PLANNING MANUAL

Supporting Land Use Decision Making in the Republic of Kiribati

coastal zone management pty ltd

Kiribati Adaptation Project

KAP II: Component 1.3.2

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About This Manual

This Manual is designed to provide guidance to decision makers by summarising the key outcomes of work conducted under two components of the Kiribati Adaptation Program (KAP II) (Component 1.3.2 and Component 1.4.0). Consultants involved in each of these components of the KAP II worked in unison to develop information on projected sea level rise in Kiribati and the hazard extent relative to each projected sea level rise, including , storm tide levels.

This information is valuable for decision makers across Government departments and should be readily accessible for inclusion in decision-making processes. Consequently, the objective of this Manual is to summarise the primary outcomes of the work conducted to establish projected sea level rise in Tarawa under a range of timeframes and scenarios. This information should be applied to support decisions across the government of Kiribati (GoK) that influence the use and development of land and its resources. For example, the information may support decision making for urban development and the location and design of key infrastructure.

A number of other reports and tools have been produced through this work. These include:

- Coastal calculator handbook;
- Coastal calculator tool;
- Risk assessment handbook; and
- Adaptation planning handbook.

The relationship between this Planning Manual and other key reports produced through Component 1.3.2 and 1.4.0 are shown in Figure 1. The reports are referenced in this Manual and are available in full from the KAP II Project Management Unit.

Document Outline

Section 1 provides results for mean levels of the sea, storm tide levels (extreme sea levels) for the Tarawa lagoon shoreline and for storm tide + wave set-up levels for the Tarawa ocean shore, for the three selected I-Kiribati climate change scenarios and three timeframes. This information is derived from the coastal calculator (as presented in Chapter 3 of the Coastal Calculator Operational Handbook).

Section 2 provides hazard extent maps that indicate the level of inundation during mean high water springs (MHWS) for the three selected I-Kiribati climate change scenarios and three timeframes, based on the information presented in Section 1.

Section 3 is an accompanying data CD that contains Google earth files. The files can be opened in Google earth and indicate the projected extent of inundation during MHWS and storm events for the highest I-Kiribati climate change scenario (A1FI) and four timeframes (2030, 2050, 2070 and 2100).

Those in the Government of Kiribati, and those supporting the government, can use the information presented in the Manual, to incorporate sea level rise inundation risk into decision making.

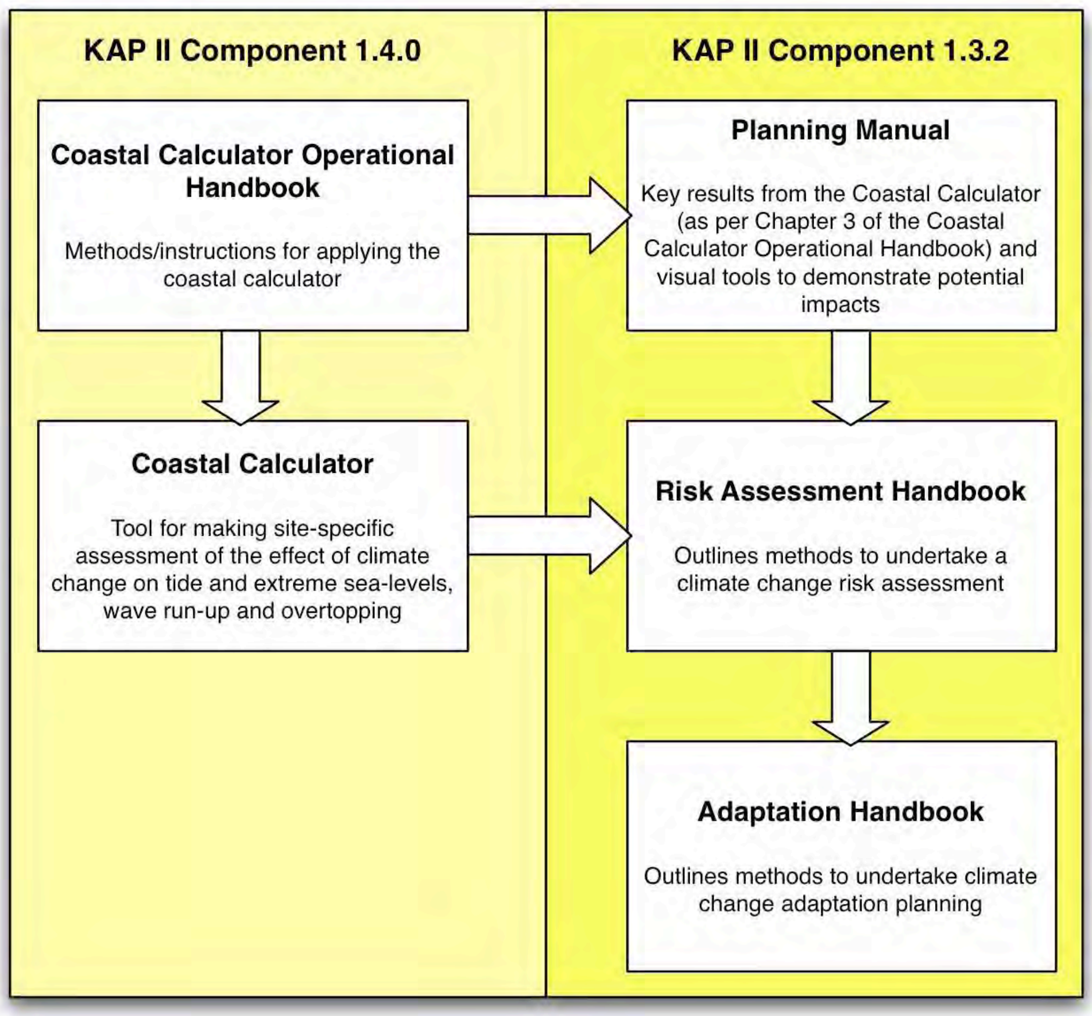


Figure 1: Supporting documents

Section 1: Sea level rise projections

This chapter presents the projected change in mean level of the sea and storm tide levels for three different climate change scenarios and timeframes. The information presented in this chapter is drawn from the Coastal Calculator Operational Handbook.

The data presented in this chapter may be applied to enhance the mainstreaming of climate change into land and development planning, by enabling:

- Setting minimum ground levels or floor levels for the construction of new buildings (or rebuilding) by the Government.
- Engagement with community regarding minimum ground levels for building (or rebuilding) of community buildings and infrastructure.

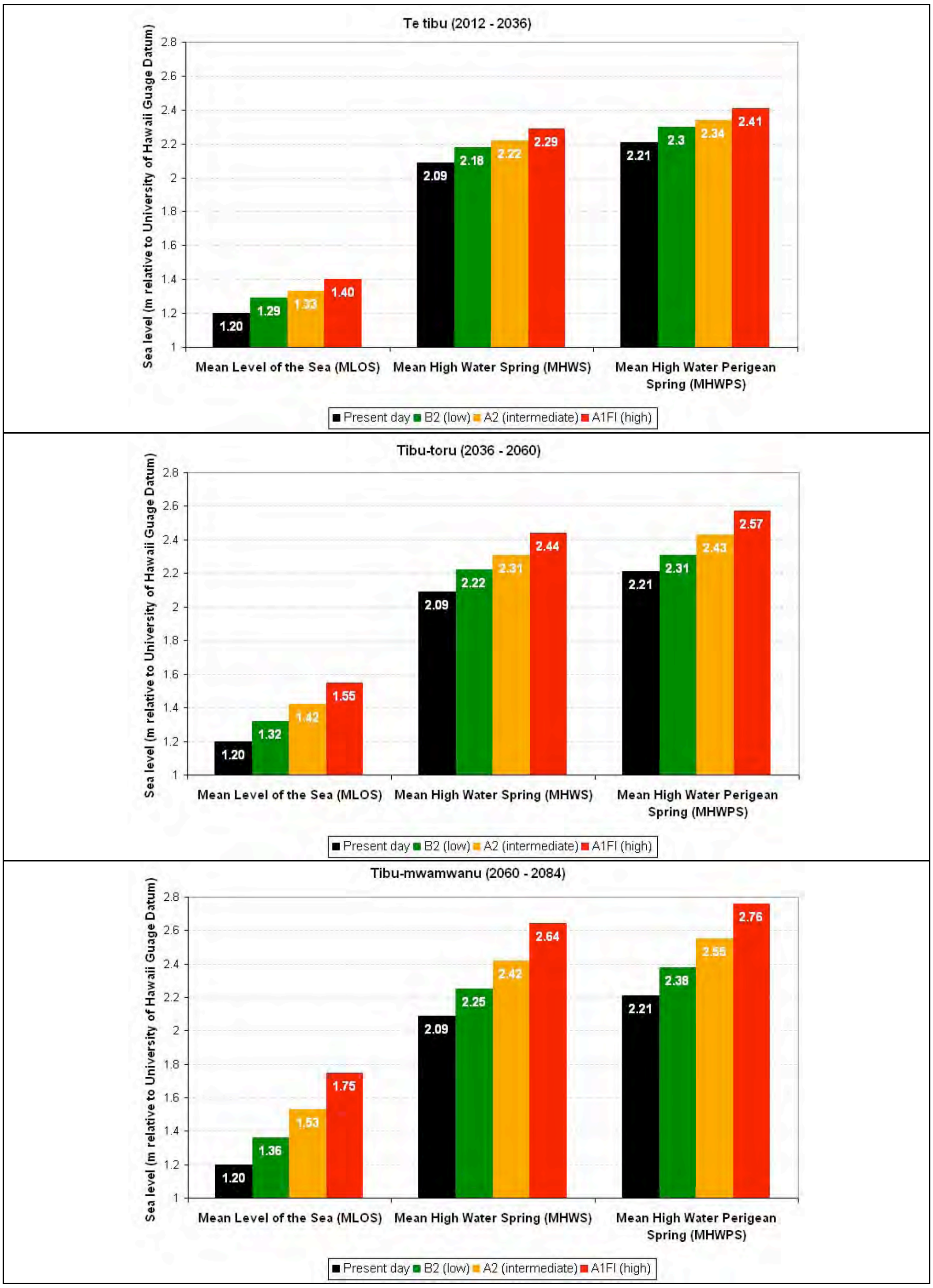
The coastal calculator will need to be applied using appropriate parameters for the local reef and shoreline characteristics (see the *Coastal Calculator Operational Handbook* for further information for consideration of:

- Different timeframes or climate change scenarios; and
- Assessment of local inundation potential immediately behind the shoreline where wave run-up and overtopping may be a factor,).

