyclone hazard maps
  - Seismic zoning
  - Flood hazard maps
- Location of critical infrastructure and supporting infrastructure
- Historical and projected information on hazards for each country
- Damage history of each institution
- Previously conducted studies or country reports

Site visits were also conducted to the respective schools. These visits focused primarily on collecting physical infrastructure data and assessing the vulnerability of the facilities as they relate to the various hazards.

1.2.1.2 STEP 2 - EXPOSURE ANALYSIS AND ADAPTIVE CAPACITY



EXPOSURE ANALYSIS

Exposure analysis involved accessing various databases, including geospatial mapping using GIS, to identify the hazards to which the schools were exposed, as well as site assessments and discussions with stakeholders to ascertain history of hazard events. Mapping hazard exposure vulnerabilities enables stakeholders to visualize individual hazardous settings and identify cumulative hazard scenarios. This mapping also provides an effective tool to anticipate, plan and manage resources effectively in advance of these hazards. This geospatial framework is the foundation of the vulnerability assessment process.

The Consultants used the assessment tools from the MSSP toolkit to gather relevant information to help to inform exposure.

ADAPTIVE CAPACITY ASSESSMENT

The adaptive capacity for each school was determined by examining the characteristics that influence the school's capacity to prepare for, respond to and recover from hazards and disasters. The interaction between natural processes and the built environment is intrinsically linked, and it is the adaptive capacity that determines the risks and burdens created by hazards.

Some of the major factors assessed that influence adaptive capacity included:

- Are the proposed systems associated with each asset/facility designed to anticipate a hazard, cope with it, resist it and recover from its impact?
- Conversely, are there barriers to the ability to anticipate, cope, resist or recover?
- Are the systems associated with the school's assets/facilities already stressed in ways that will limit their capacity to anticipate, cope, resist or recover?
- Is the rate of impact from hazards likely to be faster than the adaptability of the systems?
- Are there efforts already underway to address impacts of hazards of interest related to the school's assets/facilities?

These variables outlined above were adopted for this project along with other indices. A systematic examination of building elements (as elaborated below), facilities, population and other components was carried out to identify features that are susceptible to damage from the effects of specific hazards. A qualitative scoring method was developed to determine the vulnerability of specific structures, exposed population and selected geographic areas. This data was analysed and used to prioritize mitigation activities and to guide disaster risk management within the schools.

The Consultants conducted targeted interviews with school administrators and students during the site visit to identify gaps and needs for each school (institutional framework, physical infrastructure, human and financial resources). During the adaptive capacity analysis, the Consultants used the MSSP toolkit to identify gaps, needs and recommendations for capacity building measures and other interventions. Additionally, the Consultants provided a qualitative summary for each school.

Building Condition Assessment Methodology

The structural condition assessment was limited to visual observations and included both non-structural and structural-related issues. No finishes were removed to reveal hidden conditions, and no material or load tests were conducted to ascertain the structural capacity of the buildings' components. Moreover, the survey was limited to cursory inspection of electrical and mechanical systems such as ventilation, water services, plumbing and sewer utilities; egress, fire-suppression, or fire rating of the building components.

As such, any comments offered regarding concealed construction are the professional opinions of the Consultants based on analyses, and our joint engineering experience and judgment, and are derived in accordance with the standard of care and practice for evaluations of building structures.

The following standard conditions assessment definitions were used in describing the general state of the elements.

Good condition:

- It is intact, structurally sound and performing its intended purpose.
- There are a few or no cosmetic imperfections.
- It needs no repairs and only minor or routine maintenance.

Fair condition:

- There are early signs of wear, failure or deterioration, although the feature or element is generally structurally sound and performing its intended purpose.
- There is failure of a sub-component of the feature or element.
- Replacement of up to 25% of the feature or element is required.
- Replacement of a defective sub-component of the feature or element is required.

Poor condition:

- It is no longer performing its intended purpose.
- It is missing.
- It shows signs of imminent failure or breakdown.
- Deterioration or damage affects more than 25% of the feature or element and cannot be adjusted or repaired.
- It requires major repair or replacement.

The above was used qualitatively in conjunction with CDEMA's Enhanced Building Condition Assessment Tool (EBCAT) and the findings are contained in Section 5.1.

1.2.1.3 STEP 3 - VULNERABILITY ASSESSMENT

The data and information collected from Step 1 (Hazard Characterisation) and Step 2 (Exposure Analysis and Adaptive Capacity) were combined to determine how and where each school is vulnerable to hazards using the following formula:

HAZARD EXPOSURE + ADAPTIVE CAPACITY = VULNERABILITY

1.3 LIMITATIONS

This assessment represents a one-day snapshot of the school that may or may not be the total depiction of what occurs daily. The team based its findings on the data provided and individual observations made during this one- day time frame. Please be mindful that this assessment is not binding but is merely an independent review to assist school officials in their quest to examine practices and procedures to better serve their student population. It is therefore incumbent upon the Ministry of Education, education officers and school staff to consider the report and determine what they believe is legitimate and critical to address when considering school safety management issues.

Comments in this report are intended to be representative of observed conditions. The consultants have made every effort to reasonably inspect and analyze the main structural components as well the non-structural components which form part of the building envelope. If there are perceived omissions or misstatements in this report regarding the observations made, we ask that they be brought to our attention as soon as possible so that we can address them fully and in a timely manner.

2. COUNTRY RISK PROFILE / SITUATIONAL CONTEXT

Barbados is the most easterly island of the Lesser Antilles with the Atlantic Ocean at its eastern border, located at 13°10' N 59°32' W, 160km to the east of the Windward Islands archipelago, neighbouring St Vincent and the Grenadines and Saint Lucia. It is relatively flat, with soft slopes in the central highland region; the highest elevation is Mount Hillaby, in the Scotland District, 336m above sea level. The island is 32km long and 23km across, with a total area of 432km^2, a coastline that is 92km long and an exclusive economic zone (EEZ) of 167,000km^2.

Of the islands in the Lesser Antilles, Barbados is the only country not formed by volcanic rocks. Approximately 96% of the island is characterized by terraced karst landscape with deeply fractured and gullied limestone up to 100m thick. For this reason, there are numerous gullies present underlain by a complex system of underground caves. Other sedimentary rocks i.e. shales, clays, sandstones and some volcanic ash, Joe's River muds, saline soils and oil deposits, complement the karst limestone geology in highly folded, faulted and unstable layers. Barbados has mainly residual soils, including clays, which are rich in lime and phosphates.

3. HAZARD IDENTIFICATION/ASSESSMENT

As with many other countries in the Caribbean, there are two broad categories of hazards that can cause potentially minor to significant impacts at any given time:

- Hydro-meteorological hazards
  - Hurricanes and Tropical Storms
  - Flooding
  - Drought
  - Storm Surge
  - Landslide

- Geological hazards
  - Earthquake
  - Volcano
  - Tsunami

Based on a review of reports, site visits and consultation with the key stakeholders, Barbados is exposed to a wide range of natural and anthropogenic hazards, with a high level of risk exposure. The hazard profile for Barbados is predominantly coastal and hydrometeorological, specifically sea level rise, storm surge and increased tropical storm and hurricane intensity and frequency. These effects commonly result in significant impacts on food production, drought, rainfall patterns, disease outbreaks and storm damage, as well as exacerbating existing vulnerabilities to health and water availability. According to data from the OFDA/CRED International Disaster Database, the greatest historical disasters that have affected Barbados in the last decades have been principally storms and floods (Table 3-1).

TABLE 3.1: SUMMARY OF HISTORICAL HAZARDS IN BARBADOS

HAZARD TYPE	TIME PERIOD	EVENTS	RETURN PERIOD
Drought	1946 - 2009	22	2.86
Flooding	1886 - 2000	34	3.35
Tropical Systems	1786 - 2010	20	11.20
Earthquake (and felt shocks)	1670 - 2014	10	34.40
Landslide	1901 - 2000	8	12.38
Tsunami	1751 - 2000	7	35.57

Sources: compilation by Evanson, D. (2014) and extracts from compilation Boruff, B.J., (2006)

