United Nations Development Program

Nanumaga Detailed Design Report
Tuvalu Coastal Adaptation Project
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<tr>
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<td>Artur Webb</td>
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1. INTRODUCTION

1.1 General

Consisting of nine islands and atolls spread over 750,000km², Tuvalu is the fourth smallest nation in the world in land area with a population of just over 10,000. It is one of the most vulnerable countries in the world to the impacts of climate change and particularly sea-level rise and the possibility of intensifying storm events. Recent cyclones have caused population displacement, significant loss and damage of infrastructure as well as destruction of agricultural resources, contamination of ground water and changes in shoreline systems. Such impacts negatively affect the wellbeing of communities and long-term sustainable development aspirations. In response to this increasing challenge, the Government of Tuvalu (GoT) and the Green Climate Fund (GCF) have jointly committed US$38 million for the Tuvalu Coastal Adaptation Project (TCAP).

Three main islands have been selected for the proposed GCF project: Funafuti, Nanumea and Nanumaga. Nanumaga was selected due to the severity of the damage incurred following the passage of Tropical Cyclone (TC) Pam in 2015. The funding application proposed that TCAP resources finance locally appropriate coastal protection measures along the high value zone (450m) in Nanumaga. The lack of a landing facility suitable for a large dredge or working vessels limits the coastal protection infrastructure that may be constructed on Nanumaga. As such, soft measures including beach nourishment and dune restoration have been recommended. Subsequent feasibility studies including hydrodynamic and coastal processes, an ESIA, and geotechnical investigations led to the selection of Berm Top Barriers (BTB) built from large geotextile containers as the recommended coastal adaptation measure for Nanumaga.

1.2 Project and report objectives

TCAP will build coastal resilience which is an urgent national priority. The project will address the financial and capacity constraints at all levels – from technical to community awareness. TCAP was approved in June 2016 and the project implementation commenced in September 2017. The project will run until September 2023. TCAP has 3 main outputs:

Output 1: Strengthening of institutions, human resources, awareness and knowledge for resilient coastal management.

Output 2: Vulnerability of key coastal infrastructure is reduced against wave induced damages in Funafuti, Nanumea and Nanumaga.

Output 3: A sustainable financing mechanism established for long-term adaptation efforts.

The following body of work progresses Output 2, which has two main task areas or Activities:

- Activity 2.1: Coastal protection design. Site-specific assessments and ESIA undertaken in all islands in a participatory manner.
- Activity 2.2: Coastal protection measures implemented.

The objective of this report is to provide detailed design parameters and present the finalised coastal protection measures on Nanumaga ready for construction (implementation). This report is designed to be read in conjunction with the IFC drawings attached in Appendix A.
1.3 Report background

This report has brought together the findings of several investigations used to inform the design and implementation of the TCAP Nanumaga coastal protection design, these investigations include, but are not limited to:

- TCAP Concept Design Report (UNDP, 2020)
- Nanumaga Environmental and Social Impact Assessment (SPC, 2020a)
- Nanumaga Geotechnical Investigation (SPC, 2020b)
- Exploratory study for the development of ship landing facilities at Niutao and Nanumaga (Deltares, 2017)

These investigations accompany extensive stakeholder consultation, site investigations and interviews with contractors working in the region to inform the detailed design presented herein.

1.4 Report outline

The structure of this report can be summarised as follows:

- Section 2 presents the design life, a brief description of the site as well as the basis of design
- Section 3 presents a description of the Nanumaga coastal protection design and associated aspects including the boat harbour design.
- Section 4 presents an overview of the project’s proposed implementation
- Section 5 provides a summary of the key findings of the Detailed Design and recommendations.
2. BASIS OF DESIGN

2.1 Design Life

The Australian Standard Guidelines for the design of maritime structures (AS 4997-2005) specifically excludes the design of “coastal engineering structures such as rock armoured walls, groynes, etc.” The Berm Top Barrier design presented in the Concept Design Report adopts buried geosynthetic mega containers (GMC) for the core of the structure. Geotextile containers were originally expected to have a service life of at least 25 years in their earlier design iterations. Improvements in geosynthetics have been reported to have design lives exceeding 40 years (Bettington, 2018). This has been adopted as the design life of the BTB structure.