Location / water level information	Timeframe	Location in Figure
Tide levels (MLOS,MHWS, MHWPS)	Te tibu (2012-2036) Tibu-toru (2036-2060) Tibu- mwamwanu (2060-2074)	Top Centre Bottom
Lagoon shoreline 10%, 2% & 1% AEP storm tide levels	Te tibu (2012-2036) Tibu-toru (2036-2060) Tibu- mwamwanu (2060-2074)	Top Centre Bottom
Tarawa ocean shore (south) 10%, 2% & 1% AEP wave set-up levels	Te tibu (2012-2036) Tibu-toru (2036-2060) Tibu- mwamwanu (2060-2074)	Top Centre Bottom
Tarawa ocean shore (north (east)) 10%, 2% & 1% AEP wave set-up levels	Te tibu (2012-2036) Tibu-toru (2036-2060) Tibu- mwamwanu (2060-2074)	Top Centre Bottom

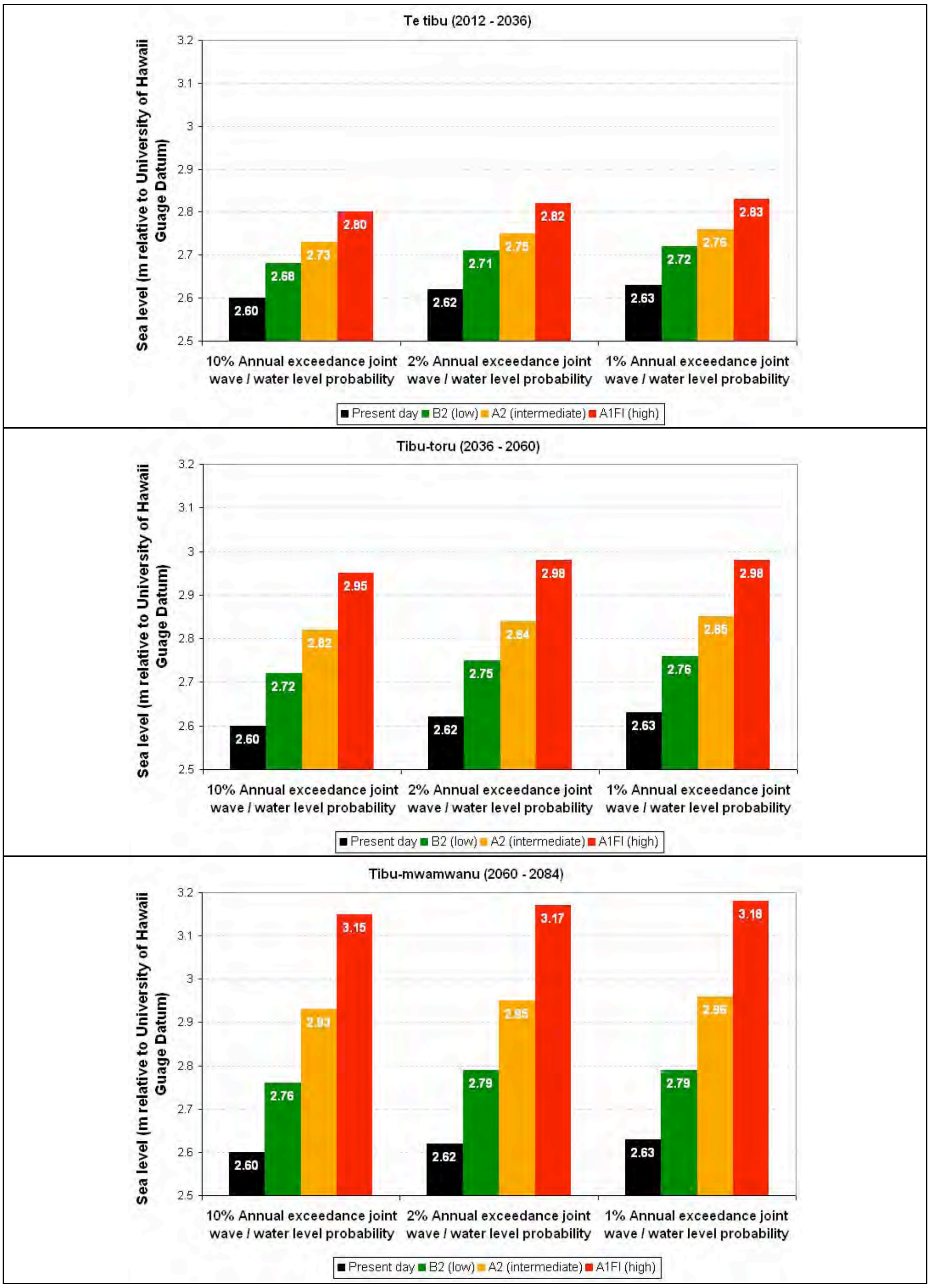
Refer to the Coastal Calculator Operational Handbook (Chapter 3) for details on the variability of the lagoon and ocean shorelines, and how this variability may influence inundation levels.

Tide levels



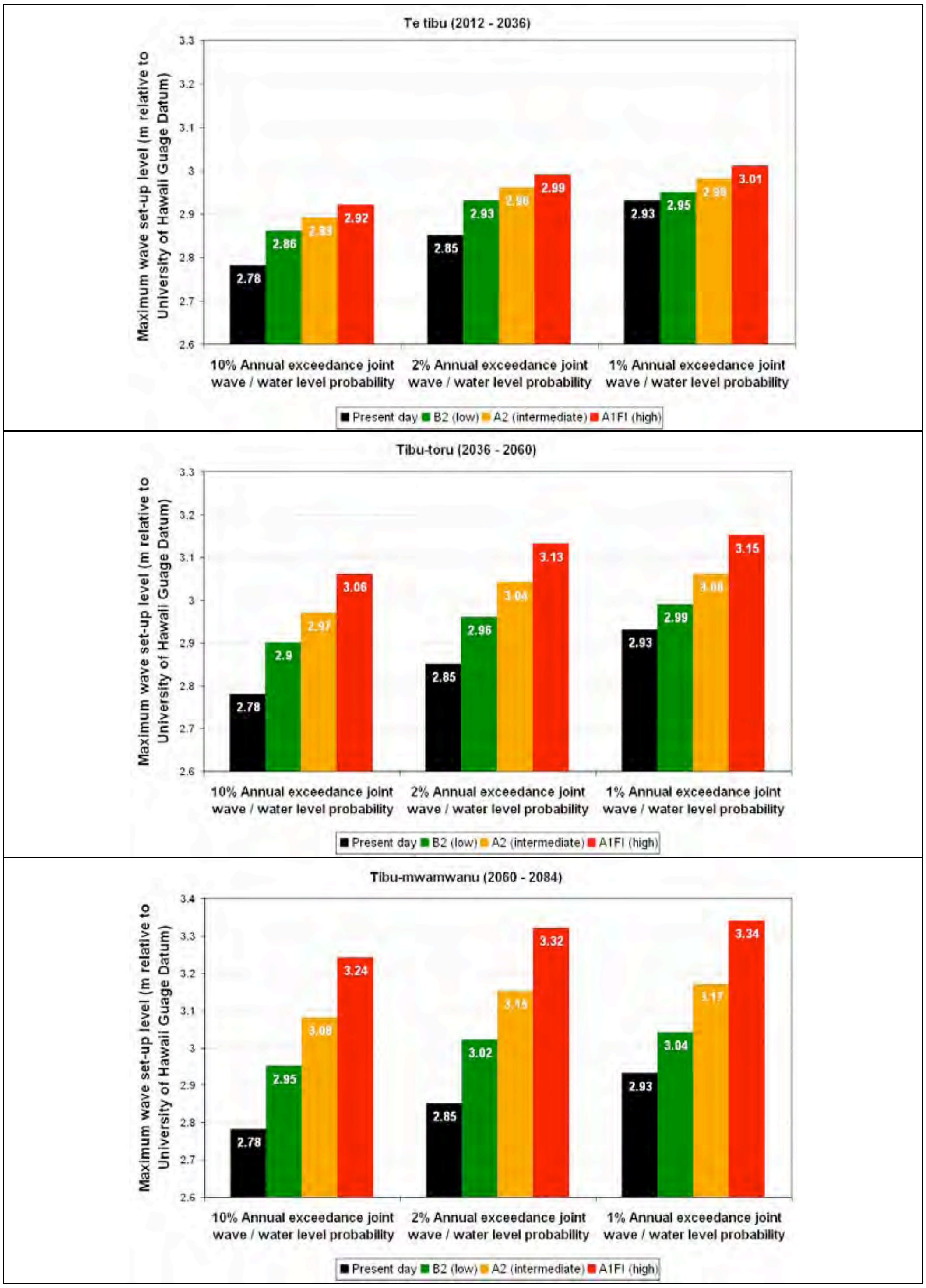
Mean level of the sea and high tide for the present day (1980-1999 average) and three I-Kiribati climate change scenarios (B2 – green, A2 – orange, A1FI - red) and timeframes (Te tibu – top, Tibu-toru – middle, Tibu-mwamwanu – bottom).