3.1 HYDROMETEOROLOGICAL

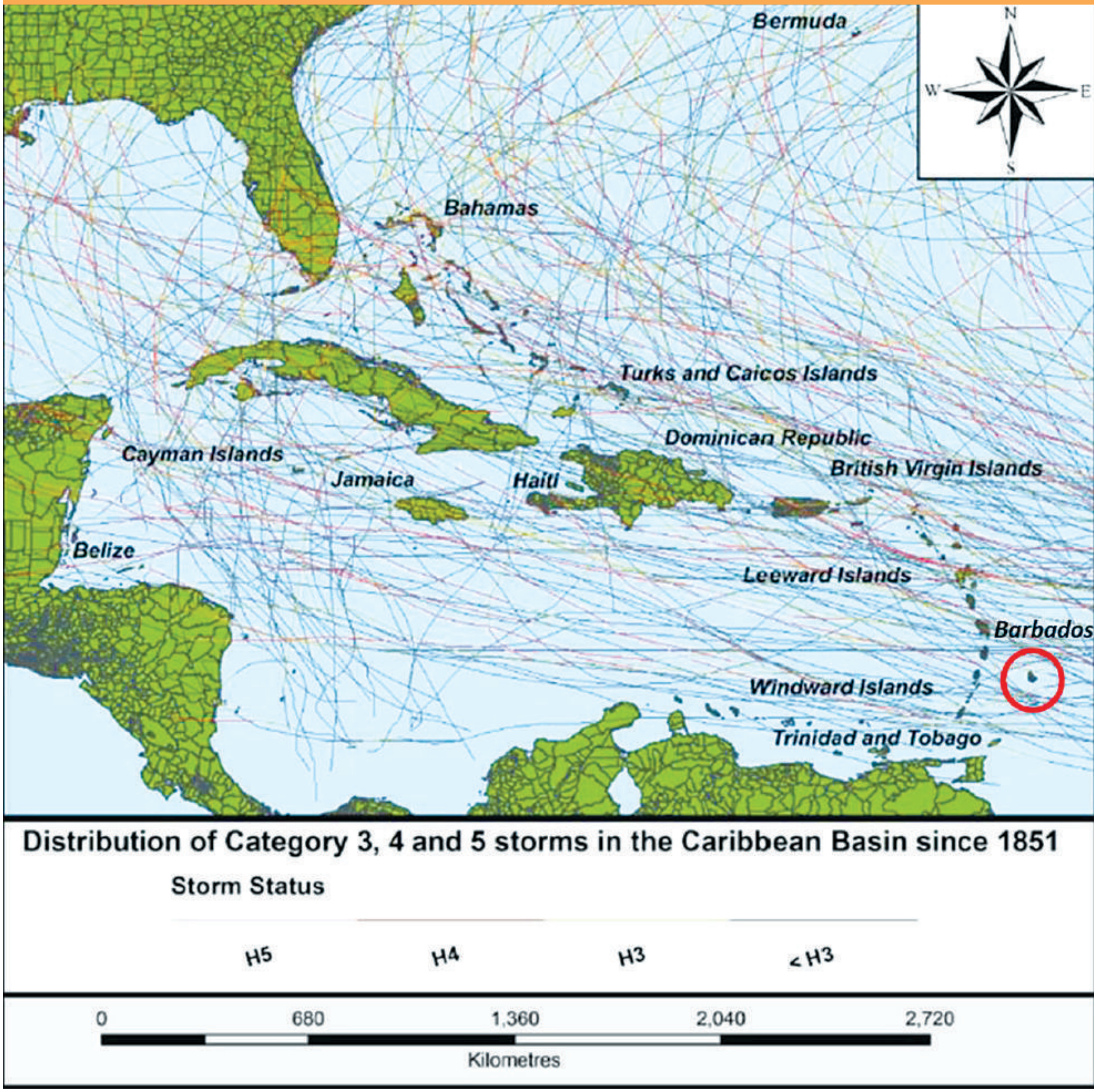
3.1.1 TROPICAL STORMS AND HURRICANES

The most significant natural hazard risk in the Caribbean is hurricane risk, particularly because of the possibly large span of territories which can be impacted by any single event (CRIF). In Barbados, tropical storms, hurricanes, and their associated impacts (strong winds, heavy rain, storm surge and flooding) threaten all exposed structures including residential, public and commercial buildings, telecommunications, agriculture, tourism facilities, roads, bridges and utilities (gas, water, electricity). Due to its location on the southern edge of the North Atlantic Hurricane Belt Barbados is rarely directly hit by hurricanes however the island frequently experiences the effects from these events. According to Second Natl Comm:

> "Since Hurricane Janet in 1955, Barbados has experienced several sizeable storm systems. On 24 September 2002, over 2,000 Barbadians were affected by Tropical Storm Lili, which caused US$ 200,000 in damages. On 8 September 2004, Hurricane Ivan affected 880 people and resulted in US$ 5 million in damages. In 2010, Tropical Storm Tomas caused US$ 8.5 million in damages and affected 2,500 people and 1,500 houses (Simpson et al, 2012). The intense winds, high seas and heavy rainfall associated with Tropical Storm Tomas caused damage to coastal residences and infrastructure, with many houses losing their roofs and thousands of residents without short-term electricity or water supply. On 11 April 2011, a low-pressure system passed over Barbados and caused flooding along much of the western coast. The country experienced repeated flooding due to heavy rains during April and May 2011."

Historical hurricane tracks indicate that 64 meteorological events (hurricanes, tropical storms and tropical depressions) have passed within a 100km radius from the centre of Barbados since 1855 (98 within a 150km radius). The most recent significant impact from a meteorological event at a national scale occurred in 2010 when Tropical Storm Tomás passed just to the south of Barbados.

FIGURE 3.1: CATEGORY 3, 4 AND 5 STORMS AFFECTING THE CARIBBEAN BASIN SINCE 1851; BARBADOS DELINEATED IN RED (SOURCE: NOAA-NHC)



3.1.2 FLOODS

Barbados is exposed to three main types of flooding – flash, coastal and ponding. The island receives rainfall directly from tropical storms or hurricanes and/or during the rainy season, averaging between 114-152cm annually. Additionally, low pressure systems can bring extended periods of rain or intense rainfall. During these periods, flash floods are common, largely stemming from poor drainage, blocked gullies and/or inadequate storm water infrastructure. Some of the areas generally prone to flooding include Speightstown and Gibbes in St Peter; Weston and Holetown in St James; the plains of the Constitution River, Chapman Lane, Bayville and Aquatic Gap in St Michael; and Graeme Hall and Wotton in Christ Church.

Barbados also experiences ponding from the accumulation of rainfall in low-lying areas. This type of flooding has associated impacts from the stagnation of water which can lead to health risks and disruption in transportation.

Historical data indicate that Barbados experiences a major[1] flooding event about every 12 years. Due to the low- lying geography of many areas, Barbados' infrastructure, settlements and facilities are prone to impacts from these events. Further, much of the island's infrastructure and settlements are located within 2km of the coast.

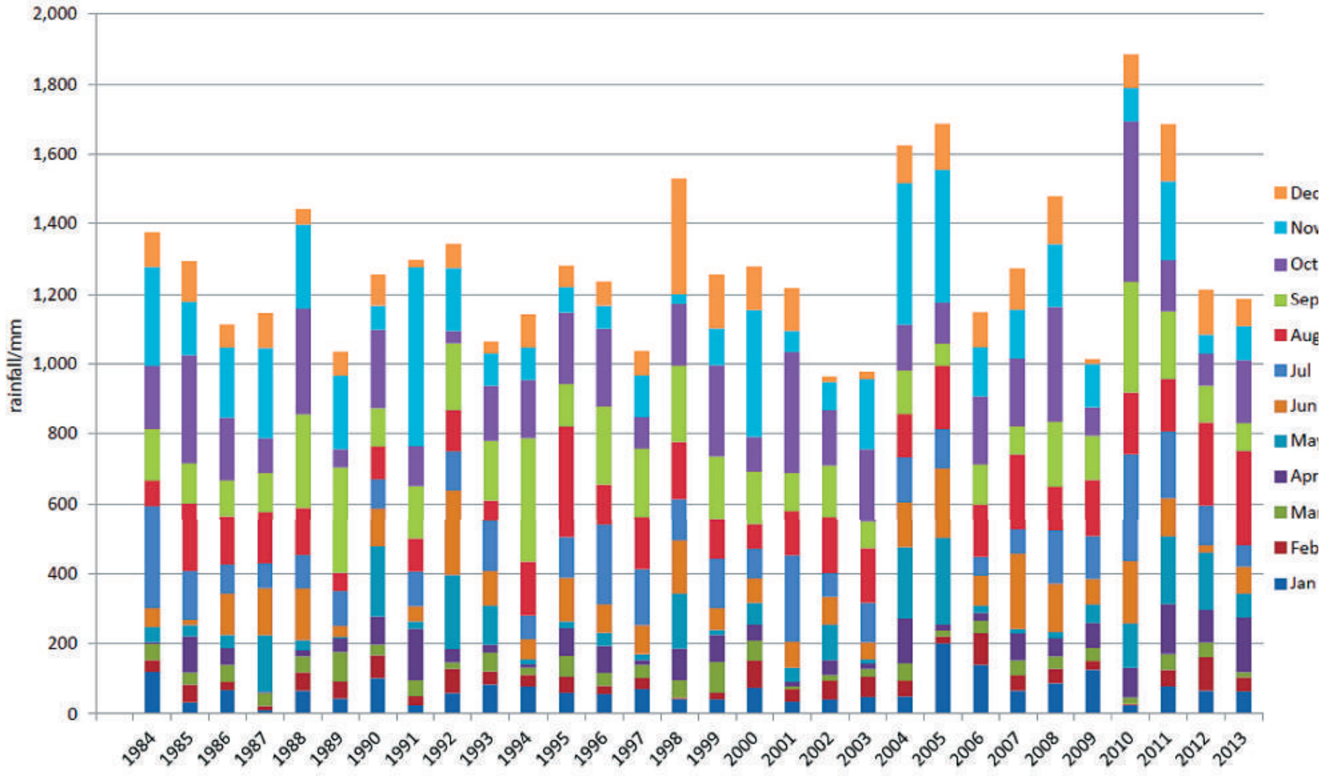
FIGURE 3.2: EFFECTS OF FLOODING IN BARBADOS (SOURCE: VARIOUS)

1 Major flooding is defined to have extensive inundation of structures and roads (Source: www.weather.gov)

3.1.3 DROUGHT

Barbados is classified as a naturally water scarce country. The island experiences drought conditions approximately 3 in every 10 years (drr doco) and these periods generally correlate with El Niño events. Data indicate that very wet years are commonly followed immediately by very dry years, with serious implications for resource and watershed management planning, agriculture, groundwater recharge and flooding. The last decade has seen severe drought conditions, with abnormally dry periods.