2.2 Design event

A 100-year Average Recurrence Interval (ARI) value has been adopted for the stability of any structures. The recurrence of the return event for overtopping design of the BTB is a one-year ARI based on safe average overtopping volumes for pedestrian access behind the structure crest after EurOtop (2018).

2.3 Site

Nanumaga is a table reef with a single reef island (Tanyama, 1952). The island is oval shaped, replicating the shape of the reef platform. It is approximately 3.1km long in the north-south axis and 1.5km wide in east-West axis. Nanumaga island evolved in the same way as Funafuti atoll, with Nanumaga’s much smaller lagoon infilling to reach a maximum state, with only a remnant low-lying area in its centre (Figure 1).

Nanumaga is located approximately 400km to the North West of Funafuti. The island has an unprotected, 100m long, 10m wide boat channel cut into the reeftop midway along the western coast of the island which extends to the sandy shoreline. The boat channel is the only port of any kind in the island.
Figure 1: Tuvalu setting (top) and Nanumaga digital elevation model (bottom) with TCAP site marked by red polygon. Please note heights have been approximated with respect to Mean Sea Level (MSL). (source: Fugro, 2019).
2.3.1 Bathymetry and topography

A marine Light Detection and Ranging (LiDAR) survey was undertaken of all Tuvalu’s nine islands was commissioned by TCAP in August 2019. The resultant dataset provided a high resolution topographic and bathymetric digital earth model (DEM) to a depth of approximately 40m, the bathymetry and topography at the project site on Nanumaga’s western coast is provided in Figure 2.

![Figure 2: Topographic and bathymetric contour map of proposed TCAP coastal protection site on Nanumaga's western coast taken from FUGRO Marine LiDAR survey, August 2019.](image)

2.3.2 Geomorphology

Geotechnical surveys have shown the island is composed of loose foraminifera rich sands with occasional loose coral gravel layers. Excavations of a large pit near the eastern shoreline found that loose foraminifera-rich sand continued to a depth below the level of the present-day fringing reef, suggesting the reef island was formed by calcareous sediment infilling a pre-existing lagoon of the small atoll.

A 6-8m (above TGZ) storm berm is the major geomorphological feature along the western shore of the island and is the highest natural feature, Figure 3. Boreholes taken from the storm berm were seen to contain light sandy soils, with unaltered sand on the active beach. The light sandy soils are described as foraminifera-rich sand with occasional coral gravel fragments. The light sandy soils are distinguished from the unaltered sands due to the presence of organic content (roots, leaves and branches) in various stages of decomposition, which have stained the calcareous sand to a variety of different shades of grey depending on the organic content.
Figure 3: Map of Nanumaga landform units after SPC, 2020a (Source: McLean et al, 1991).
2.4 Design inputs

2.4.1 Water levels

No long-term water level measurements have been undertaken at Nanumaga Island at the time of this report. Tidal planes for Nanumaga are presented in Figure 4 from tide tables produced by the Climate and Oceans Support Program in the Pacific (CoSPac, 2020) with levels reduced to Tide Gauge Zero (TGZ) at Funafuti following the levelling program undertaken by FUGRO for TCAP in 2019.

Figure 4: Tidal plane at Nanumaga with respect to Tide Gauge Zero (TGZ) at Funafuti Port. (source: CoSPac, 2020)

<table>
<thead>
<tr>
<th>Tidal Plane</th>
<th>Recorded Height (m TGZ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest Astronomical Tide (HAT)</td>
<td>3.22</td>
</tr>
<tr>
<td>Mean High Water Springs (MHWS)</td>
<td>2.73</td>
</tr>
<tr>
<td>Mean High Water Neap (MHWN)</td>
<td>2.21</td>
</tr>
<tr>
<td>Mean Sea Level (MSL)</td>
<td>1.88</td>
</tr>
<tr>
<td>Mean Low Water Neap (MLWN)</td>
<td>1.57</td>
</tr>
<tr>
<td>Mean Low Water Neap (MLWS)</td>
<td>1.047</td>
</tr>
<tr>
<td>Lowest Astronomical Tide (LAT)</td>
<td>0.687</td>
</tr>
<tr>
<td>Tide Gauge Zero (TGZ)</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Nanumaga tide gauge relationship to Funafuti