Tarawa lagoon shoreline: Extreme water levels (storm side)



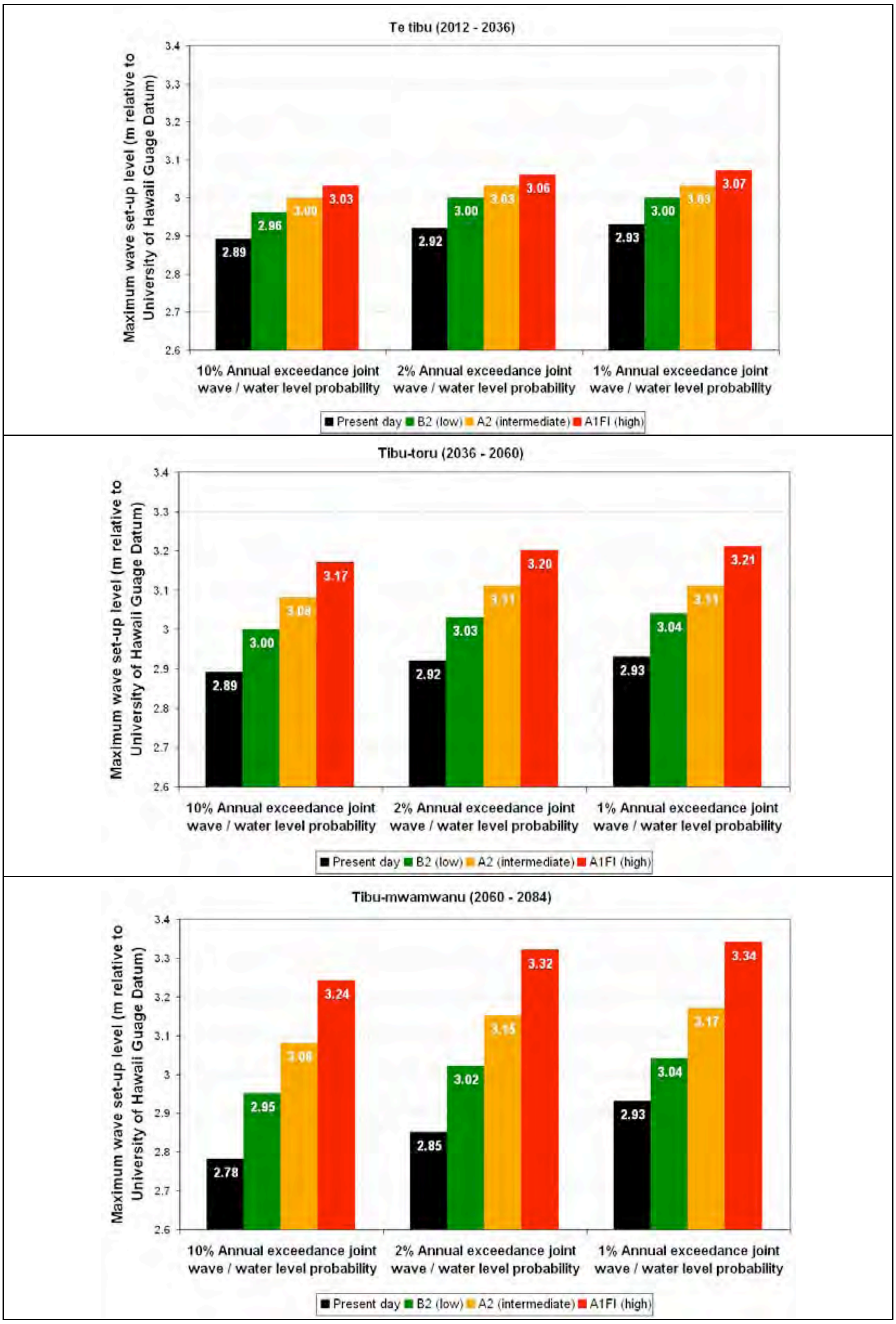
10%, 2% and 1% AEP storm tide levels for the present day (1980-1999 average) and three I-Kiribati climate change scenarios (B2 – green, A2 – orange, A1FI - red) and timeframes (Te tibu – top, Tibu-toru – middle, Tibu-mwamwanu – bottom).

Tarawa ocean shore (south): Extreme water levels (storm tide + wave set-up)



Extreme sea levels (comprising tide, storm surge and wave set-up) corresponding to the wave / water level conditions with a 10%, 2% and 1% chance of occurring in any one year for the present day and three I-Kiribati climate change scenarios and timeframes.

Tarawa ocean shore (north (east)): Extreme water levels (storm tide + wave set-up)



Extreme sea levels (comprising tide, storm surge and wave set-up) corresponding to the wave / water level conditions with a 10%, 2% and 1% chance of occurring in any one year for the present day and three I-Kiribati climate change scenarios and timeframes.

Section 2: Hazard Extent Maps

The maps presented in this chapter present potential inundation extents during mean high water springs (MHWS) for the three selected I-Kiribati climate change scenarios and three timeframes.

The information presented in this chapter may be applied to climate proof land and development planning, by:

- Establishing the extent of existing building inundation risk and how this may change in the future.
- Enabling the assessment of areas at potential risk from inundation (in terms of frequent events, e.g. high tides) and how these may change.

For further information on the process by which these outputs were developed: see the *Risk Assessment Handbook* and the *Adaptation Handbook*.

To view the projected inundation extents during storm events, refer to the data CD available in Chapter 3.

Three scenarios for climate change have been selected for use in reviewing potential climate change hazards in Kiribati. These are:

- IPCC B2 – low climate change scenario
- IPCC A2 – medium climate change scenario
- IPCC A1FI – high climate change scenario

The scenarios represent different projections for climate change. Importantly, no scenario by the Intergovernmental Panel on Climate Change (IPCC) is more likely to occur than another. However, it is important to note that the global-mean sea level rise is currently tracking (from 1990 – 2005) in accordance with the highest IPCC climate change scenario, A1FI.

For each map presented in this chapter, the height of land likely to be affected by a climate change scenario is noted. The affected land is shaded in blue. In some maps, there is no blue shading, indicating that the area will not be affected under the selected climate change scenario. Areas shaded in blue indicate an area of low-lying land that may become permanently swampy as sea levels, and consequently the water table, rise. Infrastructure and services situated in these areas will likely require increased maintenance, and certain areas of land may potentially become uninhabitable. In addition, ground water may become exposed to contaminants, as the boundaries between the freshwater interface and human activity decrease.

Important Note:

All maps contain data generated from the 1998 Tarawa Mapping Project. The mapping data was extracted from 1:8,000 photography to produce 1 metre contours accurate to 0.5m vertically. The contours used to create the maps presented in this chapter have been generated by the same company that completed the original mapping at an interval of 0.1m, which is significantly higher interval than what is recommended for this scale of photography. It is important to note that these contours will remain accurate to 0.5m vertical.

Maps Indicating Land Situated Below 2.2metres Elevation

Maps in this section indicate land situated below 2.2 m (based on University of Hawaii Datum – the same datum used in the contour maps). In the maps, the land situated below 2.2m is shaded in blue. Areas shaded in blue indicate an area of low-lying land that may become permanently swampy as sea levels, and consequently the water table, rise. Infrastructure and services situated in these areas will likely require increased maintenance and certain areas of land may potentially become uninhabitable. In addition, ground water may become exposed to contaminants as the boundaries between the freshwater interface and human activity decrease. In some maps, there is no blue shading, indicating that the area will not be affected under the selected climate change scenario.

The scenarios that align to inundation of 2.2 metres include:

- Scenario 2030 B2 - impact likely experienced by the year 2030 (applies the low scenario)
- Scenario 2050 B2 - impact likely experienced by the year 2050 (applies the low scenario)
- Scenario 2030 A2 - impact likely experienced by the year 2030 (applies the medium scenario)

The legend for each map is shown in Figure 2.

Figure 2: Map legend

Government Service One: Health, education, police facilities
Government Service Two: Water, sewerage, electricity, TSKL cable (all mapped as separate lines)
Government Service Three: Major Transport – airports, ports
Government Service Four: Roads (mapped as separate line)
Government Service Five: Government Building, not housing – for example agriculture office, diplomatic building, prison, desalination plant.

