Western Port Local Coastal Hazard Assessment

Report 3 (R03) – Methodology Overview

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1. INTRODUCTION

1.1 Background

Melbourne Water commissioned Water Technology to undertake the Western Port Local Coastal Hazard Assessment (WPLCHA) project. The project has come about through a partnership between Melbourne Water, the Department of Environment and Primary Industries, South East Councils Climate Change Alliance, Bass Coast Shire Council, Cardinia Shire Council, City of Casey and Mornington Peninsula Shire Council.

The WPLCHA is a component of the Department of Environment and Primary Industries Future Coasts program, and Western Port is one of four priority sites in which local coastal hazard assessments have or are currently being undertaken.

1.2 Scope

As detailed in the project brief, the scope of the WPLCHA is to provide information on the extent of coastal hazards and their physical impacts for the Western Port coastal environment. The WPLCHA is focussed on assessing the physical hazards of erosion and inundation. It does not include any subsequent detailed assessment of impacts of the hazards on built, economic or social infrastructure, assets or values and does not include preparing adaptation responses to the physical hazards.

The information developed by the project will assist in planning for and managing coastal hazards. It will allow management agencies and other key stakeholders to identify and define triggers as the basis for short, medium and long term management responses. Specifically, the information will provide information, data and mapping to inform consistent policy and practice and support agencies in identification and management of risk, and undertake; strategic planning, statutory planning, infrastructure maintenance and replacement schedules, natural asset management, and business planning and budgetary processes that are responsive to a changing climate, its impacts and opportunities.

The boundaries of the study area for the WPLCHA project and described as follows:

- Cape Schanck to West Head, along the shoreline of Western Port to the bridge at San Remo
- Inland from the Western Port shoreline will remain undefined enabling the assessment to be as far into the catchment as relevant
- All of the coast of French Island and the north side of Phillip Island from the bridge at Newhaven to the western extremity of Phillip Island (Seal Rocks), but excluding the south side of Phillip Island from Seal Rocks to the Bridge at Newhaven.

The study itself was undertaken in two main components:

- Part A - a broad scale Western Port wide coastal hazard assessment, and
- Part B - four local scale coastal hazard assessments.

1.3 Objectives

The purpose of this document is to provide a general overview of the study methodology and to confirm the format and extent of the study outputs for the Project Steering Group.

The document is structured as follows:

- Section 2 – Outlines the broad study methodology including the assessment scenarios,
- Section 3 – Provides an overview of the inundation hazard assessment method,
- Section 4 – Provides an overview of the erosion hazard assessment method, and

- Section 6 – Confirms the format and extent of the study outputs

This document is Report 3 of a series of reports produced as part of the Western Port Local Coastal Hazard Assessment project. It should be read in conjunction with the following:

- Report 1: Summary Report
- Report 2: Data Review
- **Report 3: Methodology Overview**
- Report 4: Inundation Hazards
- Report 5: Erosion Hazards
- Report 6: Critical Locations

2. STUDY METHOD OVERVIEW

The study has been undertaken utilising a risk management framework in accordance with ISO/SA/NZS 31000. The risk management framework provides a systematic framework for structuring the study and for managing the significant uncertainty inherent when assessing coastal and inundation hazard risks associated with climate change over long timeframes. This approach also aligns with the risk methodology outlined in the Victorian Coastal Hazard Guide as well as the Victorian Floodplain Management Strategy and will ensure consistency with these important documents and subsequent coastal/flood hazard assessments in Victoria.

2.1 Context

In order to set the general context for the study a thorough review of the historical, scientific, policy and planning context within which the coastal hazard assessment for the study area is undertaken has been completed. The review included the following components:

- An overview of the extent and magnitude of historical flooding in Western Port will be undertaken. The review considered characteristics of the basin flood hydrology and extent and scale of any recent flooding impacts for settlements around Western Port.
- A review of the historical records and extent of coastal hazard impacts in the study area based on available literature and information sources. The purpose of the review has been to provide a detailed account of the type, extent, historical frequency and cause of significant coastal hazard impacts in the study area. The review has assisted in identifying the major types of coastal hazard risks to the study area and the main processes that give rise to these hazards.
- Current Federal and State Government policy and guidance relating to the consideration of climate change and coastal/flood hazard impacts has been considered in the context of this study.
- The primary objectives of the study and the spatial and temporal scales over which the study assessment applies have been assessed.
- The main project stakeholders and their associated responsibilities have been reviewed including discussion with the stakeholders as to how the outputs from the study will be used to guide decision making and planning for these agencies.
- The relationship of this study to previous and current projects considering the impact of climate change and adaptation options for the study area.