Table 1: Calculated design water levels for Nanumaga coastal protection works

<table>
<thead>
<tr>
<th>Design parameter</th>
<th>Water level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100 Sea Level Rise¹</td>
<td>0.75m</td>
</tr>
<tr>
<td>Wave setup²</td>
<td>0.95m</td>
</tr>
<tr>
<td>HAT Nanumea</td>
<td>3.22m TGZ</td>
</tr>
<tr>
<td>IBEmax³</td>
<td>0.28m</td>
</tr>
<tr>
<td>Design Water Level</td>
<td>5.2m TGZ</td>
</tr>
</tbody>
</table>

¹ IPCC 2019 upper limit of RCP8.5 range
² Calculated as 10% of depth-limited wave height at project site (Section 2.4.3)
³ maximum recorded value of Inverse Barometric Effect (IBE)
2.4.2 Waves

There is no long-term recorded wave data for Nanumaga. Wave climate information for Nanumaga presented in Figure 5 and Table 2Figure 6 has been determined based on a long-term regional model hindcast. The site is dominated by swell (wave period, \( T_p > 8 \text{ sec} \)) with locally generated seas (\( T_p < 8 \text{ seconds} \)) only occurring on average 2% of the time. Average Significant Wave Height (\( H_s \)) is 1.7m. The dry season (May-Oct) is dominated by waves from the eastern and southerly sectors (E to SW). The island’s orientation will provide some protection to the project site from the dominant easterly waves and wind during this period.

The wet season (Nov-Apr) sees less frequent waves generated from the southerly sector, with a greater frequency in waves arriving from the north (NE to NW). The largest waves can be seen to occur from the west and the north west, these occur primarily in the wet season and are attributed to the passage of tropical cyclones in the vicinity of Nanumaga. It should be noted that cyclones passing as far away as 1100km from Nanumaga have the propensity to send waves of over 5m to Nanumaga’s reef crest, further details of cyclonic effects on Nanumaga can be found the Concept Design Report (UNDP, 2020).

The 100year annual recurrence interval (ARI) significant wave height and peak wave period for the western coast of Nanumaga is presented in Table 3.
Table 2: Long term and seasonal statistics calculated for the CAWCR model extraction points in deep water offshore of Nanumaga for the wave hindcast information 1979-2019

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Statistic</th>
<th>Long term average (40yrs)</th>
<th>Wet season (Nov- Apr)</th>
<th>Dry season (May – Oct)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hs (m)</td>
<td>Average</td>
<td>1.7</td>
<td>1.7</td>
<td>1.7</td>
</tr>
<tr>
<td></td>
<td>20%ile</td>
<td>1.4</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>90%ile</td>
<td>2.1</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>6.7</td>
<td>6.7</td>
<td>3.5</td>
</tr>
<tr>
<td>Tp (s)</td>
<td>Average</td>
<td>11.4</td>
<td>11.5</td>
<td>11.3</td>
</tr>
<tr>
<td></td>
<td>20%ile</td>
<td>9.1</td>
<td>9.5</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>90%ile</td>
<td>15.6</td>
<td>14.9</td>
<td>15.9</td>
</tr>
<tr>
<td>% of Time Sea (Tp&lt;8s)</td>
<td></td>
<td></td>
<td>2%</td>
<td>2%</td>
</tr>
<tr>
<td>% of Time Swell (Tp&gt;8s)</td>
<td></td>
<td></td>
<td>98%</td>
<td>98%</td>
</tr>
<tr>
<td>Dp (°N)</td>
<td>Weighted Average</td>
<td>129</td>
<td>13</td>
<td>155</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation</td>
<td>64</td>
<td>60</td>
<td>51</td>
</tr>
</tbody>
</table>

Table 3: Design (ARI 100 year) significant wave heights and peak wave periods offshore and on the shoreline of the western coast of Nanumaga

<table>
<thead>
<tr>
<th>Location</th>
<th>ARI 100-year wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Offshore Nanumaga (&gt;50m depth)</td>
<td>Hs = 7m, Tp = 12sec</td>
</tr>
<tr>
<td>Nanumaga shoreline</td>
<td>Hs = 2.3m, Tp = 12sec</td>
</tr>
</tbody>
</table>

2.4.3 Currents

At the time of writing there has been no water current measurements in the vicinity of Nanumaga. Offshore (deep water) currents are expected to be minimal (<1m/s) and are mostly associated with oceanic circulation or with surface wind-driven currents.