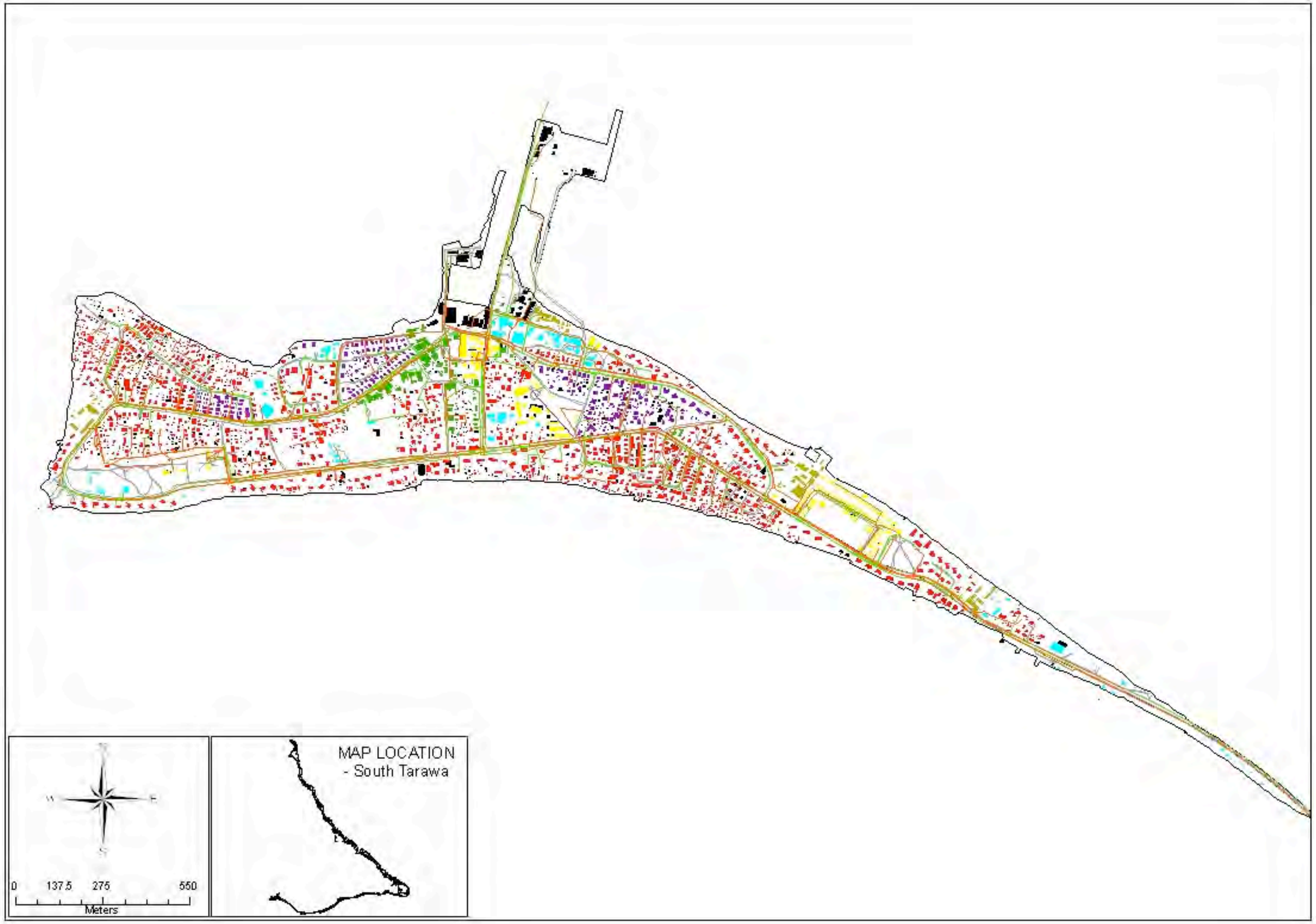


Figure 3: Betio, 2.2metres

Figure 4: Bairiki and Nanikaai, 2.2m

Figure 5: Teaoraereke, Antenon and Antebuka, 2.2m

Figure 6: Banraeba, Ambo and Taborio ST. 2.2m

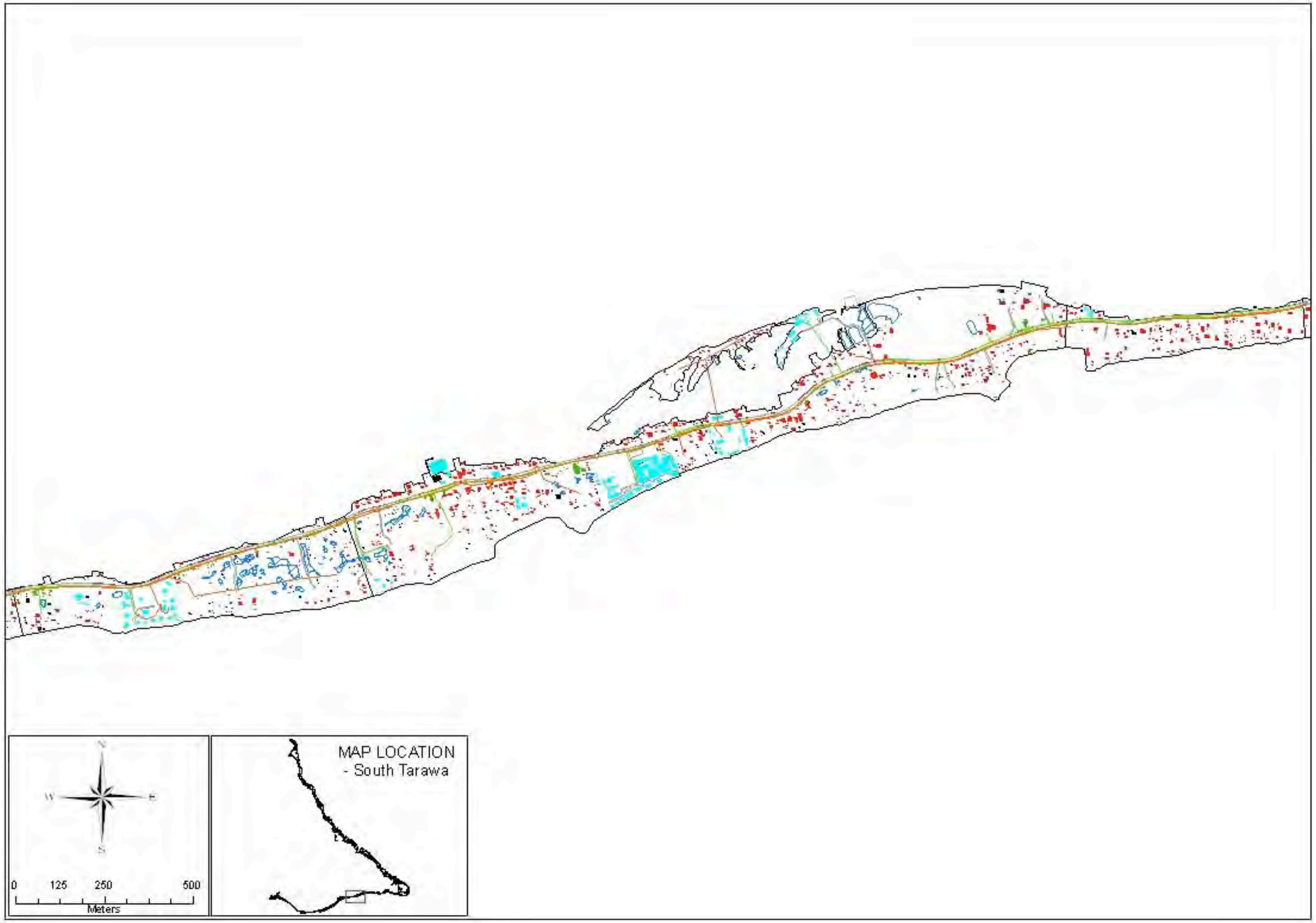


Figure 7: Tangintebu, Eita and Abarao, 2.2m

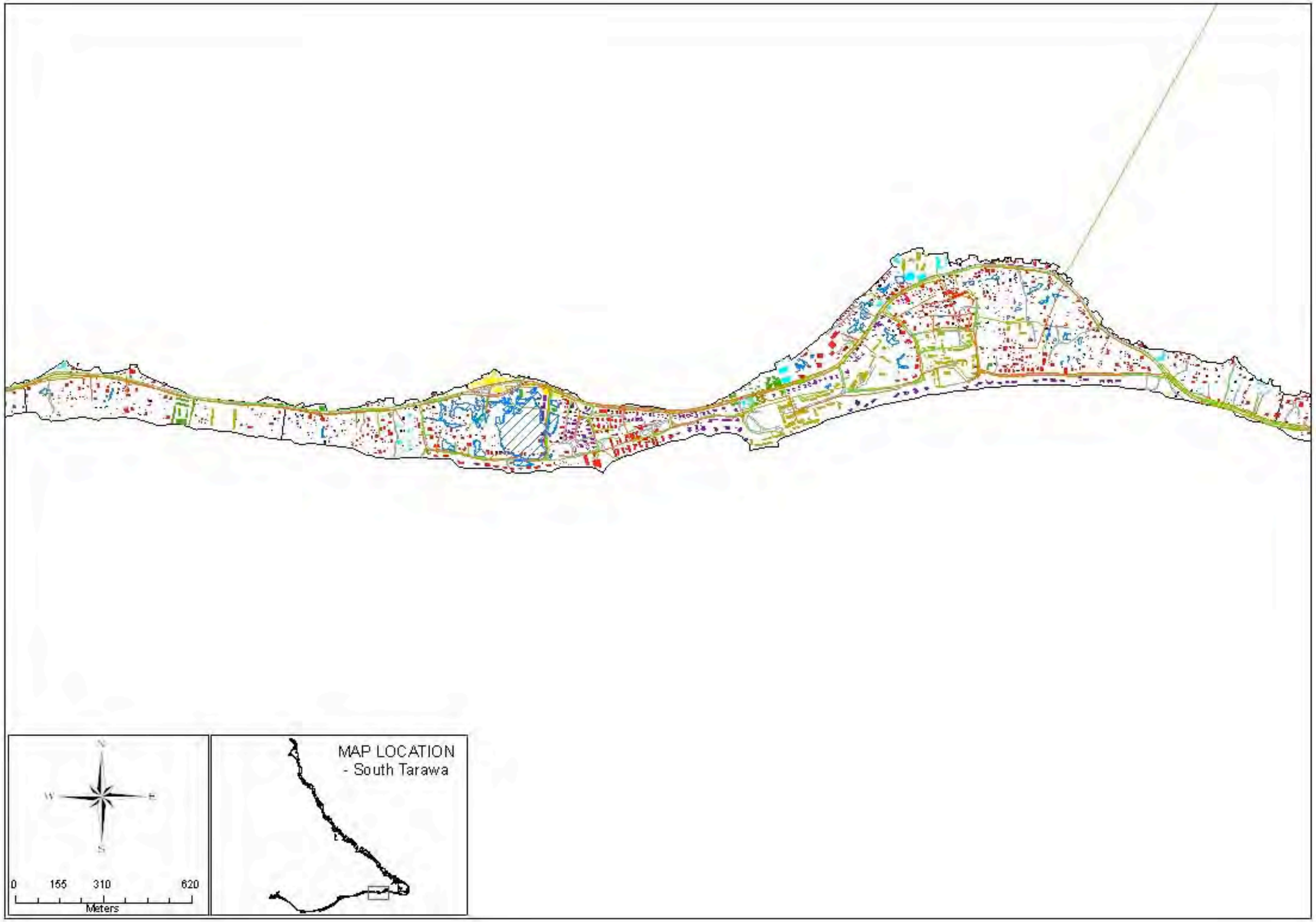


Figure 8: Bwangantebure and Bikenibeu, 2.2m

Figure 9: Nawerewere and Temaiku, 2.2m

Maps Indicating Land Situated Below 2.3 metres Elevation

Maps in this section indicate land situated below 2.3 m (based on University of Hawaii Datum). In the maps, the land situated below 2.3m is shaded in blue. Areas shaded in blue indicate an area of low-lying land that may become permanently swampy as sea levels, and consequently the water table, rise. Infrastructure and services situated in these areas will likely require increased maintenance and certain areas of land may potentially become uninhabitable. In addition, ground water may become exposed to contaminants as the boundaries between the freshwater interface and human activity decrease. In some maps, there is no blue shading, indicating that the area will not be affected under the selected climate change scenario.

