7.1 Introduction

The objective of the storm surge analysis is to assess the future risk of inundation at the study site due to the combined impact of potential future sea level rise due to climate change and likely storm surge. This information can then be used to inform decisions regarding the development of effective storm surge mitigation measures as it provides essential information for adopting optimum storm surge prevention measures, and for developing effective warning system as well as evacuation and emergency plans.

7.1.1 Mean Sea Level Rise Associated with Climate Change

According to the Climate Change in Australia Technical Report (CSIRO 2007, Section 5.7, (http://www.climatechangeinaustralia.gov.au/technical_report.php)), climate change causes a mean sea level rise (MSLR) as a result of two main processes - the melting of land-based ice which increases the height of the ocean, and a decrease in ocean density which increases the volume and hence the height of the ocean. The report outlines projections of a global MSLR of between 18 cm and 59 cm by 2100 (depending on the Intergovernmental Panel on Climate Change (IPCC) emissions scenario), with a possible additional contribution from the melting of ice sheets of 10 cm to 20 cm.

However in March 2009, the International Alliance of Research Universities held an international scientific congress on climate change, *Climate Change: Global Risks, Challenges and Decisions*, which was held in Copenhagen. At that conference, new observations of the increasing loss of mass from glaciers, ice caps and the Greenland and Antarctic ice sheets lead to predictions of a global MSLR of 1 m (±0.5 m) during the next century, about double the IPCC projections from 2007.

7.1.2 Storm Surge

A storm surge is the local change in the sea surface elevation due to the combined effect of falling atmospheric pressure associated with the passing of a weather system and intense winds which push the water against the coast. The combined effect of the weather system and persistent winds over a shallow water body is the most common cause of a storm surge and resultant flooding problems.

The term storm surge may apply to the rise of water associated with the storm, plus tide, wave run-up, and freshwater flooding.

An analysis of storm surge in addition to climate change related MSLR is important as a storm surge that occurs on a higher mean sea level will enable inundation and damaging waves to penetrate further inland.

7.2 Methodology

7.2.1 Topography and Bathymetry Data

The follow two sets were adopted for the storm surge assessment:

- Bathymetry data for Twofold bay was digitised from the Australian Hydrographic Service Chart AUS192, dated 14/11/03 and printed 23/06/08.
- Two metre height interval topographic data was acquired from the NSW Department of Lands.

These data sets were combined to produce a data set that would allow for the development of contour maps suitable for the purposes of representing worst-case inundation for Twofold Bay.

7.2.2 Tide Data

For the purposes of assessing storm surge within Twofold Bay, hourly tide data for the 24 year period of 17/09/86 through 01/05/09 from the Eden tidal gauge was obtained. The tidal record was analysed for the maximum sea level recorded at the site for each year with results summarised in **Table 7-1**.

Table 7-1 Maximum Recorded Annual Sea Level for Eden Gauge

Year	Maximum sea level (m AHD)	Year	Maximum sea level (m AHD)
1986	0.81	1998	1.21
1987	1.07	1999	1.24
1988	1.06	2000	1.15
1989	1.08	2001	1.21
1990	0.94	2002	1.17
1991	0.93	2003	1.15
1992	0.96	2004	1.00
1993	0.92	2005	1.09
1994	1.17	2006	1.03
1995	1.29	2007	1.13
1996	1.04	2008	1.15
1997	0.96	2009	0.96

7.2.3 Data Analysis

The Log-Pearson Type III Distribution technique is the applied methodology recommended by the U.S. Water Advisory Committee on Water Data (1982) for flood frequency analysis. It is used to describe the probability of a given event to occur:

- during a number of events occurring in a fixed period of time;
- if these events occur with a known average rate; and
- if these events occur independently of the time since the last event.

The sea level corresponding to a range of storm return periods was estimated using this technique to analyse the data presented in **Table 7-1**.

Summarised in **Table 7-2** and depicted in **Figure 7-1** are the results of the analysis for a range of storm return periods.

Table 7-2 Results of the Log-Pearson III Analysis

Return Period (years)	Skew Coefficient	Sea Level (m AHD)
2	0.0899	1.07
5	0.8564	1.17
10	1.2099	1.22
25	1.5511	1.27
50	1.7538	1.30

Figure 7-1 Sea Level Frequency Analysis for Eden

7.3 Assessment of Potential Impacts

A combination of a one metre rise in sea level and the 1 in 50 year return period sea level elevation (storm surge) (**Table 7-2**) were used to develop the inundation contour map presented in **Figure 7-2** for Twofold Bay, and the site profiles for the study site presented in **Figure 7-3**.