Nearshore currents are driven by wave processes across the reef flats. When waves arrive perpendicular to the reef crest, wave breaking and wave setup over the reef drives currents towards the path of least resistance, small reef gunnels, around the island tips or towards the small boat channel. When waves arrive at an oblique angle to the reef crests and island
shorelines, longshore currents are set up along the west coast of Nanumaga. During south to south-west swells, net northward longshore currents would be expected. This is expected to also drive a net northerly longshore transport of sand along the shoreline when wave heights are large enough. During the wet season when intermittent storms result in westerly or northerly wave events, these longshore processes are expected to reverse with currents and sediments flowing toward the islands southern tip at a reduced rate.

2.4.4 Wind regime

The wind climate at Nanumaga was assessed using data extracted from a regional hindcast model from the Centre for Australian Weather and Climate Research (CAWCR). The wind roses in Figure 6 and wind climate statistics in Table 4 show prevailing winds are dominated by easterly trades of moderate strength. The range of wind directions is relatively larger during the wet season, with stronger wind speeds originating from the north and west.

Table 4: Wind climate statistics for Nanumaga.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Statistic</th>
<th>Long term averages (41-years) - CAWCR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>All seasons</td>
</tr>
<tr>
<td>Wind speed [m/s]</td>
<td>Mean</td>
<td>5.1</td>
</tr>
<tr>
<td></td>
<td>20%ile</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>50%ile</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>75%ile</td>
<td>6.4</td>
</tr>
<tr>
<td></td>
<td>90%ile</td>
<td>7.8</td>
</tr>
<tr>
<td></td>
<td>99%ile</td>
<td>10.9</td>
</tr>
<tr>
<td></td>
<td>99.5%ile</td>
<td>12.1</td>
</tr>
<tr>
<td></td>
<td>Max</td>
<td>26.2</td>
</tr>
<tr>
<td>Wind direction</td>
<td>Weighted mean [°N]</td>
<td>101</td>
</tr>
<tr>
<td></td>
<td>Standard deviation [°]</td>
<td>51</td>
</tr>
</tbody>
</table>
Figure 6: Annual, wet season and dry season wind roses for Nanumaga.
3. COASTAL PROTECTION DESIGN

3.1 Overview

Full details on the design process and iterations of the Nanumaga coastal protection can be found in the Concept Design Report (UNDP, 2021a) and is summarised in the following section. Appendix A: and Error! Reference source not found. provide the IFC detailed design drawings and bill of quantities. Table 5 provides an overview of the key parameters of the Nanumaga Coastal Protection design.

Table 5: Overview of TCAP design parameters for Nanumaga Coastal Protection works

<table>
<thead>
<tr>
<th>Design parameter</th>
<th>Design value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berm Top Barrier Length</td>
<td>665m</td>
</tr>
<tr>
<td>Berm Top Barrier Height</td>
<td>8.5-10m TGZ at crest of BTB</td>
</tr>
<tr>
<td>Berm Top Barrier volume</td>
<td>9,500m³</td>
</tr>
<tr>
<td>Boat ramp design</td>
<td>Stacked 2.5m³ geotextile synthetic containers topped by 75m² of cellular concrete blocks</td>
</tr>
</tbody>
</table>

Figure 7: Site plan of the TCAP Nanumaga coastal protection design

3.2 Structure details

Berm Top barriers (BTB) are to be constructed of buried Geotextile Mega Containers (GMC) laid end to end. The GMC are to be ‘keyed in’ to the surface of the storm berm on Nanumaga’s west coast by excavating the topsoil layer by around 500mm. A layer of geotextile material is to be placed in the excavation footprint and pinned to the ground. The GMC is to be positioned and hydraulically filled from locally sourced (TYPE B) sediment. The whole structure is buried under replaced and locally sourced (TYPE A) sand at an angle of natural repose (30-35°) and
revegetated with native vegetation and larger (palm or coconut) palms on the horizontal extremities of the works.