The scenarios that align to inundation of 2.3 metres include:

- Scenario 2070 B2 (low scenario) – impact likely experienced by the year 2070 (applies the low scenario)
- Scenario 2050 A2 (medium scenario with 0.1m scaled up ice sheet discharge) – impact likely experienced by the year 2050 (applies the medium scenario)
- Scenario 2030 A1FI (high scenario with 0.2m scaled up ice sheet discharge) - impact likely experienced by the year 2030 (applies the high scenario)

The legend for each map is shown in Figure 2.

Figure 10: Betio, 2.3metres

Figure 11: Bairiki and Nanikaai, 2.3m

Figure 12: Teaoraereke, Antenon and Antebuka, 2.3m

Figure 13: Banraeba, Ambo and Taborio ST. 2.3m

Figure 14: Tangintebu, Eita and Abarao, 2.3m

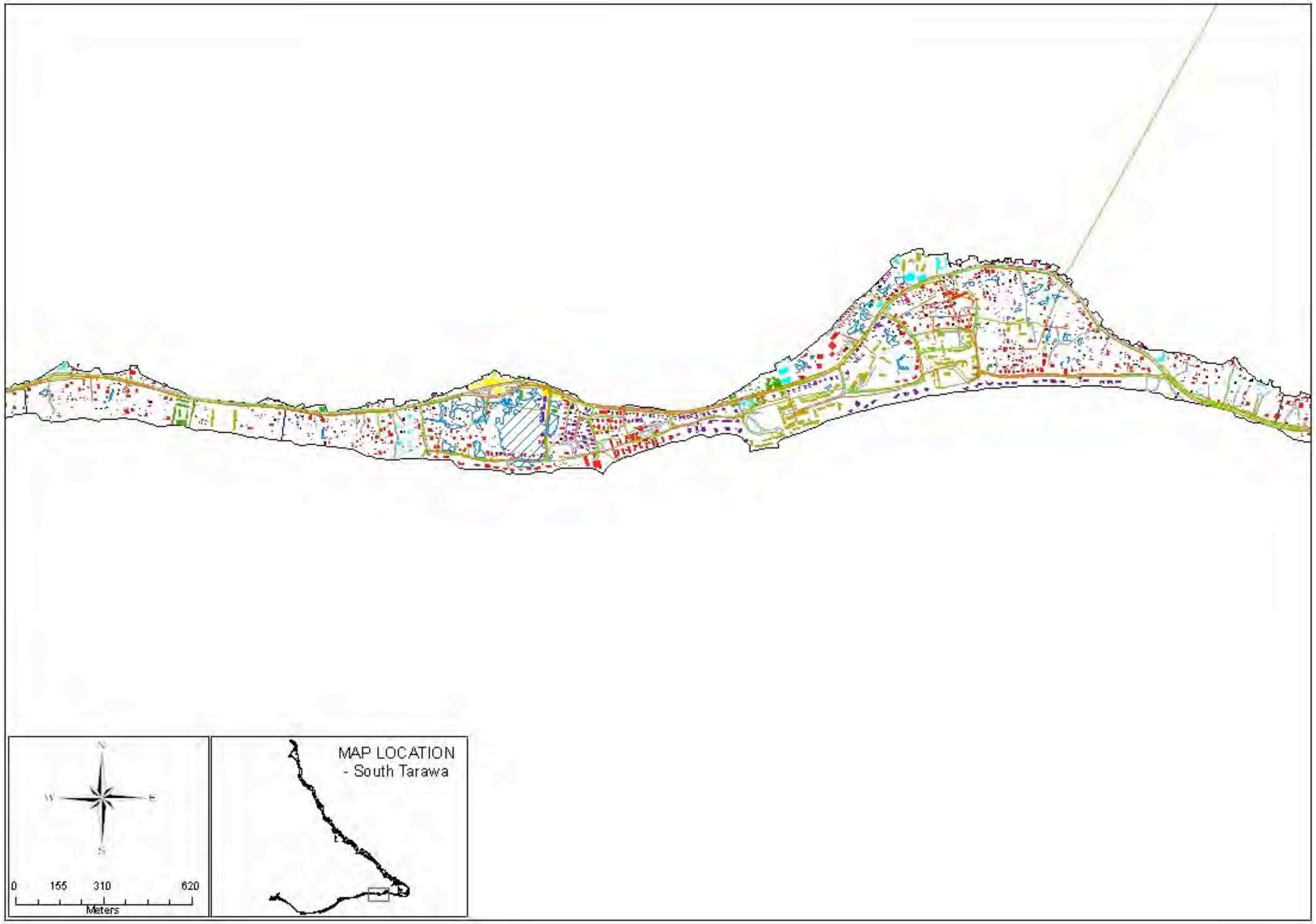


Figure 15: Bwangantebure and Bikenibeu, 2.3m

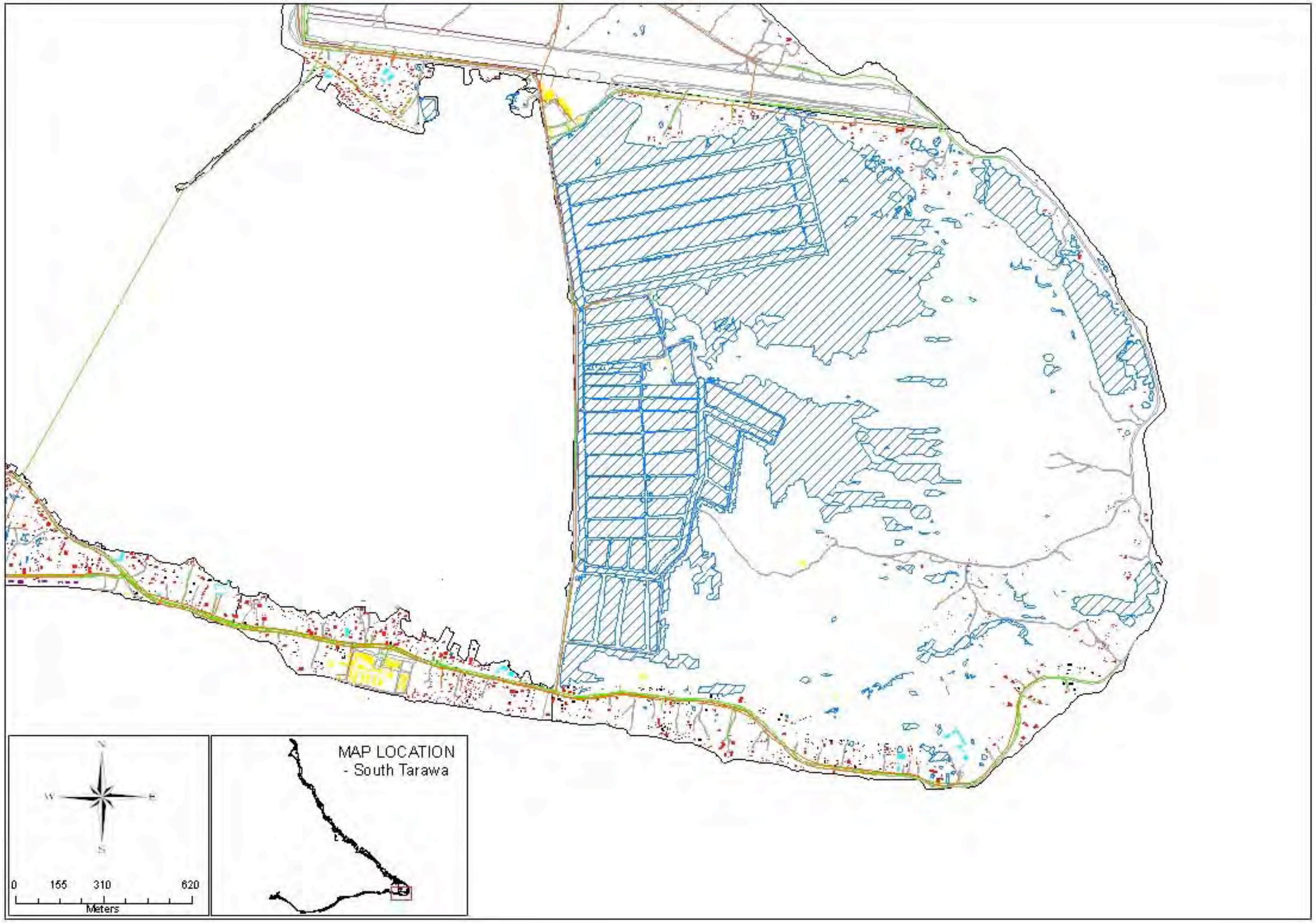


Figure 16: Nawerewere and Temaiku, 2.3m

Maps Indicating Land Situated Below 2.4 metres Elevation

Maps in this section indicate land situated below 2.4 m (based on University of Hawaii Datum). In the maps, the land situated below 2.4m is shaded in blue. Areas shaded in blue indicate an area of low-lying land that may become permanently swampy as sea levels, and consequently the water table, rise. Infrastructure and services situated in these areas will likely require increased maintenance and certain areas of land may potentially become uninhabitable. In addition, ground water may become exposed to contaminants as the boundaries between the freshwater interface and human activity decrease. In some maps, there is no blue shading, indicating that the area will not be affected under the selected climate change scenario.