2.2 Hazard Identification

The sources of hazard and their potential impacts in the study area have been identified, focusing on inundation and erosion hazards. For each of the potential hazard sources and pathways, a detailed assessment of the magnitude of these hazards and the processes/factors associated with the source of the hazards has been undertaken. Details of these hazard identification and assessment on a broad Western Port scale are provided in Report 4: Inundation Hazards and Report R05: Erosion Hazards of this study. Quantification of the impact of future climate change scenarios on the sources of potential hazards has been included.

A more detailed assessment of coastal hazards at four critical locations is detailed in Report 6: Review of Critical Locations.

2.3 Coastal Hazard Analysis

2.3.1 Overview

The coastal hazard analysis integrates the physical processes occurring in the study area to assist in evaluation of the coastal hazard extents for a range of sea level rise scenarios. The analysis has involved the application of a number of numerical modelling tools to simulate a range of forcing/boundary condition scenarios to provide quantitative predictions of the coastal hazard extents within the study area. Numerical, empirical and analytical methods have been employed as part of the analysis to estimate hazard extents. The choice of method has been dependent upon the process being investigated and the current best available knowledge on sea level rise response.

The Part A and Part B reports (Reports 4, 5 and 6) provide details of all specific analyses undertaken, and the reasons behind the choice of a particular approach.

The hazard analysis has identified sources of uncertainty in both available data and knowledge and where possible these uncertainties have been evaluated to assess the impact on the extent of the coastal hazard risks identified across study area. Any outstanding data or knowledge gaps are discussed in the Part A and Part B reports (Reports 4, 5 and 6).

2.3.2 Coastal Hazard Scenarios

The Victorian Coastal Strategy (Victorian Coastal Council, 2008) requires planning for sea level rise of not less than 0.8 m by 2100, which is reflected in the three sea level rise scenarios up to + 0.8 m that have been considered in this study.

The three scenarios of combined storm tide, wave height, catchment flow and sea level rise were selected from those presented in the project brief to form the basis of the coastal hazard assessment (Table 2-1). The scenarios all included the 1% annual exceedance probability (AEP) storm tide and wave height and 10% AEP catchment flows, with current sea level, +0.2 m sea level rise, +0.5m, and +0.8 m sea level rise. A sea level rise of +0.2m is considered about as likely as not in 2040, and a sea level rise of +0.8 m is considered about as likely as not by 2100 under current climate projections.

Table 2-1 Coastal hazard scenarios

Present	2040	2070	2100	Combination of events to assess coastal hazards	Scenario
Likely	Virtually Certain			1% AEP storm tide and wave height with 10% AEP catchment flows	Base
Unlikely	About as likely as not	Likely	Virtually Certain	0.2 m of sea level rise plus 1% AEP storm tide and wave height with 10% AEP catchment flows	1
Very Unlikely	Unlikely	About as likely as not	Likely	0.5 m of sea level rise plus 1% AEP storm tide and wave height with 10% AEP catchment flows	2
		Very unlikely	About as likely as not	0.8 m of sea level rise plus 1% AEP storm tide and wave height with 10% AEP catchment flows	3

The storm tide and catchment inundation conditions have been modelled separately and the resultant inundation combined within the project GIS. Details regarding this approach are provided in Report 4.

3. INUNDATION HAZARDS

3.1 Overview

A number of townships are located adjacent to the shorelines of Western Port lie at relatively low elevations and are therefore vulnerable to inundation associated with elevated water levels. Extreme elevated water levels within Western Port are a function of a number of different physical forcings and hydrodynamic processes including coastally driven water levels, wind and wave set-up and catchment generated streamflows, Figure 3-1. Detailed hydrodynamic modelling was used to integrate these processes to enable estimates of extreme water levels to be assessed and predict how the processes respond to increased mean sea levels.

Analysis of the terrestrial LiDAR prior to the modelling highlighted the low and vulnerable nature of the plains surrounding Westernport, particularly surrounding Tooradin, and from Main Drain to Jam Jerrup. At present the low lying plains are protected by a series of informal levees or elevated topographic features constructed by land owners. The importance of these coastal levees is highlighted in the cross-section extracted from the terrestrial LiDAR near Lang Lang, shown in Figure 3-2.