FIGURE 3.3: ANNUAL RAINFALL FOR BARBADOS 1984-2013 RECORDED AT GRANTLEY ADAMS INTERNATIONAL AIRPORT SHOWING MONTHLY VARIATION. (SOURCE DATA: BARBADOS METEOROLOGICAL SERVICE)



3.1.4 STORM SURGE

The projections of higher sea levels and increased tropical storm activity are expected to increase storm surge frequency and intensity. The main impact of storm surge is flooding and, because of Barbados' generally low-lying topography, it has been estimated that storm surge flooding events could extend over 150–300m inland (Nurse L., 2011b). Communities and livelihoods are already experiencing the impacts of storm surge when coupled with sea level rise (SLR) and tropical storm/hurricane activity, and these impacts are projected to increase with climate change.

3.1.5 LANDSLIDE

Small scale landslides are associated with coastal escarpments where undercutting by wave action creates instability. However, most landslide activity is restricted to the Scotland District, where slumps, earth flows, and debris flows are the main landslide types present. Failures occur when the clay soils decrease in strength due to increased pore-water pressure. This may be in direct response to intense rainfall or perched water tables associated with the bedding within the bedrock or older clay-sealed slip surfaces. Roads are often undermined by failing slopes and blocked by displaced slide material. The structural stability of housing is also impacted.

3.2 GEOLOGICAL

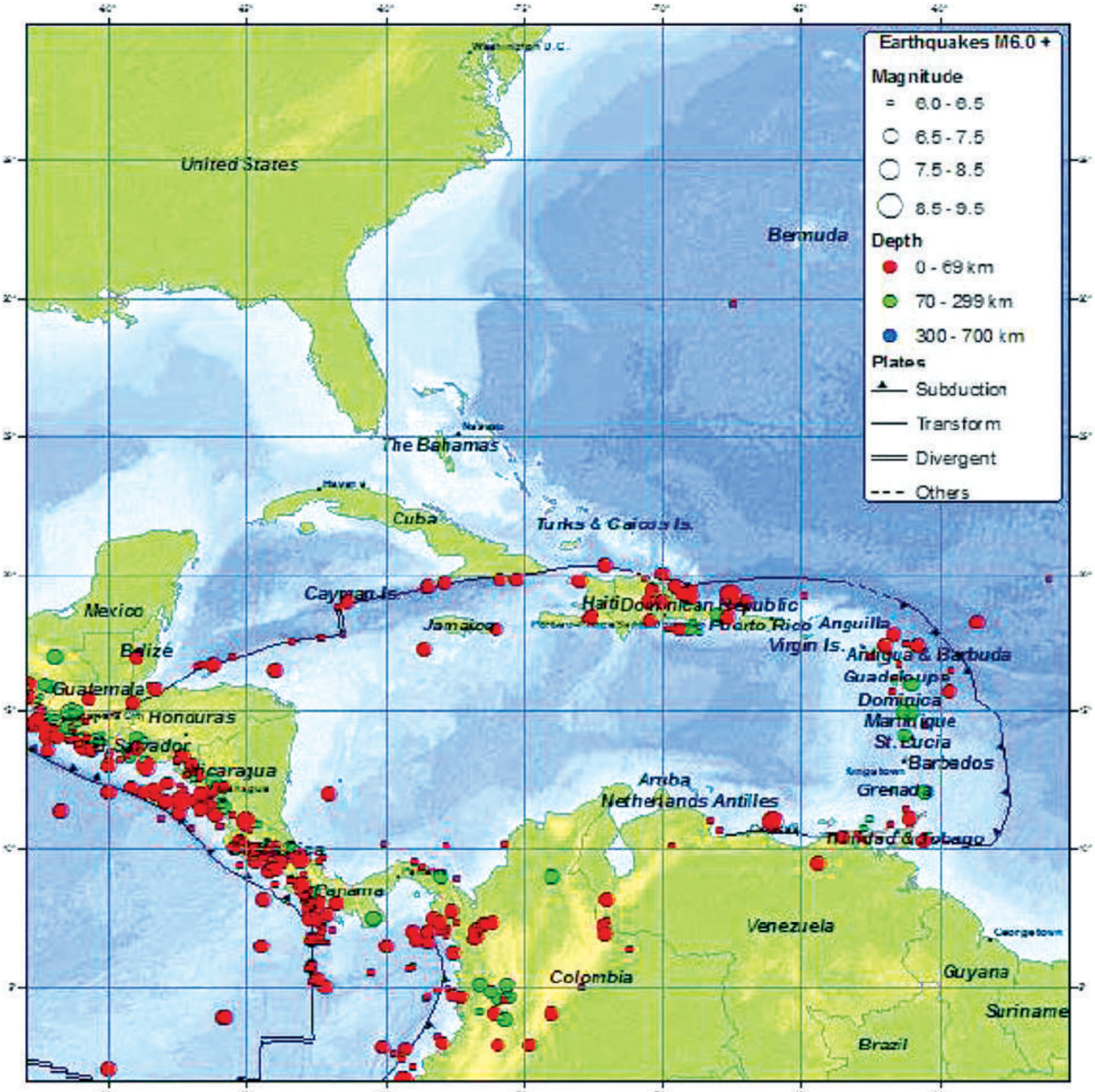
3.2.1 EARTHQUAKE

Barbados does not experience earthquakes as frequently as other hazards e.g. hurricanes, however the vulnerability of the country to earthquakes lies primarily in its infrequency and therefore the potential unpreparedness of the population. This was demonstrated during the 2007 event when a 7.4 magnitude earthquake (on the Richter scale) at a depth of 156km off the coast of Martinique was felt in Barbados.

A probabilistic seismic hazard analysis has been performed by the Seismic Research Centre (SRC) of the University of the West Indies (UWI) in order to compute probabilistic seismic hazard maps for the Eastern Caribbean region (10-19°N, 59-64°W), from Anguilla to Trinidad and Tobago. Barbados is located within seismic zone 3 (SZ3) of the 15 in the region, which includes shallow-focus earthquakes (≤50km). The island lies closest to the subduction zone between the North American and Caribbean plates, which extends to depths of 200km, generating earthquakes of up to 8.0 on the Mercalli Intensity scale[2]. Other authors (CDMP, OAS-OFDA) have estimated that the Barbados zone could experience earthquakes of level VII on the Modified Mercalli intensity scale for a return period of 50 years, which would imply damage to some construction and different signs of movement.

1 Intensity scales, like the Modified Mercalli Scale, measure the amount of shaking at a particular location while the Richter scale describes the earthquake's magnitude by measuring the seismic waves that cause the earthquake. The Mercalli scale is linear and the Richter scale is logarithmic. i.e. a magnitude 5 earthquake is ten times as intense as a magnitude 4 earthquake. (Source: usgs.com)

FIGURE 3.4: CARIBBEAN SEISMICITY MAP FOR 1900 TO MARCH 2012 (SOURCE: USGS)



3.2.2 VOLCANO

Barbados is not directly exposed to volcanic hazards however the active submarine volcano Kick 'em Jenny, located at 260 km southwest of the island, poses a threat of tsunamis.

3.2.3 TSUNAMIS

Tsunamis are not considered a major recurrent risk for the Caribbean region, however the low-lying nature of coastal developments and the concentration of the population and critical infrastructure in coastal settlements make them vulnerable to tsunami activity (GFDR). The Eastern Caribbean is in a zone of significant tectonic changes, with all tsunamigenic sources (earthquakes, volcanoes, landslides) in proximity. Since 1498, there have been over 350 tsunamis in the region of the Caribbean Sea and Bermuda, with events as recent as June 2013 (NGDC, 2014). In Barbados, the most recent observations recorded for a tsunami impact are from December 25,1969 with a recorded wave height of 0.46m (UNISDR doc). The teletsunami[3] of 1755 produced wave heights in Carlisle Bay of 1.5m (NGDC, 2014).

3.3 CLIMATE PROJECTIONS

As a low-lying Small Island Developing State situated on the southern edge of the North Atlantic Hurricane Belt, Barbados is highly vulnerable to the predicted consequences of climate change. The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) presented evidence of the following impacts:

- Rise in global temperatures by 0.3–4.8°C
- Mean sea level rise (SLR) of 0.26–0.82m by the end of the century (IPCC, 2013).

Related predictions for the Caribbean region over the same period included a 1–4°C increase in atmospheric temperature with a trend towards drier conditions during the traditional wet season (from June to November), a 12% decrease in total annual precipitation and 0.5-0.6 m of mean SLR.

The country is already experiencing effects of climate variability and change from extreme weather systems and events, changes in temperature and rainfall patterns. According to the Government of Barbados, the major issues of climate change in Barbados are SLR and the likelihood of more intense weather systems and periods of drought.

3 Originates more than 1000km or 3 hours travel time away.

3.3.1 TEMPERATURE

The trend in rising air temperatures has been an increase by approximately 0.4 °C per decade since the 1960s and an increase in the annual number of 'hot' days over 30C since 1973 (Economic Commission for Latin America and the Caribbean (ECLAC) 2011a). Global climate models predict an increase of 0.5–1.8°C by 2050 and 0.9–3.1°C by 2080 (relative to the 1970–99 mean), however regional climate models predict a more rapid temperature increase of 2.4–3.2°C by the 2080s (Simpson et al, 2012). The projected mean temperature for Barbados is likely to increase from 28°C to 31°C by the end of the 21st century.