Atop the replaced fill of the BTBs, a 1m wide footpath will be constructed, consisting of geotextile and wooden planks filled with coral rubble or larger (Type A) fill. A typical section of the BTB is shown in Figure 8.

![Figure 8: Typical section of Berm Top Barrier (top) and footpath and GMC detail (below)](image)

Table 6: Geosynthetic container design sizes

<table>
<thead>
<tr>
<th>Type</th>
<th>Height (mm)</th>
<th>Length (mm)</th>
<th>Width (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GMC</td>
<td>1,500 – 2,100</td>
<td>20,000</td>
<td>1,500 – 4,800</td>
</tr>
</tbody>
</table>

3.2.1 Alignment and crest levels

Generally, the alignment of the BTB has been designed to follow the natural alignment of the storm berm on Nanumaga’s west coast. The alignment can be seen to meander along its length (Figure 7), this is to provide sufficient barrier from private and public infrastructure and roadways. The final alignment is expected to change during construction due to new infrastructure having been built since original design, however the objective of the design is to increase the level of the highest landform of the island (storm berm) by an additional 1500mm. The height of the finished BTB will be between 8.5-10m TGZ.
The BTBs are to be located at the crest of the natural storm berm, not in the usual active shoreline zone. The geosynthetic bags are intended to remain buried and will be vegetated to become a reasonably seamless raised part of the natural berm system. This means that should wave attack wash away the vegetated outer layer the geosynthetic bag will remain as an immovable line of defence. Thus, the BTB will augment natural berm height and if subject to damaging wave conditions will persist. Even in the highly unlikely event that a BTB inner geosynthetic bag was punctured, it contains beach sand. This will simply become additional volume to the natural berm.

3.2.2 Durability and maintenance
There is potential that the BTB may be overtopped during extreme wave and water level events in excess of the design event. It is recommended that the BTB be inspected after any significant overtopping event or if the GMC units is exposed. In these instances, maintenance is to be undertaken to repair any tears or holes in the GMC unit and to fill any areas where erosion has occurred.

The geotextile used for the construction of the units will be designed to be vandal and UV-resistant, TEXCEL 1200R or similar. Full geotextile specifications are provided in the IFC drawings (Appendix A). Even though this design intendeds to bury the geotextile containers they are designed to withstand exposure to wave action, sunlight, high volumes of pedestrian traffic and recreational fishing, etc; however, there is potential for the bags to be damaged by impacts from large debris during very large events. Should units become exposed or damaged, the Government of Tuvalu Public Works department (PWD) will be trained in the repair of the units.

3.3 Drainage
The BTB has been designed to reduce inundation and overtopping events from the ocean. During rainfall events, drainage patterns will be altered very little from their current arrangement, as the BTB will be placed atop the highest existing landform (storm berm). During construction, it is imperative that the excavation footprint is built such that water discharged through the hydraulic filling process of the GMC units runs to the ocean and not the village.

3.4 Borrow areas
The borrow area for the estimated 9,500m$^3$ of fill required for the Nanumaga Coastal Protection works was identified on the north eastern tip of Nanumaga by the TCAP team in 2017 with further investigation and geotechnical testing undertaken by SPC in 2020 (SPC, 2020b). The TC Pam deposit was conservatively estimated at approximately 120,000m$^3$ of sediment in November 2017 following the passage of TC Pam, Figure 9. It is recommended that a reassessment of the geomorphology of the deposit is undertaken prior to extraction taking place. When extraction takes place, care should be taken to minimise the risks of increased coastal erosion associated with the extraction, for example sand should not be extracted from the active beach of the storm deposit.