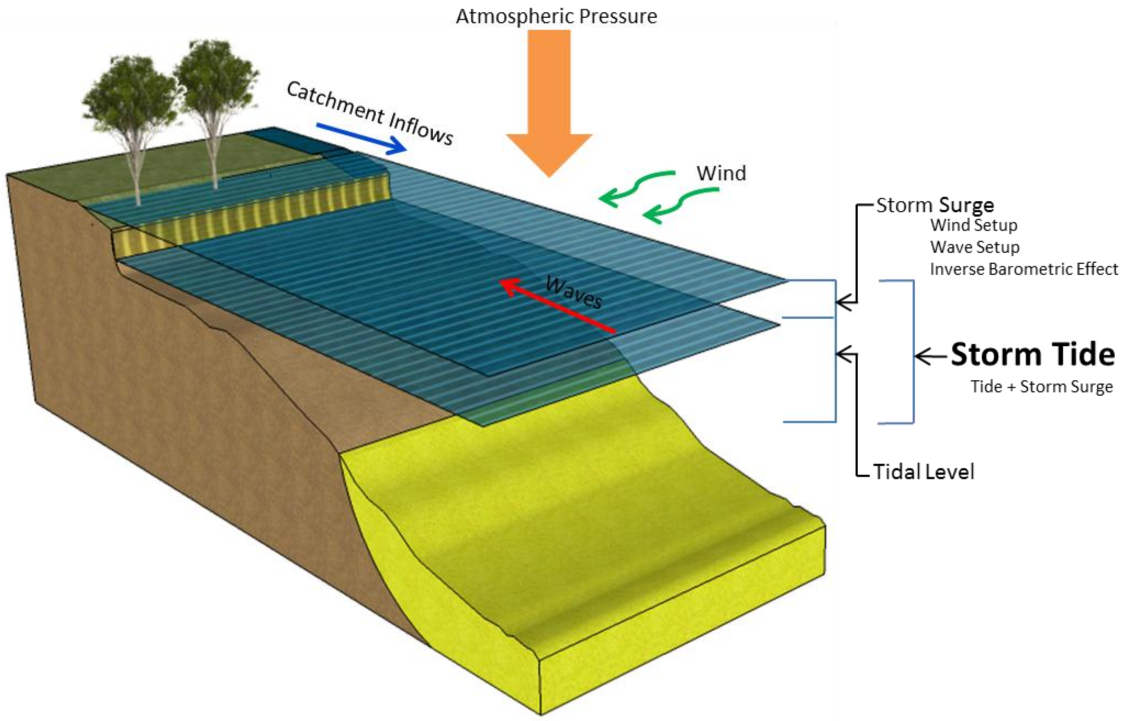

Figure 3-1 Schematic Showing the Main Processes Contributing to Inundation in Westernport

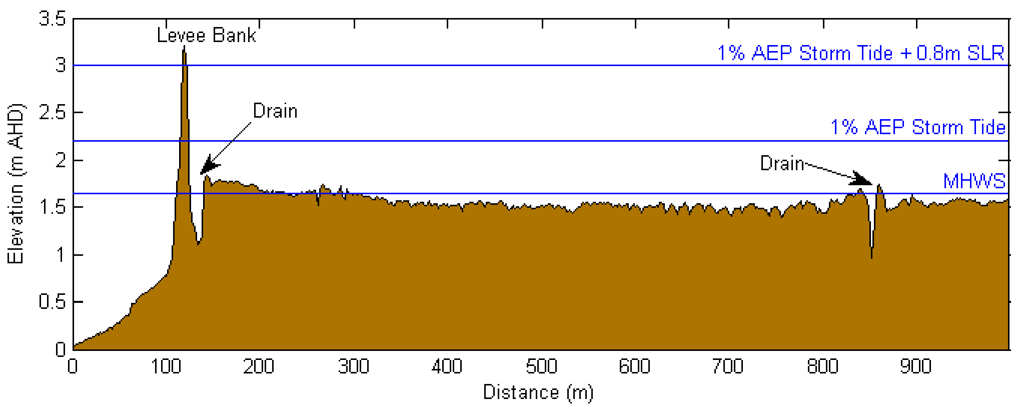

Figure 3-2 Topographic Cross-section Extracted from the Terrestrial LiDAR Near Lang Lang. *The MHWS level is based on hydrodynamic modelling undertaken as part of this project and the 1% AEP Storm Tide level is from McInnes et. al., (2009).*