With regards to sea surface temperatures (SST), Barbados has experienced an increase of approximately 0.1°C since the 1960s. Global Climate Model (GCM) projections indicate that SST will rise between 0.8°C and 3.0°C by the 2080s (Simpson et al, 2012) and are likely to contribute to increased tropical storm activity affecting Barbados and the Caribbean region (ECLAC, 2011a).

3.3.2 RAINFALL

Transitions between El Niño and La Niña events primarily control rainfall patterns. Global and regional climate model projections suggest that mean rainfall will decrease in Barbados, creating a tendency for drier conditions through the wet season.

3.3.3 HURRICANES AND TROPICAL STORMS

Over the last three decades, there has been an observed increase in the frequency and intensity of tropical storms globally, and hurricanes have been observed developing at lower latitudes. Notably, Hurricane Ivan (2004) formed at 8°N. Projections suggest that the trend towards an increase in storm intensity and frequency of stronger storms will continue. Barbados is considered to at risk to these projected impacts given the increased probability of hurricanes making landfall on the island and the vulnerability of coastal infrastructure. This in turn leads to heightened storm surge, larger volumes of storm water runoff and associated wind damage.

3.3.4 SEA LEVEL RISE

The areas at greatest risk in Barbados are largely found along the west and south-west coasts. These include areas around Speightstown and Holetown which lie at less than 6m above sea level and parts of the Spring Garden Highway (a major thoroughfare). Other vulnerable low-lying areas include Bridgetown and the surrounding area, as well as areas on the south coast around Kendal Point.

Over the period 1961 - 2003, observed records of sea level rise (SLR) indicate a global mean of 1.8 (+/-0.5) mm per year (Bindoff et al., 2007) with acceleration rates detected in most regions in during the 20th century (Woodworth et al., 2009; Church and White, 2006). Projections for the Caribbean are largely consistent with the global trend, with a projected increase of 26 to 39cm by 2050. SLR has the potential to cause serious impacts, especially during intense storm swell conditions and has been identified as one of the major issues of climate change for Barbados. The estimated coastline retreat due to SLR will have serious consequences for land uses along the coast (UNFCCC, 2000; Mimura et al., 2007; Simpson et al., 2010).

3.3.5 STORM SURGE

According the Climate Change Risk Atlas for Barbados, changes to the frequency or magnitude of storm surge experienced at coastal locations are likely to occur as a result of the combined effects of:

1. Increased mean sea level in the region, which raises the base sea level over which a given storm surge height is superimposed.

2. Changes in storm surge height, or frequency of occurrence, resulting from changes in the severity or frequency of storms.

3. Physical characteristics of the region (bathymetry and topography) which determine the sensitivity of the region to storm surge by influencing the height of the storm surge generated by a given storm.

The main impact of storm surge is flooding and, because of Barbados' generally low-lying topography, it has been estimated that storm surge flooding events could extend over 150–300m inland (Nurse L., 2011). Additional impacts on storm surge flood return periods may also include:

1. Potential changes in storm frequency: some models suggest a global or regional reduction in storm frequency in the future. If this occurs, it may offset increases in flood frequency at given elevations.

2. Potential increases in storm intensity: evidence suggests overall increases in the intensity of storms[4] which may lead to increases in associated storm surges and contribute to increases in flood frequency at a given elevation.

4. EXPOSURE ANALYSIS

The term exposure is used to indicate those elements-at-risk that are subject to potential losses. Important elements-at-risk that should be considered in analysing potential damage of hazards are population, building stock, essential facilities and critical infrastructure. Critical infrastructure consists of the primary physical structures, technical facilities and systems which are socially, economically or operationally essential to the functioning of a society or community, both in routine circumstances and in the extreme circumstances of an emergency (UN-ISDR, 2009).

This exposure analysis involves developing a hazard profile for the school by assigning ratings (from 0 to 3) to the parameters listed in Table 4-1 below and averaging the parameter scores for each hazard. Based on the average scores, the school is characterized by the degree of exposure to each hazard and further assigned an **Overall Exposure Index** (sum of the average scores for all hazards).

The objective is to quantify the school's level of exposure and subsequently the potential impact (direct or indirect) of a specific hazard on people, essential facilities, and property. This will enable school administrators, the Ministry of Education and other key decision makers to have a better understanding of the hazards that present the highest risk to the school and focus planning efforts on making schools safer in this context.

4 Lower pressure, higher near storm rainfall and wind speeds.

The consultants used existing data and available hazard maps to determine the level of exposure of the school to specific hazards.Table 4-2 presents the findings of the exposure analysis.

Based on the hazard identification (Section 3) and the exposure analysis, the Ellerslie Secondary School has a high degree of exposure to hurricanes and tropical storms (and associated wind), earthquakes and tsunamis. Additionally, the school is highly likely to be affected by the climate change projections made for the area and the region (Section 2.3). Based on this analysis, the school has been assigned an exposure index of **9.4** (**Moderate**; Table 4-2). It would be prudent for the school to prioritise all hazards that have been given a rating of high or moderate.

OVERALL EXPOSURE INDEX

0 - 4	VERY LOW	
5 - 9	LOW	
10 - 14	MODERATE	
15 - 19	HIGH	
20 - 24	VERY HIGH	

TABLE 4.1: PARAMETERS AND RANKINGS USED IN EXPOSURE ANALYSIS (SOURCE: ADAPTED FROM FEMA HAZARD ANALYSIS WORKSHEET)

PARAMETER	RANKINGS	SCORE
Frequency	**Highly Likely:** Near 100% probability in next year.	3
	Likely: Between 10 and 100% probability in next year, or at least one chance in 10 years.	2
	Possible: Between 1 and 10% probability in next year, or at least one chance in next 100 years.	1
	Unlikely: Less than 1% probability in next 100 years.	0
Warning (potential speed of onset)	Minimal (or no) warning.	3
	6 to 12 hours warning.	2
	12 to 24 hours warning.	1
	More than 24 hours warning.	0
Severity	**Catastrophic:** Multiple deaths; Complete shutdown of facilities for 30 days or more; More than 50%of property is severely damaged.	3
	Critical: Injuries and/or illnesses result in permanent disability; Complete shutdown of critical facilities for at least two weeks; More than 25%of property is severely damaged.	2
	Limited: Injuries and/or illnesses do not result in permanent disability; Complete shutdown of critical facilities for more than 1 week; More than 10%of property is severely damaged.	1
	Negligible: Injuries and/or illnesses are treatable with first aid; Minor quality of life lost; Shutdown of critical facilities and services for 24 hours or less; Less than 10% of property is severely damaged.	0

TABLE 4.2: FINDINGS OF THE EXPOSURE ANALYSIS FOR THE ELLERSLIE SECONDARY SCHOOL

HAZARD	COMMENTS	FREQUENCY		WARNING TIME		SEVERITY		DEGREE OF EXPOSURE	
		RANKING	SCORE	RANKING	SCORE	RANKING	SCORE	RANKING	AVERAGE SCORE
Hurricanes and Tropical Storms	While direct hits are uncommon, hurricanes and storms frequently pass with 50km of the island resulting in considerable impacts.	**Likely**	**2**	**12-24 hrs**	**1**	**Catastrophic**	**3**	**HIGH**	**2.0**
Flooding (from hurricanes, storms or extreme rainfall events)	School officials report no significant damage history as a result of flooding impacts. While flooding from storms and hurricanes are likely, the severity may be low for the school.	**Likely**	**2**	**24+ hrs**	**0**	**Negligible**	**0**	**LOW**	**0.7**
Drought	Drought impacts the entire island of Barbados, with ranging severity but high likelihood.	**Highly likely**	**3**	**24+ hrs**	**0**	**Limited**	**1**	**MODERATE**	**1.3**
Storm Surge	The school is not exposed to storm surge as it is located ~27m above sea level (ASL).							**NOT EXPOSED**	
Landslide	Landslides are largely restricted to the Scotland District. The topography of the area where the school is located is flat, and there is no risk of a landslide.							**NOT EXPOSED**	
Earthquake	Seismic activity is a risk for all Caribbean islands. The lack of warning and potential for catastrophic impacts suggest that the school has a high exposure to earthquakes.	**Likely**	**2**	**Minimal (or no warning)**	**3**	**Catastrophic**	**3**	**HIGH**	**2.7**
Volcano	Landslides are largely There are no volcanos on the island of Barbados.							**NOT EXPOSED**	
Tsunamis	The school is located within 1km of the coast. Eruptions from the sub-marine volcano, Kick 'Em Jenny, or seismic activity could trigger a tsunami in the vicinity of the school with minimal warning time.	**Likely**	**2**	**Minimal (or no warning)**	**3**	**Catastrophic**	**3**	**HIGH**	**2.7**
OVERALL EXPOSURE INDEX								**MODERATE**	**11.7**

4.1 OTHER HAZARDS

Comprehensive school emergency planning utilizes an "all-hazards" approach, which considers a wide range of possible threats and hazards. It includes those that might take place in the community and surrounding area that could impact the school. Examples include:

1. Technological Hazards

- Hazardous materials in the community from industrial plants, major highways or railroads
- Hazardous materials in the school e.g. gas leaks, sewage breaks or laboratory spills
- Infrastructure failure e.g. dam, electricity, water, communications or technology systems

2. Biological Hazards

- Infectious diseases
- Contaminated food outbreak
- Water contamination
- Toxic materials present in schools e.g. mould, asbestos, substances in school science laboratories

3. Adversarial, Incidental and Human-Caused Hazards

- Fire
- Medical Emergency
- Intruder
- Active shooter/Threats of violence
- Fights
- Gang violence
- Bomb threat
- Child abuse
- Cyber attack
- Suicide
- Missing student or kidnapping
- Off-site emergencies
- Dangerous animal
- Riots

The school's safety plan (referred to as the Multi-Hazard Emergency Plan) considers many of the above based on previous walk-throughs and assessments conducted. With regards to priority hazards, according to the school officials, their focus is primarily on Category 3: Adversarial, Incidental and Human Caused Threats. Physical security of staff and students is paramount in their disaster and emergency management as given their previous experiences with security breaches, the likelihood and consequences of these events is thought to be high.