Full details of sediment quality and PSD are available in SPC (2020b). Fill requirements for the Nanumaga Coastal Protection works are presented in Table 7.
Figure 9: top: Borrow area for TCAP coastal protection works at the northern point of Nanumanga, April 2020 (Source: Department of Lands and Survey, Tuvalu). Bottom left: An identified 120,000m$^3$ (approx.) of sediment deposited following TC Pam. right: seaward edge of the deposit looking south 90m from the established vegetation line (Source: TCAP, 2017).

Table 7: Sediment size requirements for the Nanumaga Coastal Protection works

<table>
<thead>
<tr>
<th>Fill Type</th>
<th>Properties</th>
<th>Use</th>
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</thead>
<tbody>
<tr>
<td><strong>TYPE A</strong></td>
<td>≥90% passing 75mm sieve</td>
<td>Fill over GMC units</td>
</tr>
<tr>
<td></td>
<td>300mm maximum particle size</td>
<td>Larger size particles and coral to be separated for use in footpath</td>
</tr>
<tr>
<td><strong>TYPE B</strong></td>
<td>100% passing 26.5mm sieve</td>
<td>GSC, GMC unit fill</td>
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</table>
3.5 Boat ramp

The central section of Nanumaga Village provides access to the ocean by a recently constructed cellular concrete (Flexmat™ or similar) boat ramp. The eastern extent of this ramp terminates just west of the Store and the footings of the old church site, see Figure 10. The TCAP Coastal protection works will extend the boat ramp over the berm and into the village.

The present accessway has over many years of use caused a depression in the height of the naturally storm berm (around 1.0 – 1.5m) and combined with the influence of the boat channel is known to be a major source of marine water overtopping volumes during large events. By raising the landward end of the road TCAP can reduce overtopping risk and volumes.

The berm height will be raised by pyramid stacking GSC units (2+1), laying geotextile and fill atop the GSC units and then installing the cellular concrete ramp mat as per manufacturer specifications mating into the existing ramp. A cross-section of the proposed ramp is provided in Figure 11.

Figure 10: recently constructed Flexmat™ cellular concrete boat ramp on Nanumaga.
4. PROJECT IMPLEMENTATION

4.1 General

The United Nations Development Programme (UNDP), Pacific Office in Fiji act as the Project Management Unit (PMU) for TCAP, implementing the project in partnership with the GoT. Assistance throughout the implementation phase has also been provided by the Pacific Community (SPC) has also been engaged by UNDP to conduct the ESIA, coastal vulnerability and geotechnical components.

The following section describes non-design related aspects of the project implementation.

4.2 Project governance and oversight

TCAP has been led at the highest political level by a Technical Working Group (TWG) comprising key government departments and Non-governmental Organisation (NGO) associations representing vulnerable communities. The GCF financing, through TCAP, will enable the GoT to address the financial and capacity constraints at all levels – from technical to community awareness – that have so far prevented a sustainable coastal protection solution.

TCAP will strengthen institutional and community capacity for sustaining and replicating project results. It is envisaged that the project will help to strengthen governmental capacity for coastal management and its legacy will be a Coastal Management Strategy for Tuvalu with internal agency capacity for its implementation.

4.3 Procurement strategy

Due to the works complexities stemming from the remote location of the project sites, the unique atoll environments and the nature of the construction works in Tuvalu, UNDP have proposed a 3-stage Interactive Dialogue Procurement Strategy. The construction works will be tendered as a complete package of works encompassing Funafuti, Nanumea and Nanumaga. The procurement stages are briefly described below:

- Pre-qualification (PREQ): The PREQ procedure is aimed at identifying qualified applicants for the next stage of the procurement process based upon their expertise,
financial and technical capacity, and experience in construction in remote undeveloped atoll islands.

- Request for Proposal (RFP): A formal RFP will be issued to pre-qualified tenderers to provide both a formal technical and financial response to the tender. A pre-bid conference will be undertaken prior to the submission of the tenderer’s RFP response.

- Interactive Dialogue (ID): The interactive dialogue allows UNDP and tenderers to discuss the scope and complexities around the project and for tenderers to understand better the RFP requirements. ID offers significant and clear benefits; enabling risk and assumptions to be thoroughly tested, innovative solutions to evolve and the foundations established for ensuring a successful contractual outcome of the tender. After completion of the ID sessions, the offerors are expected to submit their proposals within the stipulated deadline. The evaluation of the proposals including the contract award will follow the standard UNDP RFP process.