3.2 Methodology

3.2.1 Overview

A coupled hydrodynamic and spectral wave model of Westernport was developed in order to test a range of coastal inundation scenarios under various sea level rise scenarios. The model extended from approximately 10km into the Bass Strait offshore of Phillip Island, and inland covering all areas surrounding Westernport below approximately 3.0 m AHD. The model was calibrated to known tidal constituents, gauged water level data at Stony Point and Tooradin, ADCP data, and measured wave conditions at Jam Jerrup, Lang Lang and Grantville.

An overview of the conceptual process used for the inundation modelling is shown in Figure 3-3.

In addition to the surface water inundation hazards a high level overview of groundwater hazards in Westernport was also undertaken. This included a review of current hazards within the study area and identification of potential future hazards.

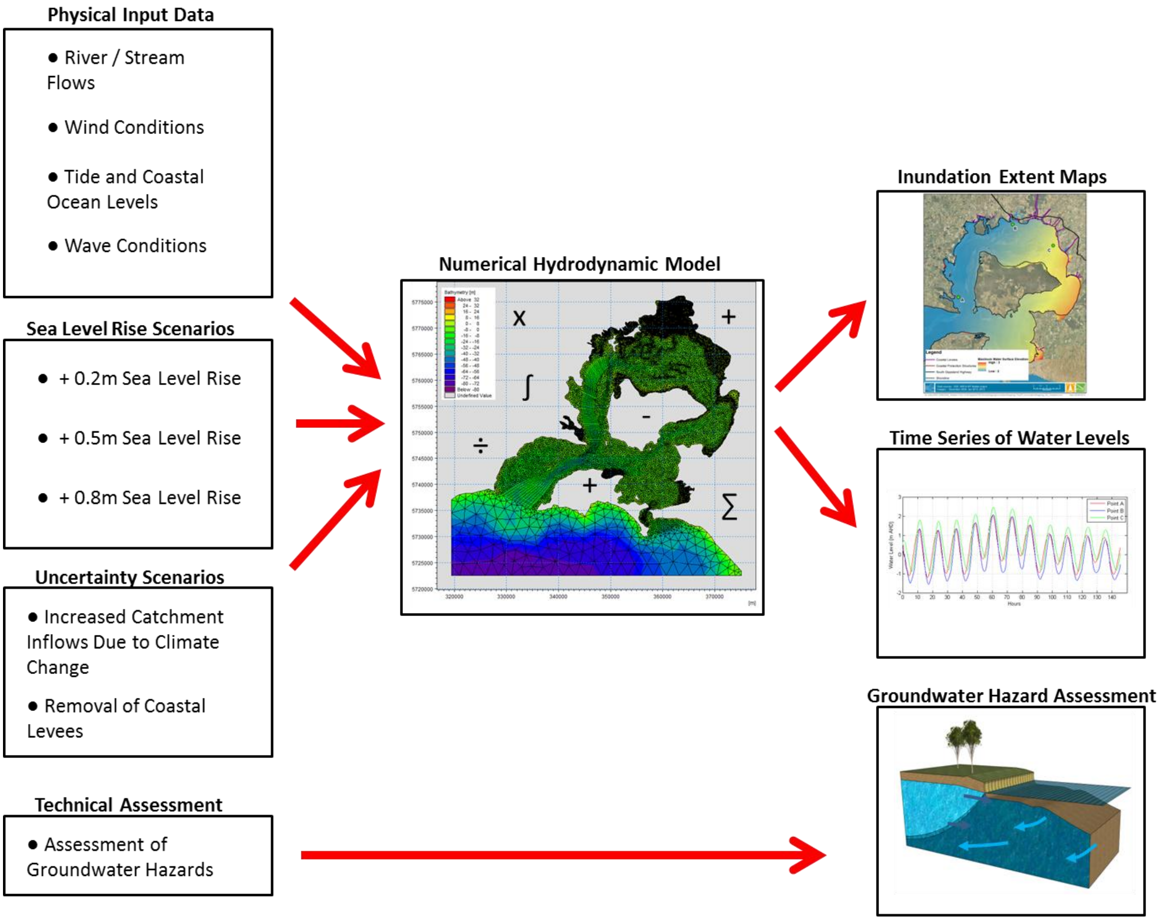

Figure 3-3 Conceptual Process by which the Inundation Hazards throughout Westernport were Assessed