5. ADAPTIVE CAPACITY

The adaptive capacity analysis describes the ability of the school to accommodate potential damage, to take advantage of opportunities, or to respond to consequences with minimum disruption or minimum additional cost (Climate Impacts Group, King County, Washington, and ICLEI-Local Governments for Sustainability, 2007). It describes the capacity of the school to learn from previous experiences and to apply those lessons to cope in future.

The analysis among other things discusses the below in the context of what each school may be exposed to (Section 3):

- If the school is already able to accommodate changes
- If there are any barriers to the school to accommodate changes
- If the rate of the projected change, particularly climate change, is likely to be faster than the adaptability of the school
- If there are efforts already underway to address impacts of various hazards in the school

To develop an overall index of adaptive capacity, 24 indicators were selected and grouped according to five determinants of adaptive capacity in the context of the hazards that may impact each school (Section 3). The indicators were selected using information garnered from the MSSP toolkit checklists, interviews and desk review of other existing data and information. The index was calculated by aggregating the scores for the individual indicators to obtain an **Overall Adaptive Capacity Index**.

OVERALL ADAPTIVE CAPACITY INDEX		
0 - 4	VERY LOW	
5 - 9	LOW	
10 - 14	MODERATE	
15 - 19	HIGH	
20 - 24	VERY HIGH	

This approach provides a holistic perspective on the school's ability to plan for, design and implement effective adaptation strategies or to react to evolving hazards and stresses which may ultimately reduce the likelihood of the occurrence and or the severity of harmful outcomes resulting from hazards. It considers all elements of Comprehensive Disaster Management (Preparedness, Mitigation, Response and Recovery)[5]. The analysis is presented in Table 5-2.

5 https://www.cdema.org/cdm

TABLE 5.1: DETERMINANTS OF ADAPTIVE CAPACITY USED IN SCHOOL ASSESSMENT (ADAPTED FROM SMIT ET AL. 2001)

DETERMINANT	RATIONALE
Economic	■ Greater economic resources increase adaptive capacity ■ Lack of financial resources limits adaptation options
Information and skills	■ Lack of informed, skilled and trained personnel reduces adaptive capacity ■ Greater access to information increases likelihood of timely and appropriate adaptation
Infrastructure and Technology	■ Lack of technology limits range of potential adaptation options ■ Less technologically advanced regions are less likely to develop and/or implement technological adaptations ■ Greater variety of infrastructure can enhance adaptive capacity, since it provides more options ■ Characteristics and location of infrastructure also affect adaptive capacity
Institutional	■ Well-developed social institutions help to reduce impacts of climate- related risks and therefore increase adaptive capacity ■ Policies and regulations may constrain or enhance adaptive capacity
Natural/Ecological /Climate	■ Elements of the natural, physical or ecological environment of a region may enhance or limit the possibilities for adaptation (including projected climate change impacts)

TABLE 5.2: SUMMARY OF ADAPTIVE CAPACITY ANALYSIS FOR ELLERSLIE SECONDARY SCHOOL (2019)

DETERMINANT	INDICATOR	SCORE	COMMENTS
Institutional	**1.** Is there a national policy on climate change adaptation and/or comprehensive disaster management (or related) for the education sector? **[YES = 1; NO = 0]**	1	The Government of Barbados has drafted a National Climate Change Policy Framework that provides the country's overarching approach to climate change adaptation and mitigation. Though not specific to the education sector, the primary goal of this policy framework is to "establish a national process for adapting to climate change effects and minimising greenhouse gas emissions over the short, medium and long term, and to do this in a manner that is coordinated and consistent with the broader sustainable development aspiration." Barbados is also signatory to the Antigua and Barbuda Declaration on School Safety and is in the process of implementing the Model Safe School Programme.
	2. Have there been additions to the curriculum that integrate climate change/disaster preparedness/emergency management? **[YES = 1; NO = 0]**	0	In the formal education system, there is no established curriculum on climate change (or disaster preparedness etc), although the curricula for geography and integrated science contain some related material. There are also additional resources available to schools e.g. the Caribbean Youth Environment Network (CYEN) offers opportunities for education and training on climate change;
	3. Is an updated emergency management or disaster management plan in place? **[YES = 1; NO = 0]**	1	The school has a Multi-Hazard Assessment Plan (MEP) with clear guidelines for the identification of and response to emergency incidents which are likely to occur.
	4. Do the plans address priority hazards based on previous assessment(s)? **[YES = 1; NO = 0]**	1	The MEP addresses all the natural hazards that can have a direct or indirect impact on the school based on the profile of Barbados, and speaks to man- made hazards e.g. explosion, intruder/dangerous person etc. These were selected based on previous assessments.
	5. Is there a designated environmental/health & safety officer, emergency response team or related position/team? **[YES = 1; NO = 0]**	1	The school has an Occupational Health and Safety Officer.
Information and Skills	**6.** Has the school done a walk through to identify and prioritize hazards for the population and visitors? **[YES = 1; NO = 0]**	1	Yes, the school has done previous assessments with the aid of private contractors.

TABLE 5.2: SUMMARY OF ADAPTIVE CAPACITY ANALYSIS FOR ELLERSLIE SECONDARY SCHOOL (2019)

DETERMINANT	INDICATOR	SCORE	COMMENTS
Information and Skills	**7.** Are all teachers and school staff assigned roles in the overall response, pre-, during and post-hazard event? [YES = 1; NO = 0]	1	The MEP outlines the specific responsibilities and duties of individuals, including members of staff, students, parents, persons who live and work in the surrounding community, during and after an emergency.
	8. Have staff received training in emergency/disaster management? [YES = 1; NO = 0]	1	Yes, all staff have received training in emergency management based on the roles and responsibilities outlined in the MEP. There are also trained first aiders on staff.
	9. Are there regular drills with staff, parents and students? [YES = 1; NO = 0]	1	The most recent drill was conducted in February 2019 as a part of the school's ongoing sensitization process to prepare students and staff with the knowledge of how to respond in emergencies.
	10. Is the school able to manage an event independently if help is not immediately available? E.g. fire extinguishers, first aid kits, triage? [YES = 1; NO = 0]	1	Based on the evaluation of the drill conducted in early 2019, the school is able to independently manage an event. During the drill, they set up a Command Centre in the main office to deal with the following matters including internal and external communication, to make or take emergency calls and speak to the media where necessary. Persons staffing the Command Centre are assigned titles and associated roles, which they are expected to perform in the event of an emergency. The school is also equipped with first aid kits, fire extinguishers, emergency kits, a warning bell, fire blankets and other emergency management materials.
Infrastructure and Technology	**11.** Does the school have reserve water storage with adequate supply for at least 3 days? [YES = 1; NO = 0]	0	While there are storage tanks on the property, there is not enough water stored to serve the population of over 900 persons for at least 3 days[6]. Given that there is a high likelihood of drought occurring in Barbados, a water scarce country, this can be considered one of the school's shortcomings with regards to disaster planning and adaptive capacity.
	12. Does the school employ water conservation strategies to adapt to current usage or plan for future changes to water supply? [YES = 1; NO = 0]	0	Students and staff acknowledge that they must make efforts to conserve water. There are also storage tanks located on the school compound. No other strategies were observed at the time of the assessment e.g. metred taps/low flow toilets etc.

6 The recommended storage quantities for water should accommodate one gallon of water per person per day for three days.

TABLE 5.2: SUMMARY OF ADAPTIVE CAPACITY ANALYSIS FOR ELLERSLIE SECONDARY SCHOOL (2019)

DETERMINANT	INDICATOR	SCORE	COMMENTS
Infrastructure and Technology	**13.** Does the school actively harvest rainwater? [YES = 1; NO = 0]	0	No, there are no rainwater harvesting initiatives underway.
	14. Does the school employ energy conservation/efficiency mechanisms? [YES = 1; NO = 0]	1	The school has done an energy audit for the administrative building and has installed energy saving LED bulbs. They also have solar powered water heaters on campus. Staff and students are also sensitized to the importance of energy conservation and have plans for implementing additional measures.
	15. Is there back up electrical power? [YES = 1; NO = 0]	0	This is an area for improvement as there is no back up electrical power.
	16. Does the school employ other green practices? E.g. recycling, greenhouse/garden, green policy etc? [YES = 1; NO = 0]	1	No, there are no green initiatives underway, however the school does have an environmental club.
	17. Can the building withstand the impacts of a hazard in its current condition? [YES = 1; NO = 0]	1	Based on the building condition assessment, there is no immediate concern about the structural integrity of the building. It is anticipated that the building should perform adequately for its life and during a hazard event. Several broken windows and doors were observed, the timely repairs of which will be critical in order to ensure that the building envelope is not compromised. **NOTE:** The building was found to be at risk to both wind and flooding. Additionally, the number of toilets is was found to be inadequate[7], and those on the property are in poor condition.