The scenarios that align to inundation of 2.4 metres include:

- Scenario 2050 A1FI- impact likely experienced by the year 2050 (applies the high scenario with 0.2m scaled up ice sheet discharge)
- Scenario 2070 A2 - impact likely experienced by the year 2070 (applies the medium scenario with 0.1m scaled up ice sheet discharge)

The legend for each map is shown in Figure 2.

Figure 17: Betio, 2.4metres

Figure 18: Bairiki and Nanikaai, 2.4m

Figure 19: Teaoraereke, Antenon and Antebuka, 2.4m

Figure 20: Banraeba, Ambo and Taborio ST. 2.4m

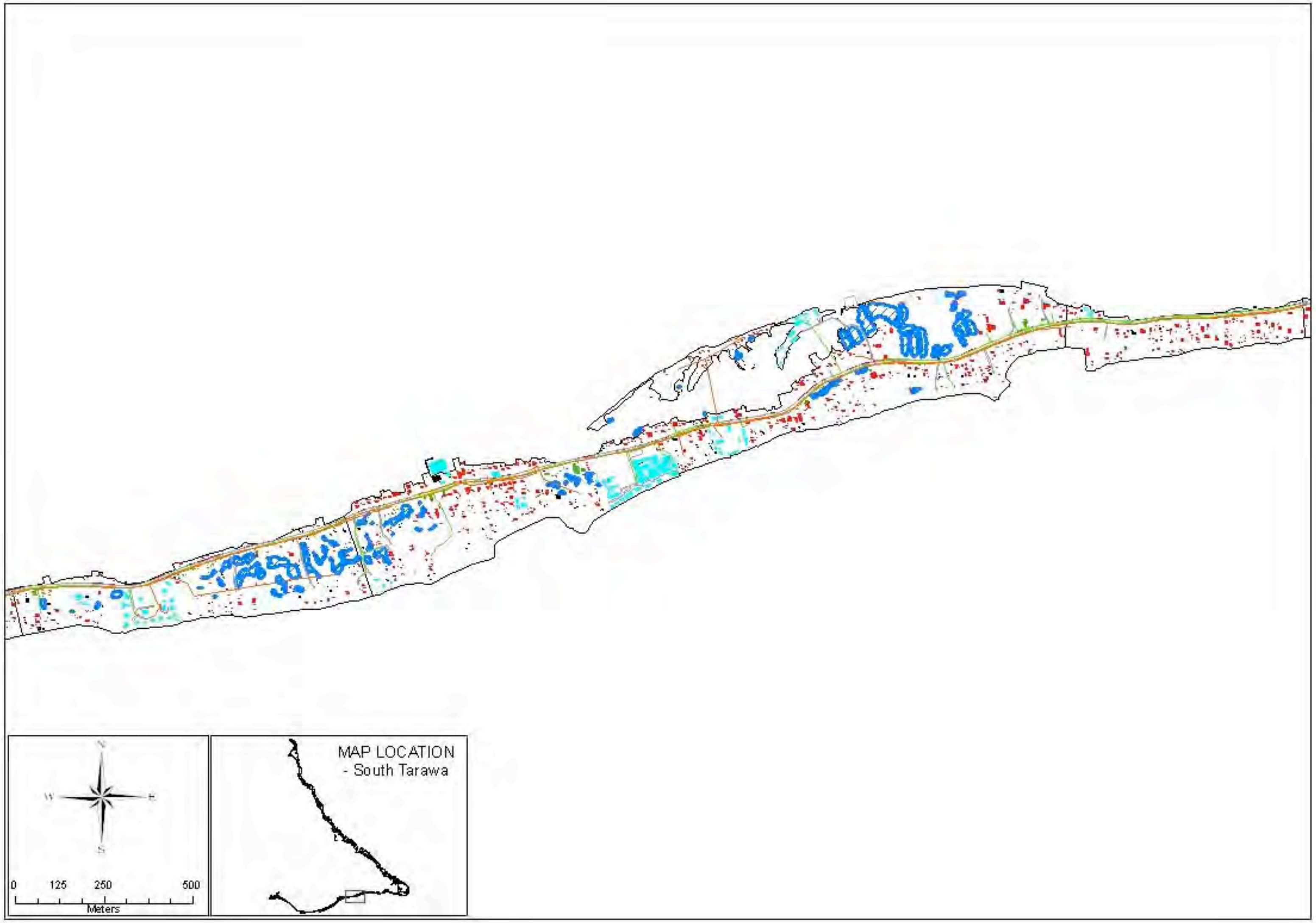


Figure 21: Tangintebu, Eita and Abarao, 2.4m

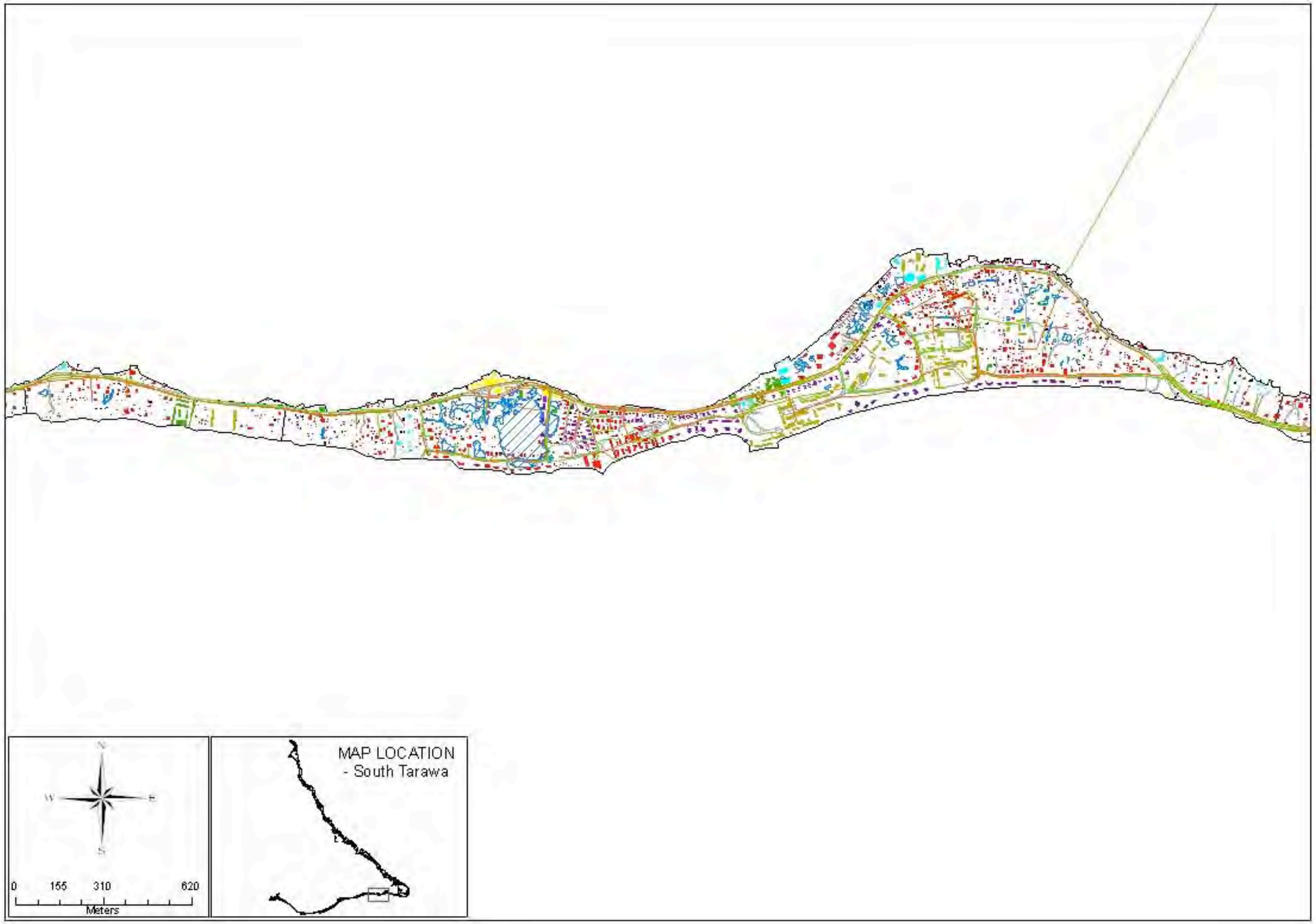


Figure 22: Bwangantebure and Bikenibeu, 2.4m

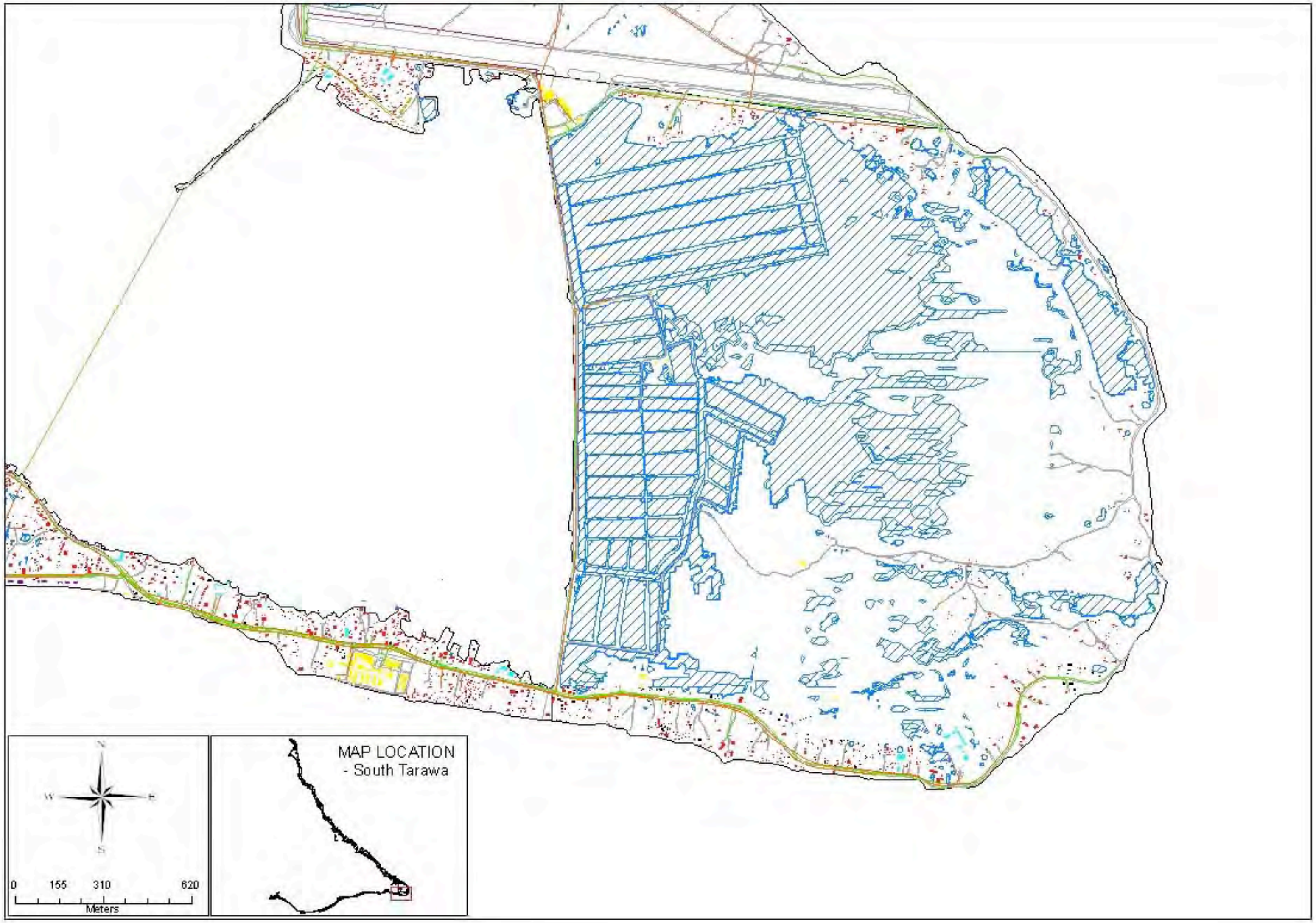


Figure 23: Nawerewere and Temaiku, 2.4m

Maps Indicating Land Situated Below 2.6 metres Elevation

Maps in this section indicate land situated below 2.6 m (based on University of Hawaii Datum). In the maps, the land situated below 2.6m is shaded in blue. Areas shaded in blue indicate an area of low-lying land that may become permanently swampy as sea levels, and consequently the water table, rise. Infrastructure and services situated in these areas will likely require increased maintenance and certain areas of land may potentially become uninhabitable. In addition, ground water may become exposed to contaminants as the boundaries between the freshwater interface and human activity decrease. In some maps, there is no blue shading, indicating that the area will not be affected under the selected climate change scenario.

The scenarios that align to inundation of 2.6 metres include:

- Scenario 2070 A1FI - impact likely experienced by the year 2070 (applies the high scenario with 0.2m scaled up ice sheet discharge)

The legend for each map is shown in Figure 2.