3.2.2 Design Boundary Conditions

Extreme storm tide conditions in Western Port can potentially be generated from a large range of different tidal, storm surge and wind- wave combinations. Therefore, analysis of the available water level, wind, wave, and catchment inflow data was analysed and a set of design boundary conditions derived representing the 1% AEP storm tide, wind and wave conditions and the 10% AEP catchment inflow conditions. Detailed explanations of how the boundary conditions were derived are given in Report 4 – Inundation Hazards, and the conditions are summarised in Table 3-1. The three sea level rise scenarios were simulated by raising the offshore boundary water level time series and initial condition water levels by +0.2, +0.5 and +0.8m above the corresponding existing conditions water levels.

Table 3-1 Summary of the Derived Representative Conditions Used to Force the Hydrodynamic Model

Physical Process	Derived Conditions
Astronomical Tidal Water Level (at Stony Point)	1.16m AHD
Maximum 1% AEP Storm Surge Water Level (at Stony Point)	0.82 m AHD
Total 1% AEP Maximum Storm Tide Water Level (at Stony Point)	1.98 m AHD
1% AEP Wind Conditions (Constant over Domain)	25.1 m/s from the NW
1% AEP Wave Conditions (at the Offshore Model Boundary)	5.2 m (significant) from 210° with a Peak Period of 12s
10% AEP Catchment Inflows	• Bunyip River = 103 m^3/s • Lang Lang River = 196 m^3/s • Bass River = 63 m^3/s • Yallock Outfall = 145 m^3/s • Cardinia Creek = 47 m^3/s • Toomuc and Deep Creek = 76 m^3/s • Tooradin Inlet Drain = 19.5 m^3/s • Muddy Gates Drain = 9.5 m^3/s

4. EROSION HAZARDS

4.1 Overview

Various assets, ranging from economic to environmental, are located adjacent to the shorelines of Western Port and lie at relatively low elevations making them vulnerable to inundation and erosion associated with sea level rise. Shoreline erosion within Western Port is a function of a range of key processes and different physical forcing factors, the relative importance of which vary considerably depending on the shoreline geology and morphology. Detailed assessments including hydrodynamic modelling have been used to integrate these processes to enable estimates of potential shoreline erosion to be developed taking into account how the processes respond to increased mean sea levels.

4.2 Methodology

The broad scale assessment of potential coastal erosion hazards undertaken for this study is detailed in Report 5: Erosion Hazards. The key elements of the assessment method are described below.

- **Identification of the physical, environmental and biological characteristics of the Western Port shoreline which contribute to or impact upon potential shoreline erosion hazards**;

  The characteristics and susceptibility of the shorelines of Westernport to coastal hazard impacts, including sea level rise, is integrally related to the nature and variations in geology, geomorphology, coastal vegetation and the hydrodynamic setting that exists in Western Port. These aspects were assessed through literature reviews, site visits, aerial photograph interpretation, technical workshops and expert discussion to provide a broad overview of the nature and variability of the physical environment of Western Port as a basis for understanding the potential type, extent and susceptibility of the shorelines of Western Port to coastal hazards.

  Key outputs included:

- Developed an understanding of the geologic context of the study area and the variations in the major landforms within the study area
- Development of an understanding of the extent and processes in which the study area coastline has responded to pre-historic sea level variations.
- Identification of the role of vegetation (mangroves, salt marsh etc) in influencing shoreline morphology and evolution within the study area.

- **Delineation of the Western Port shorelines into major shoreline classes based on key geomorphic/ecologic characteristics, relevant processes and rates of change;**

  Using the extensive review of the regional geology, geomorphology and coastal landform evolution a series of shoreline classes were identified. For each shoreline class conceptual models were developed to understand the temporal and spatial scales and variability over which these landforms have evolved historically and could be expected to evolve in the future due to climate change in the study area.

  The review of the ecology of Western Port identified the key peripheral vegetation communities, their spatial distribution and indicators of their current condition, ability to modify the shoreline or protection against erosion, and likely responses to long term sea level rise. This knowledge was incorporated into the conceptual models for specific shoreline types were appropriate.