Cumulative impacts of storm surge and climate change within Twofold Bay are predicted to have the greatest impact on Aslings Beach located on Calle Calle Bay to the north and Whale Beach, Kiah Inlet and Towamba River to the south west.

In terms of direct impacts on the project, the analysis highlighted the site is sufficiently elevated above the current sea level (30 m AHD) to allow for sea level rise associated with storm surge inundation and climate change with no significant increases in the potential for adverse impacts.

7.4 Mitigation Measures

The scale of predicted impacts does not suggest the need for specific mitigation measures.

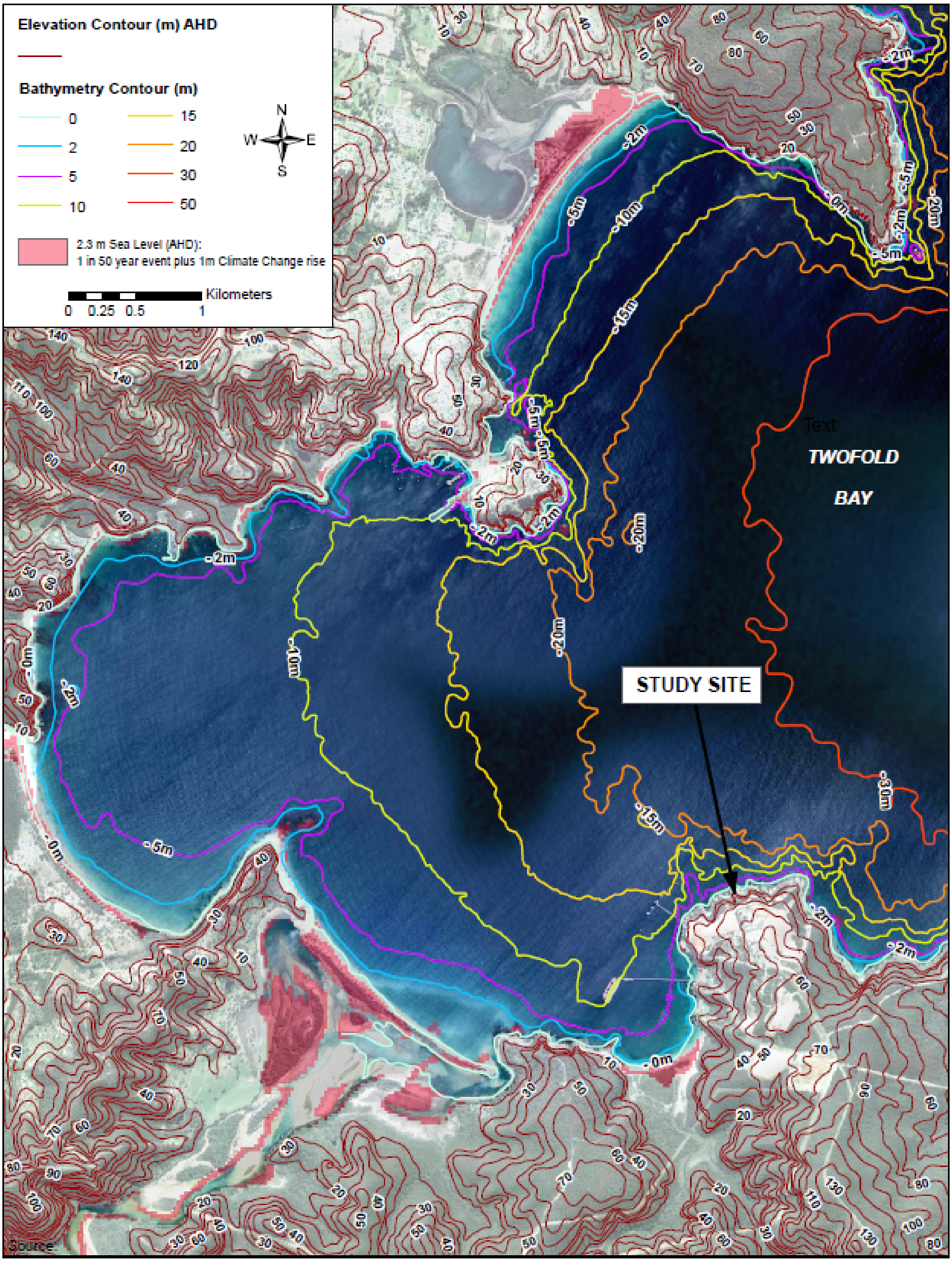

Figure 7-2 Inundation Map for a 1 in 50 Year Storm Combined with 1m Rise in Sea Level