Figure 24: Betio, 2.6metres

Figure 25: Bairiki and Nanikaai, 2.6m

Figure 26: Teaoraereke, Antenon and Antebuka, 2.6m

Figure 27: Banraeba, Ambo and Taborio ST. 2.3m

Figure 28: Tangintebu, Eita and Abarao, 2.6m

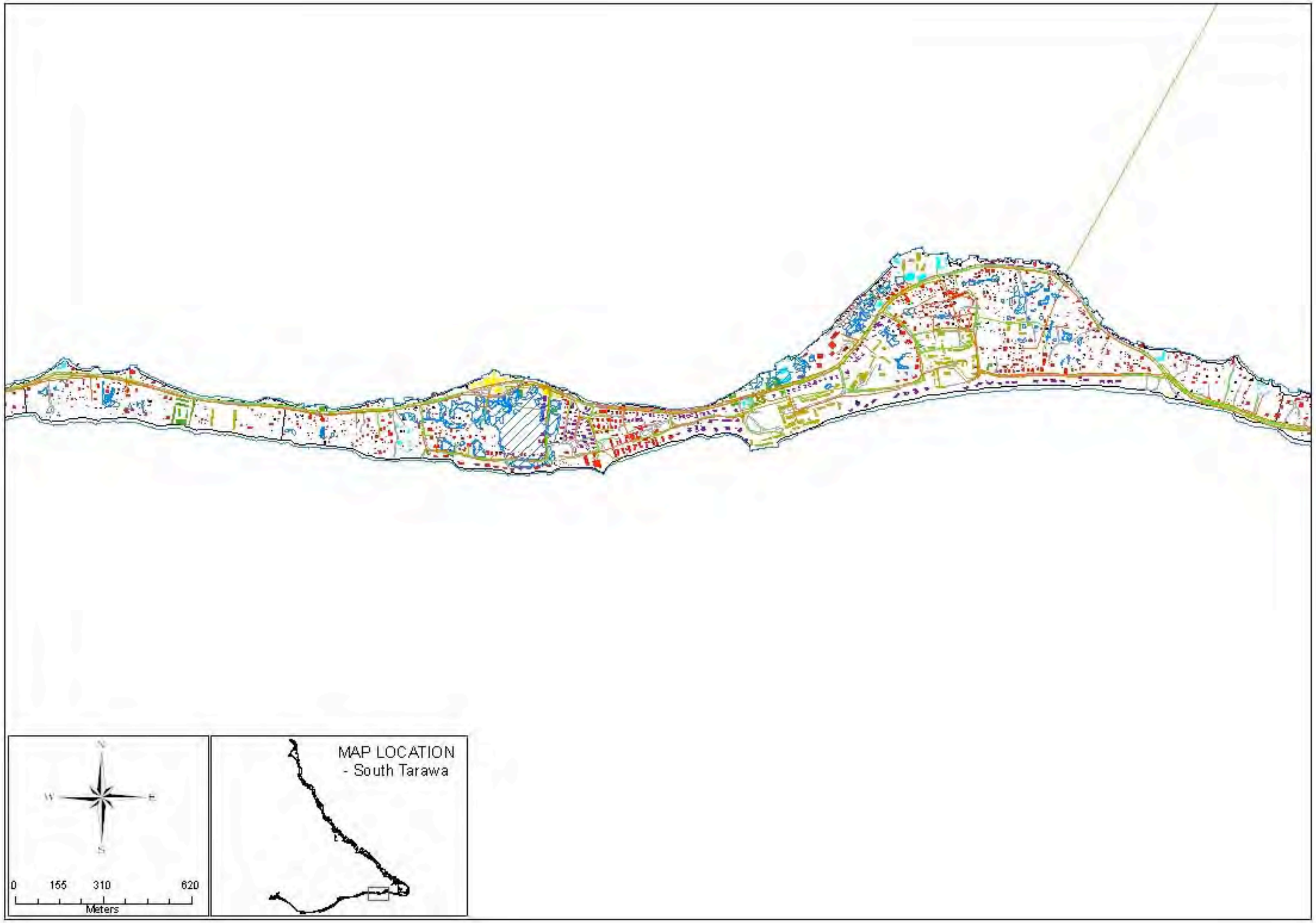


Figure 29: Bwangantebure and Bikenibeu, 2.6m

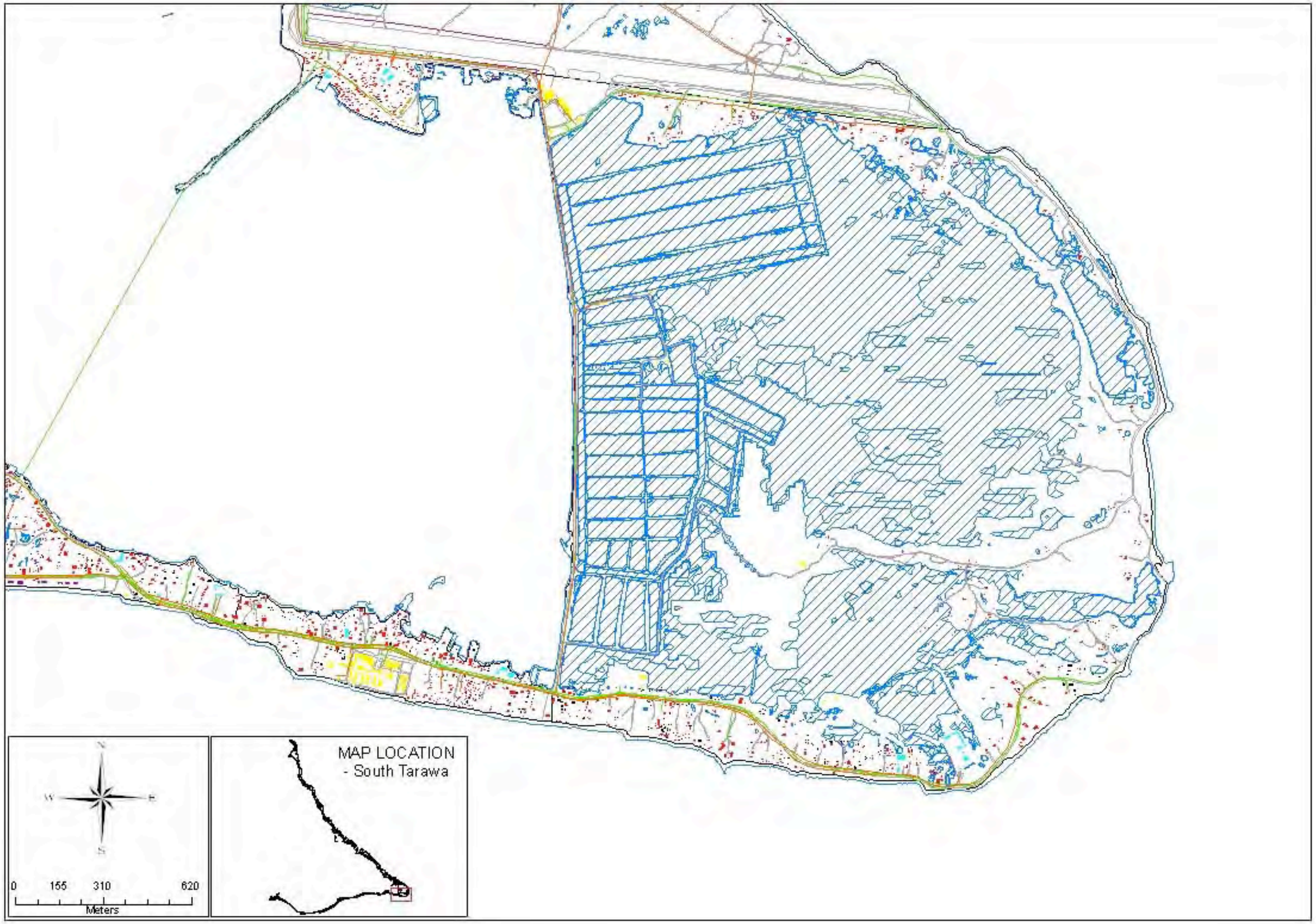


Figure 30: Nawerewere and Temaiku, 2.6m

Section 3: Hazard Extent Visual Tools

The accompanying CD contains Google Earth files that demonstrate potential hazard extents of inundation due to sea level rise during:

- Mean high water springs (MHWS): 2030, 2050, 2070 and 2100 (A1FI scenario); and
- 1 in 10 year storm event: 2030, 2050, 2070 and 2100 (A1FI scenario).

The files indicate the rise in mean sea level that is projected for MHWS and storm events. However, the projections of sea level rise do not include wave set up. They only indicate static water levels during MHWS and storm events. Consequently, the extent of inundation may be higher than presented in the mapping files.

The levels of inundation associated with each of the hazard extents in the attached CD are shown in Table 1, and were obtained from the Coastal Calculator.

Table 1: Water levels associated with rise in mean sea level for different timeframes under the A1FI scenario

Year	Event	Water Level (UoH datum)
2030	MHWS	2.3m
	Storm	2.8m
2050	MHWS	2.5m
	Storm	2.9m
2070	MHWS	2.6m
	Storm	3.1m
2100	MHWS	2.9m
	Storm	3.4m

The projections are based on the A1FI climate change scenario. This is the most pessimistic climate change scenario presented in the IPCC Fourth Assessment Report. However, it is important to note that the global-mean sea level rise is currently tracking (from 1990 – 2005) in accordance with the highest IPCC climate change scenario, A1FI.

The information presented in this chapter may be applied to climate proof land and development planning, by:

- Enabling the assessment areas at potential risk from inundation (both in terms of frequent events, e.g. high tides, to less frequent storm-related events) and how these may change.