7 Different literature and country standards use a ratio 1 toilet for 20-40 children. For example, "British Standard 6465-1: 2006+A12009" states the appropriate number of units for secondary school children:

- Male toilet and urinals: one per 20 students while urinals should constitute no more than two-thirds of the boys' fixtures.
- Female toilets: one per 20 students.
- Handwash basins: one per toilet/urinal where there are three or fewer fixtures. Two per three toilets/urinals where there are three or more fixtures. Toilets and urinals should be near to a handwash basin.

TABLE 5.2: SUMMARY OF ADAPTIVE CAPACITY ANALYSIS FOR ELLERSLIE SECONDARY SCHOOL (2019)

DETERMINANT	INDICATOR	SCORE	COMMENTS
Infrastructure and Technology	**18.** Have school buildings/plant been repaired or retrofitted to the building code? **[YES = 1; NO = 0]**	0	No, there is a need to repair the roof and roof drainage as there are signs of deterioration and in some cases leaks. Water ingress around windows was identified as the main defect to be addressed. Storm water drainage system needs to be enhanced and regularly monitored and maintained. There is no access for persons with disabilities (PWD) to the bathroom facilities. As the school is a designated emergency shelter to be used in the event of hurricanes or other hazards, this is a significant shortfall.
ARE THERE ANY EXISTING BARRIERS TO ADAPTATION?			
Natural / Ecological / Climate	**19.** Physical or ecological limits? E.g. landscape/physical location limits range of adaptation options to priority hazards? **[YES = 1; NO = 0]**	1	The school is not located in an ecologically sensitive area nor is it physically bound in such a way that would impede adaptation options. For example, they have physical space to implement rainwater harvesting, solar panelling, water storage etc. Interviews with school officials revealed that they have a challenge with encroachment from their immediate neighbours, which while not a problem now, may limit their adaptation options in future.
	20. Is climate change likely to exacerbate any of the current hazards? **[YES = 1; NO = 0]**	0	Based on climate projections, the current hazards are projected to be exacerbated.
	21. Is the rate of climate change likely to outpace adaptation efforts? **[YES = 1; NO = 0]**	0	The impacts of certain climate-related hazards, particularly those that affect the adequate supply of potable water are already being experienced islandwide and at the school.
Infrastructure and Technology	**22.** Technological limits? Availability of technological options for adaptation e.g. warning systems/ impacts of disruptions on any technology-based emergency communication resources; electronic data storage. **[YES = 1; NO = 0]**	1	The school has an electronic bell for warnings during drills and actual emergencies. In the event of a power outage, they do have a handheld bell and teacher offices assigned to each block for streamlined communication. They also practice electronic backup of school data though the majority of their operations is still paper based.

TABLE 5.2: SUMMARY OF ADAPTIVE CAPACITY ANALYSIS FOR ELLERSLIE SECONDARY SCHOOL (2019)

DETERMINANT	INDICATOR	SCORE	COMMENTS
Economic	**23.** Financial barriers? E.g. Lack of resources may limit the ability of some schools to afford proposed adaptation mechanisms. [YES = 1; NO = 0]	0	The school is funded by the government.
Information and Skills	**24.** Information or cognitive barriers (individuals tend to prioritize the risks they face, focusing on those they consider – rightly or wrongly – to be the most significant to them at that point in time)? E.g. concern about one type of risk is heightened while worry about other risks decreases; lack of experience of climate-related events inhibits adequate responses. [YES = 1; NO = 0]	1	Based on interviews with school officials, there is a culture of holistic safety from natural to man-made hazards. They are cognizant of the climate-related hazards and they frequently run drills to ensure an appropriate level of readiness and response.
OVERALL ADAPTIVE CAPACITY INDEX		**15**	**HIGH**

5.1 BUILDING CONDITION ASSESSMENT

The building is generally in good condition and well maintained. Remedial works and retrofitting are recommended report related to the windows and sealants, roof and storm water drainage and flood mitigation interventions. No other significant deficiencies were observed or reported regarding the property elements, buildings or related structures.

TABLE 5.3: RESULTS OF BUILDING CONDITION ASSESSMENT (MAY 2019)

	BUILDING 1	BUILDING 2	BUILDING 3	BUILDING 4	BUILDING 5	BUILDING 6	BUILDING 7	BUILDING 8
Number of Storeys per Building:	3	3	1	2	1	1	1	1
Floor Type:	**Description:** Reinforced concrete. **Observation:** Floor slab in generally good condition with some spalling concrete at some areas.	**Description:** Reinforced concrete. **Observation:** Floor slab in generally good condition with some spalling concrete at some areas.	**Description:** Reinforced concrete. **Observation:** Floor slab in generally good condition.	**Description:** Reinforced concrete. **Observation:** Floor slab in generally good condition.	**Description:** Reinforced concrete. **Observation:** Floor slab in generally good condition.	**Description:** Timber. **Observation:** Floor in generally good condition.	**Description:** Reinforced concrete. **Observation:** Floor slab in generally good condition.	**Description:** Timber. **Observation:** Floor in generally good condition.
Wall / Partition Type:	**Description:** Reinforced masonry in fair condition. Hairline cracks were not uncommon.	**Description:** Reinforced masonry in fair condition. Hairline cracks were not uncommon.	**None**	**Description:** Reinforced masonry in good condition.	**Description:** Reinforced masonry in fair condition. Hairline cracks were not uncommon.	**Description:** Timber panels in good condition.	**Description:** Reinforced masonry in good condition.	**Description:** Timber panels in generally good condition.
Roof Structure:	**Description:** Reinforced concrete roof slab and beam in generally good condition.	**Description:** Reinforced concrete roof slab and beam in generally good condition.	**Description:** Reinforced concrete roof slab and beam in generally good condition.	**Description:** Timber structure in generally good condition.	**Description:** Structural steel in fair condition.	**Description:** Timber structure in generally good condition.	**Description:** Timber structure in generally good condition.	**Description:** Timber structure in generally good condition.
Roof Covering:	**Description:** Reinforced concrete roof slab with waterproofing membrane in generally fair condition.	**Description:** Reinforced concrete roof slab with waterproofing membrane in generally fair condition.	**Description:** Reinforced concrete roof slab with waterproofing membrane in generally fair condition.	**Description:** Aluzinc sheets in generally good condition.	**Description:** Aluzinc sheets in poor condition.	**Description:** Aluzinc sheets in generally good condition.	**Description:** Aluzinc sheets in generally good condition.	**Description:** Aluzinc sheets in generally good condition.
Repairs / Retrofitting Conducted:	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
Is there Disabled Access/ Special Needs Access to the Building?	**None**	**None**	**None**	**None**	**None**	**None**	**None**	**None**
Approx. Age of Each Building	**More than 40 years**	**More than 40 years**	**More than 40 years**	**12 years**	**More than 40 years**	**2 years**	**More than 40 years**	**More than 40 years**
Building Use	**Classrooms, Toilets**	**Classrooms, Toilets**	**Auditorium**	**Admin**	**Kitchen, Classroom**	**Sixth Form**	**Classroom**	**Classroom**
Overall Condition	**Fair**	**Fair**	**Fair**	**Good**	**Poor**	**Good**	**Good**	**Good**

5.1.1 SITE OBSERVATIONS / DISCUSSION

The below presents a summary of the observations made of the physical plant:

EXTERIOR

WALLS
There were some signs of water ingress through the external walls that may be porous, and the affected areas can be corrected by re-plastering of defective areas.

SLAB & BEAMS
Found to be in generally good condition with some isolated areas of spalling concrete.

COLUMNS
Found to be in good condition generally.

INTERIOR

WALLS
Interior walls were of masonry and timber. Masonry walls were in good condition as were the timber panels.

WINDOWS
Several broken windows were also observed the timely repairs of which will be critical in order to ensure that the building envelope is not compromised during an extreme wind event.

DOORS
Doors were all of timber in conditions varying from good to poor. The problems ranged from termite infestation to broken or missing ironmongery and for which the timely repairs will be critical in order to ensure that the building envelope is not compromised during an extreme wind event.

GENERAL CONDITION

The summary of our 3 main observations is as follows:

- Historically, the issue of water ingress is normally not associated with structural assessments, however in recent times a direct link between water ingress and structural deterioration has been established. Generally, water ingress through inadequate seals around windows are doors as well as wall flashing need to be addressed. Water ingress around windows was identified as the main defect to be addressed.
- There is also the need to repair roof and roof drainage as there are signs of deterioration, crude repairs and in some cases leaks.
- There were some signs of water ingress through the external walls that may be porous and the affected areas can be corrected by re-plastering of defective areas.

Photographs obtained during our inspection are provided in the Appendix.

6. VULNERABILITY ASSESSMENT

The final step in the vulnerability assessment process is to combine the findings of exposure and adaptability to determine how and where the school is vulnerable. It is important to note that the vulnerability assessment does not remain static, it can improve or worsen with time. Changes can occur within the school, such as implementation of preparedness activities, and/or new threats may emerge. These can all influence the school's overall vulnerability.