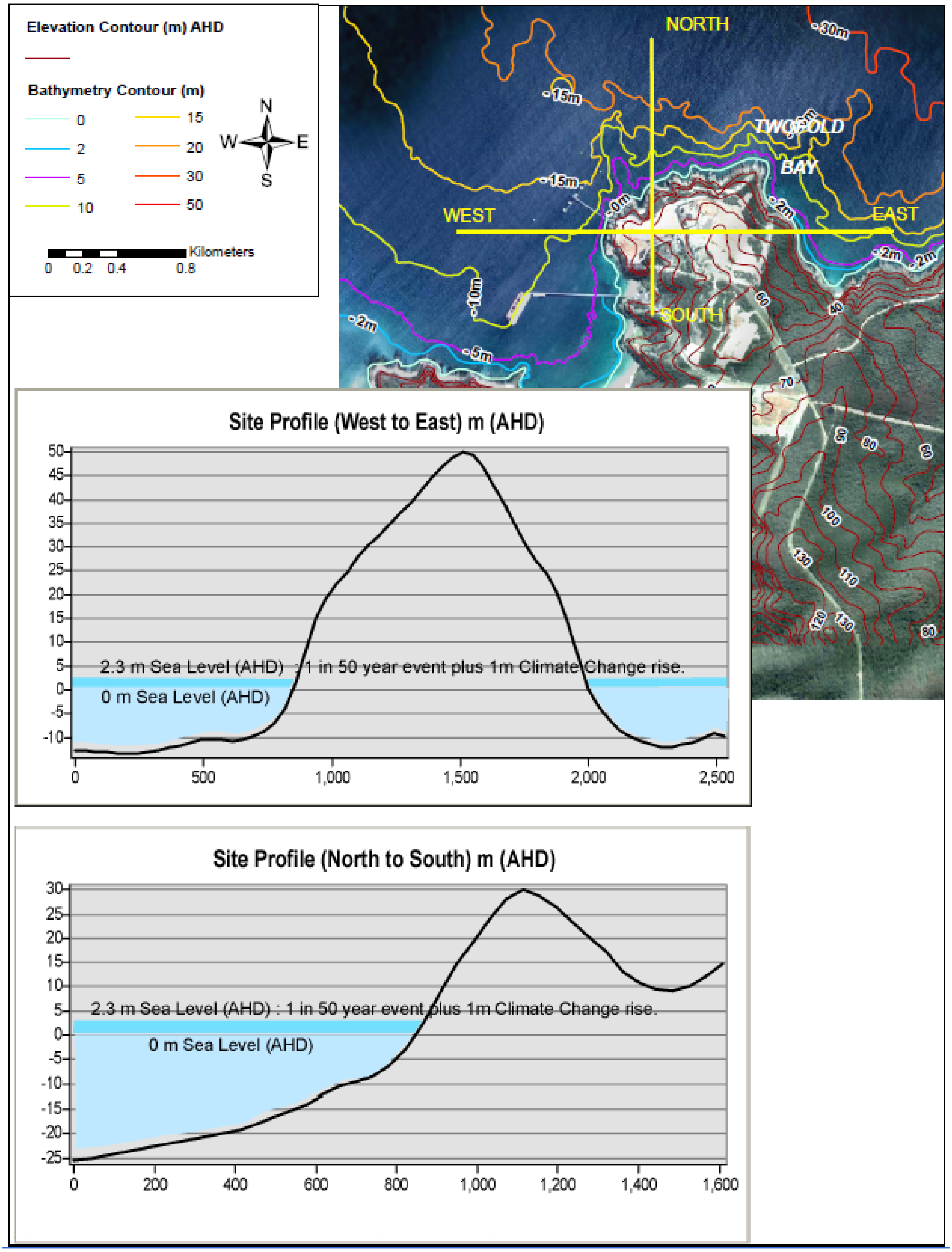

Figure 7-3 Profiles for a 1 in 50 Year Storm Combined with 1m Rise in Sea Level