- Establishing the extent of existing building inundation risk and how this may change in the future.

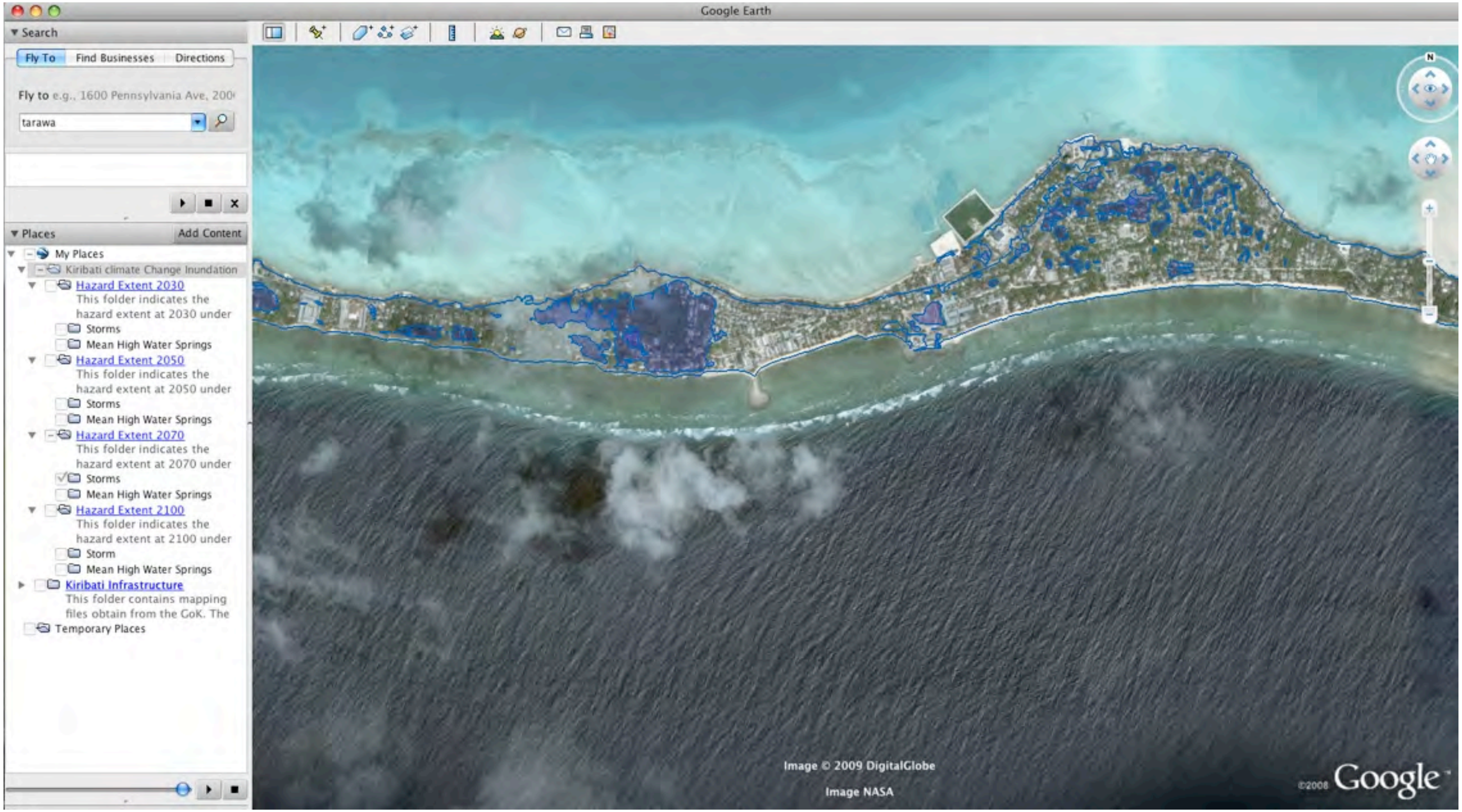
To view the files in the attached CD, follow these steps:

1. Save the content of the CD onto your computer.
2. Open Google Earth (if you do not have Google Earth on your computer, you can download it for free from: http://earth.google.com/)
3. In Google Earth, click on 'File' and then select 'Open'.
4. Navigate the to location where you saved the contents of the CD and select the file called, 'Kiribati Climate Change Inundation.kmz'[1]

This file contains imagery that indicates the hazard extent for four timeframes, 2030, 2050, 2070 and 2100. To view the hazard extent, click in the square box next to each year. You can view the extent of hazard that is projected during storm events and during Mean High Water Springs. An example of the Google Earth imagery with the hazard extent at 2010 (storm events) is presented in Figure 31.

[1] This is a large file and it may take a while to load into your Google Earth program.

Figure 31: Google earth



Conclusion

The information presented in this Manual is a summary of the key outcomes of work conducted in two components of the KAP II program (Component 1.3.2 and Component 1.4.0). It provides guidance on the projected impact of sea level rise on South Tarawa. The projections are presented as levels of sea level rise (relative to the University of Hawaii datum) (Section 1) and as hazard extent maps (Section 2). The hazard extent maps project rise in mean sea level and the extent of permanent inundation. The impacts of storms are not presented in these maps. Consequently, Google earth visualisation tools are also provided (Section 3), which provide further information on the projected impact of rise in mean sea level for both permanent inundation (Mean High Water Springs) and inundation that will occur during storm events.

This information should be applied to support decision making across the government of Kiribati (GoK) that influence the use and development of land and its resources.