  Key outputs included:

  - Delineation of appropriate coastal/shoreline sub-cell regions for the study area to inform subsequent erosion hazard assessments. The delineation of the coastal/shoreline sub-cell regions has informed the appropriate boundaries of the critical locations.
  - Development of conceptual models for the geomorphological and vegetation communities around Western Port in relation to their current ability to modify the shoreline environment and potential trajectories of change under sea level rise scenarios.

- **Definition and refinement of the potential coastal hazard extents throughout the study area for each major shorelines class with specific focus on potential future hazard extents under a series of sea level rise scenarios**.

  Based on the conceptual model developed for each shoreline class the key drivers and rates of change of erosion along the shoreline were investigated. Tools applied included:

  - Expert interpretation of existing literature and field measurement data,
  - Outputs from the hydrodynamics modelling, such as coastal water levels and wave climate,
  - Analytical approaches such as Brunn (1962),
  - Slope failure assessment through analysis of terrain information and aerial imagery,

  For some shoreline classes more than one tool was applied in order to understand the critical processes under current mean sea level condition and develop a set of rules/method to enable the processes and rates of change predicted due to sea level rise for each shorelines class to be translated to a mapped extent in a GIS.

- **An evaluation of the significance of uncertainty relating to the key processes and drivers of change within each major shoreline class on potential future extents of coastal hazards with sea level rise.**

  The approach to assessing the sensitivity of the shoreline estimates to uncertainty was dependent on the shoreline type and the method employed to assess future change.

5. CRITICAL LOCATIONS

5.1 Overview

Recommendations were made at the completion of Part A (Reports 4 and 5) as to which locations warranted further more detailed local scale investigations in Part B of the project.

Based on discussions with the project steering group, four locations were then selected for the Part B assessment, and included:

- Somers (Mornington Shire Council)
- Tooradin and coastal villages (City of Casey)
- Lang Lang shoreline – Main drain to Jam Jerrup (Cardinia Shire Council)
- Rhyll Inlet and Silverleaves (Bass Coast Shire Council)

The focus of the critical location assessments in Part B was to review available site specific data, knowledge and models for each critical location, with the objective of reducing or testing the extent of uncertainty in the potential coastal hazard impacts associated with sea level rise.

5.2 Methodology

Due to the fundamental differences in the geology and physical environment at each critical location, the methodology employed to assess the potential extent of coastal hazards was tailored to the specific geologic setting and critical processes of interest at each site and comprised the following main components:

- A detailed review of:
  - The local geology and coastal geomorphology;
  - The key local hydrodynamic influences, such as waves or currents based on the existing hydrodynamic and wave models;
- Identification of the key local hazards and assessment of historic changes and potential future rates of change under sea level rise scenarios;
- Evaluation of the significance and sources of uncertainty in the analysis;
- Updated mapping of coastal inundation and erosion hazard zones; and
- A preliminary risk analysis of the potential risks posed by the hazards identified.

5.3 Risk Evaluation

As noted above, while not specifically requested as part of the study brief, a preliminary risk analysis has been undertaken for each of the four critical locations examined in Part B (Report 6) to provide guidance on the significance of the coastal hazard, the associated risks, and to inform subsequent decision making and planning at these locations.

The risk analysis has been undertaken by evaluating scores on the likelihood and consequence of each relevant coastal hazard components impacting assets or other relevant social and environmental value categories within the critical location over relevant timeframe/sea level rise scenarios this century. The likelihood and consequence scales have been adopted from the Victorian Coastal Hazard Guide (2012).

6. STUDY OUTPUTS AND OVERLAYS

The study has developed the following primary products/outputs to assist in communicating the predicted extent of the climate change related hazards within the study area and to assist the Steering Committee and Technical Group with their planning and statutory responsibilities.

- Detailed reports including descriptions of all data, analysis, modelling methods and model calibration, scenario modelling outputs, discussions relating to assumptions and uncertainty with the study assessments and recommendations for further investigations and monitoring.
- A concise, non-technical, standalone executive summary detailing the outcomes of the assessment.

Accompanying these documents is a project geographical information system (GIS), which includes the following outputs from the inundation and erosion hazard assessments:

- Digital geo-referenced data, including shape files of inundation and erosion hazard areas for the present mean sea level situation and for future sea level rise events.
- Digital field data acquired for the study, including location, elevation and summary output.
- Relevant model set-up and run files.