The Ellerslie School, because of its coastal location, has inherent characteristics that exacerbate the degree of exposure relative to natural hazards, climate change and variability, and has been classified as having an overall **moderate** hazard exposure. The analysis of the adaptive capacity revealed that while the school may have some barriers and limitations, their capacity to adjust to change (induced by the hazards to which they are exposed), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences is **high**. While the administration has taken active measures towards disaster management and the physical plant of the school has not been structurally compromised, there are additional strategies that the school can employ to improve their adaptive capacity, however these may come at significant cost (presented in Section 8). As the school is government funded, this may further constrain the school's capacity to adapt. As such, the Ellerslie School can be characterised as **moderately vulnerable** to hazards.

7. SUMMARY FINDINGS

Overall, the Ellerslie School can be characterised as having a strong culture of safety made apparent in their daily operations and planning. This is also reflected in the scores the school received for the various sections of the MSSP Toolkit Checklists (Appendix 10.1). Our team's assessment suggests that maintenance is a priority task for the school administration which is an integral component of disaster management and risk reduction. The critical areas for improvement included water storage, the availability of a stand-by electrical generator and the number and condition of the bathrooms.

KEY STRENGTHS:

- They have an active, trained Health and Safety Officer, supported by other key personnel whose tasks are clearly outlined in the Multi-Hazard Assessment Plan. The plan considers vulnerable groups, gender- specific issues and the integration of family and community into school safety.
- At the time of the assessment, all teachers had received some level of training in first aid, fire suppression or emergency response.
- In speaking with students, they were aware to report any hazards to teachers/administration.
- Buildings, classrooms and offices were equipped with fire extinguishers, fire blankets and first aid kits, and each building block had a teacher permanently posted with oversight on activities.
- Maintenance (routine cleanings, pest management, landscaping etc) were undertaken on a frequent basis.
- Signage was appropriately placed around the school including emergency numbers, evacuation routes, safety instructions for the use of certain equipment (e.g. in workshop areas for wood and metal) etc.
- Security protocols are strictly adhered to as all visitors/vehicles were registered upon entry and exit. Visitors were also directed the Principal's office.
- Students and staff were equipped with the necessary personal protective equipment (PPE) specific to the tasks being undertaken.

FIGURE 7.1: SELECTED PICTURES OF ELLERSLIE SCHOOL SHOWING SOME KEY STRENGTHS

AREAS FOR IMPROVEMENT:

- Access for persons with disabilities (PWD) is limited throughout the school, particularly for those who are wheelchair bound. This is of critical importance as the school is a designated emergency shelter.
- The perimeter fence at the back of the school property (surrounding the field) needs to be repaired and overhanging trees trimmed.
- The laboratories are not adequately equipped with personal protective equipment e.g. lab coats, latex gloves, respirators.
- Although the design of building is well thought out for ventilation (presence of open blocks etc.); effort needs to be taken to prevent free thoroughfare of pests (e.g. fixing of broken or missing windows/mesh on blocks). Similarly, trash receptacles (bins and skips) are open which can further attract pest.
- Some repairs required to the physical plant to ensure safety before or during a hazard event.

Section 8 – Improvement Plan and Costed Action Plan provided specific actions and timelines for recommendations on improving the overall safety of the school.

FIGURE 7.2: SELECTED PICTURES OF ELLERSLIE SCHOOL SHOWING SOME KEY AREAS FOR IMPROVEMENT (LEFT TO RIGHT: OPEN RECEPTACLES, PERIMETER FENCE IN NEED OF REPAIR AND TREE TRIMMING, WINDOWS WITHOUT MESH/SOME BROKEN WINDOWS)

8. IMPROVEMENT PLAN AND COSTED ACTION PLAN

Table 8-1 summarizes our opinion of recommended improvements and budgets for capital expenditures (remedial works, repairs, retrofitting) identified by this report. Expenditures that are expected to be managed as part of normal operations are not shown. The budgets assume a prudent level of ongoing maintenance. It should be noted that costs excluded engineering indirect costs. Opinions of cost also excluded any local taxes.

The proposed estimated cost to undertake the remedial work is **Six Hundred and SeventeenThousand Dollars Barbados Currency (BBD$617,000)**.

TABLE 8.1: IMPROVEMENT PLAN AND COSTED ACTION PLAN FOR ELLERSLIE SCHOOL

RECOMMENDATION	TASK	RESPONSIBLE PARTY	FUNDS REQUIRED	TIMEFRAME SHORT-MEDIUM -LONG TERM	RESULT
Emergency Planning and Management	Include in the school safety plan disaggregated date on student population (age, gender) as this will better inform disaster and emergency planning. This can be updated as needed and appended to the plan.	Principal and/or Safety Committee.	No cost associated.	Short	Improved Emergency Planning and Management.
On-site drainage of water (rainwater, wastewater from sinks, etc.) needs to be addressed	Upgrade of storm drains to include regrading of parking lot with additional catchment areas.	Ministry of Education in collaboration with Department of Works.	BBD$90,000	Medium	Improved drainage.
Other Infrastructural upgrades	Replace roof covering, ceiling and roof drains with current Building Code Standards.	Ministry of Education in collaboration with Department of Works. *some smaller projects can be undertaken by school/community /private organization as a special project.	BBD$101,000	Medium	Increased building resilience; improved school plant.
	Upgrade doors and windows to hurricane resistant standards.		BBD$140,000	Medium	
	Repairs to toilets.		BBD$36,000	Long	
	Construct new water storage.		BBD$90,000	Medium - Long	
	Repairs to electrical wiring.		BBD$36,000	Medium	
	Painting to affected areas.		BBD$63,000	Short	

TABLE 8.1: IMPROVEMENT PLAN AND COSTED ACTION PLAN FOR ELLERSLIE SCHOOL

RECOMMENDATION	TASK	RESPONSIBLE PARTY	FUNDS REQUIRED	TIMEFRAME SHORT-MEDIUM -LONG TERM	RESULT
Effort needs to be taken to prevent free thoroughfare of pests (e.g. fixing of broken or missing windows/mesh on blocks)	Meshing of rooms with decorative/breeze blocks.	Principal and/or Safety Committee in collaboration with MOE.	BBD$11,500	Short - Medium	Minimize pest nuisance.
Need for improved use of personal protective equipment (PPE)	Obtain additional PPE, gloves, lab coats, and dust masks.	Principal and/or Safety Committee in collaboration with MOE.	BBD$11,500	Short	Improved personal safety.
	Contingency		BBD$38,000		

NOTE:
The recommended actions should commence in the following time periods:
Short term= 1-3 yrs; Medium term= 3-5 yrs; Long term= > 5 yrs

9. REFERENCES

Boruff, B. 2006. Historical Hazard Events for Barbados.

Bozzoni, Francesca & Corigliano, Mirko & Lai, Carlo & Salazar, Walter & Scandella, Laura & Zuccolo, Elisa & Latchman, J.L. & Lynch, Lloyd & Robertson, Richard. (2011). Probabilistic Seismic Hazard Assessment at the Eastern Caribbean Islands. Bulletin of the Seismological Society of America. 101. 2499-2521. 10.1785/0120100208.

Centre for Science in the Earth System (The Climate Impacts Group Joint Institute for the Study of the Atmosphere and Ocean University of Washington and King County, Washington In association with ICLEI- Local Governments for Sustainability, 2007. Preparing for Climate Change: A Guidebook for Local, Regional and State Governments.

DeGraff, J.V., Bryce, R., Jibson, R.W., Mora, S., and Rogers, C.T. 1989. Landslides: Their extent and significance in the Caribbean. In E.E. Brabb and B.L. Harrod (eds), Landslides: Extent and Economic Significance. p. 51-80. Rotterdam: A.A. Balkema.

Government of Barbados. 2018. Barbados' Second National Communication - Under the United Nations Framework Convention on Climate Change.

Inter-American Development Bank. 2010. Indicators of Disaster Risk and Risk Management: Program for Latin America and the Caribbean – Barbados
http://idbdocs.iadb.org/wsdocs/getdocument.aspx?docnum=35160013

Intergovernmental Panel on Climate Change [IPCC]. 2013. Climate Change 2013: The Physical Science Basis. Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom: Intergovernmental Panel on Climate Change, Cambridge University Press.

MEWRD. (2002). Gully Ecosystem Management Study. Bridgetown: Ministry of Environment, Water Resources and Drainage. Government of Barbados.

Nurse, L. A. 2011. Climate Change Impacts and Adaptation: A Challenge for Global Ports. Bridgetown: University of the West Indies, Cave Hill Campus.

Nurse, L. A., McLean, R., Agard, J., Briguglio, L. P., Duvat, V., Pelesikoti, N., et al. 2014. Small Islands. In Field, C. B., Barros, V. R., Dokken, D. J., Mach, K. J., Mastandrea, M. D., Bilir, T. E. et al. (eds), Climate Change 2014: Impacts, Adaptation and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge UK and New York: Cambridge University Press.

Simpson, M. C., Clarke, J. F., Scott, D. J., New, M., Karmalkar, A., Day, O. J., Taylor, M., Gossling, S., Wilson, M., Chadee, D., Stager, H., Waithe, R., Stewart, A., Georges, J., Hutchinson, N., Fields, N., Sim, R., Rutty, M., Matthews, L., and Charles, S. 2012. CARIBSAVE Climate Change Risk Atlas (CCCRA) - Barbados. DFID, AusAID and The CARIBSAVE Partnership Department of Emergency Management (DEM). 2014. Country Document for Disaster Risk Reduction: Barbados, 2014.

Simpson, M., Scott, D., Harrison, M., Silver, N., O'Keeffe, E., Harrison, S., et al. (2010). Quantification and Magnitude of Losses and Damages Resulting from the Impacts of Climate Change: Modelling the Transformational Impacts and Costs of Sea Level Rise in the Caribbean. Barbados: United Nations Development Programme (UNDP).

Smit, B. and O. Pilifosova. 2003. From adaptation to adaptive capacity and vulnerability reduction. In J.B. Smith, R.J.T. Klein and S. Huq, eds., Climate change, adaptive capacity and development. Imperial College Press, London.

Smit, B., et al. 2001. Adaptation to climate change in the context of sustainable development and equity. In J.J. McCarthy and O.F. Canziani, eds., Climate Change 2001: Impacts, adaptation and vulnerability. Contribution of Working Group III to the 3rd Assessment Report of the Intergovernmental Panel on Climate Change.

United Nations Office for Disaster Risk Reduction (UNISDR). 2009. Global Assessment Report on Disaster Risk Reduction: Risk and Poverty in a Changing Climate – Invest Today for a Safer Tomorrow.

United Nations Office for Disaster Risk Reduction (UNISDR). 2013. Global Assessment Report on Disaster Risk Reduction: From Shared Risk to Shared Value – The Business Case for Disaster Risk Reduction.

Websites

University of the West Indies (UWI) Natural Hazards and Disasters, Landslides in Barbados: Retrieved September 2019
https://www.mona.uwi.edu/uds/Land_Barbados.html

Organization of American States (OAS): Retrieved September 2019
http://www.oas.org/en/

The National Hurricane Centre (NHC), National Oceanic and Atmospheric Administration (NOAA). Retrieved: September 2019
https://www.nhc.noaa.gov/

FEMA Hazard Analysis Worksheet. Retrieved September 2019
https://www.fema.gov/hazard-identification-and-risk-assessment

Seismic Research Centre. n.d. Tsunamis in the Caribbean. University of the West Indies, St Augustine Campus. Retrieved: September 2019
http://www.uwiseismic.com/General.aspx?id=20

10. APPENDIX

10.1 MSSP ASSESSMENT TOOLKIT RESULTS

GENERAL INFORMATION

TABLE 10.1: VITAL INFORMATION FOR SCHOOL SAFETY

NAME OF SCHOOL	ELLERSLIE SCHOOL
Type of school (Pre-school, Primary, Secondary, Tertiary)	SECONDARY
Is facility private and public?	PUBLIC
Location	ST. STEPHEN ROAD, BLACK ROAD, ST. MICHAEL
Name of Head Teacher or Principal	LT. COL. ERROL BRATHWAITE
Telephone	(246) 535-6103
Email	principal@ellerslieschoolbb.org
Year building(s) constructed	1966
Buildings contained on the school compound	7
Number of classrooms	18
Total school population	70 Total Staff (23 non-teaching) 956 Students
Students	Male: 439 Female: 499
Teachers	Male: 25 Female: 43
Non-teaching Staff	Male: 9 Female: 14
Number of first aid kits available	15
Number of fire extinguishers throughout the buildings?	More than 20
Natural disaster in the past	NO
The type of event and the time it occur	N/A
Repairs as a result of the event	N/A
School designated as an emergency shelter	YES

OVERALL SCORES

TABLE 10.2: SCHOOL SAFETY ASSESSMENT SUMMARY		
CHECKLIST	**SCORE (%)**	**CRITICAL STANDARDS MET**
Safety	88%	NO
Green	89%	YES

The above scoring is calculated based on the questions and Critical Standards applying to secondary schools only.

SAFETY ASSESSMENT SCORES

TABLE 10.3: SAFETY ASSESSMENT SUMMARY SCORES		
SAFETY THEME	**SCORE (%)**	**CRITICAL STANDARDS MET**
Disaster Planning	95%	YES
Emergency Planning	89%	YES
Safety Admin	100%	
Medical Emergencies	89%	YES
Physical Plant	77%	NO
Physical Safety	100%	
Protection of the Person	94%	
Hazardous chemicals and materials	84%	YES

GREEN ASSESSMENT SCORES

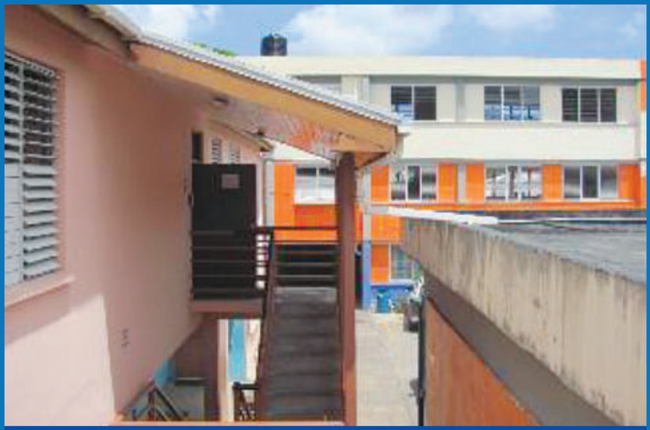
TABLE 10.4: GREEN ASSESSMENT SUMMARY SCORES		
SAFETY THEME	**SCORE (%)**	**CRITICAL STANDARDS MET**
Sustainability Management	87%	YES
Natural Resources	88%	YES
Indoor Environment	88%	YES
Hazardous Chemicals and Materials	84%	YES
Facility and Grounds Management	97%	YES
Food Service	90%	YES

10.2 SELECTED PHOTOGRAPHS

PANORAMIC VIEW

PANORAMIC VIEW

PANORAMIC VIEW



PANORAMIC VIEW

PANORAMIC VIEW

PANORAMIC VIEW

PARTIAL ELEVATIONS

PARTIAL ELEVATIONS

PARTIAL ELEVATIONS

LOWER LEVEL ADMINISTRATION BUILDING

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

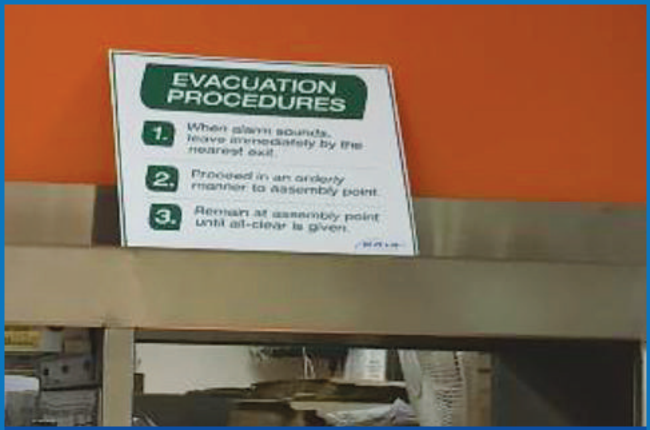
■ ELEVATIONS

■ ELEVATIONS

■ ELEVATIONS

■ ELEVATIONS

■ ELEVATIONS



■ ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ELEVATIONS

ROOF DRAINS

ROOF DRAINS

TOILETS

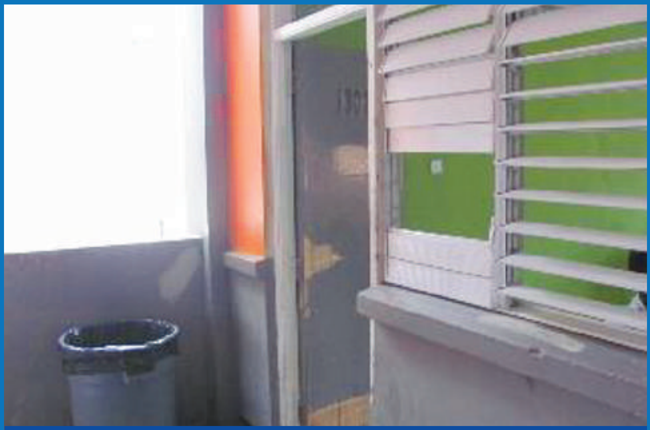
TOILETS

REINFORCED CONCRETE STRUCTURE

REINFORCED CONCRETE STRUCTURE

BROKEN FLOOR TILES

BROKEN WINDOW



BROKEN WINDOW

BROKEN WINDOW

BROKEN DOOR

BROKEN DOOR

■ FLOOR SLAB – REPAIRED CRACKS

■ POSSIBLE SIGNS OF MOLD

■ POSSIBLE SIGNS OF MOLD

■ ELECTRICAL SWITCH PROTECTIVE PLATE

■ STORM WATER INTAKE APPEARS INADEQUATE

■ STORM WATER INTAKE APPEARS INADEQUATE

STORM DRAINS

STAIRWELL

PLAY AREA

SHAD TREE

BURGLAR BAR PROTECTION

MAIN ENTRANCE

■ MAIN ENTRANCE

■ TIMBER STRUCTURES – (SIXTH FORM)

■ TIMBER STRUCTURES – (SIXTH FORM)

■ TIMBER STRUCTURES – (SIXTH FORM)