4.4 Contract delivery

The works contract will be delivered through UNDP’s standard construction contract. Terms of the contract and any proposed departures by the tenderers will be discussed during the ID phase of procurement in the presence of the UNDP Legal and Procurement Teams as well as the PMU. Contractual discussions and verifications through the ID phase will minimise the risk of contractual disputes during construction as the ID sessions provide an opportunity for both parties to explore contingencies and project risks prior to signing and commencement of works.

4.5 Construction Environmental and Social Management Plan (C-ESMP)

The planned works on Nanumaga have the potential to create a variety of impacts through their implementation. These impacts can be either positive (e.g., improved coastal protection for community members) or negative (e.g., loss of trees, impact to structures, impaired beach access or views) depending on the activity and receptors involved. The impact of this project on the physical, biological, and social environment has been assessed and is described in detail in the Environmental and Social impact Assessment Nanumaga and Nanumea undertaken by The Pacific Community – Geosciences, Energy and Maritime Division (SPC, 2020a). The key potential project impacts and risks have been identified as the following:

- Increased water turbidity from dredging works
- Changing access to, and use of, coastal marine environment
- Increased risk of traffic accidents
- Solid waste management
- Use of heavy machinery on the beach leading to increased sedimentation
- Fuel or other hazardous spills
- Noise and dust disturbance

This ESIA contains the recommended mitigation measures for Nanumaga for pre-construction, construction, and operational phases to avoid, reduce, or mitigate all identified impacts. The Contractor for the TCAP works will be required to produce a Contractor’s Environmental and
Social Management Plan (C-ESMP). The C-ESMP will be the Contractor’s governing document for the implementation of this ESIA’s recommendations during works. The C-ESMP will be reviewed and approved by the TCAP Project Management Unit and disclosed prior to commencement of civil works. A summary of the key environmental and social indicators is provided in the table below.

Table 8: Environmental and Social Indicators and parameter considered under each indicator during the impact assessment (Source: SPC: 2020a)

<table>
<thead>
<tr>
<th>Environmental and Social Indicator</th>
<th>Factors to be considered</th>
</tr>
</thead>
</table>
| **Water Quality**                 | - Water quality of coastal marine environment  
                                 | - Quantity and quality of surface water  
                                 | - Turbidity in marine environment |
| **Erosion, Drainage and Sediment Control** | - Sedimentation build up in coastal marine environment  
                                 | - Management of project site run off  
                                 | - Existing erosion and sediment deposition regimes in coastal zone |
| **Air Quality**                   | - Dust generation  
                                 | - Air quality |
| **Noise and Vibration**           | - Noise nuisance in sensitive areas  
                                 | - Vulnerability of property to damage from vibration |
| **Flora and Fauna**               | - Vegetation within the direct and indirect project footprint  
                                 | - Loss of native fauna  
                                 | - Degradation of marine habitats  
                                 | - Introduction of new invasive marine or terrestrial species  
                                 | - Spread of existing invasive species in project sites |
| **Waste Management**              | - Excavation of household waste during construction  
                                 | - Disposal arrangements of solid project and construction waste  
                                 | - Management of hazardous waste  
                                 | - Treatment and disposal of wastewater (black and grey) |
| **Chemical and Fuel Management**  | - Storage and handling of hazardous substances  
                                 | - Contamination of soils and water from spills |
| **Community Services and Infrastructure** | - Boat landing access (especially challenging on Nanumaga)  
                                 | - Water supply facilities  
                                 | - Island roads |
| **Land and Resource Use**         | - Church location  
                                 | - Agriculture and food bearing trees  
                                 | - Changing land use  
                                 | - Utilisation of private, native land |
| **Social Environment**            | - Gender and social inclusion  
<pre><code>                             | - Community perceptions and expectations |
</code></pre>
<table>
<thead>
<tr>
<th>Environmental and Social Indicator</th>
<th>Factors to be considered</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Employment</td>
</tr>
<tr>
<td>Community Health and Safety</td>
<td>• Gender based violence</td>
</tr>
<tr>
<td></td>
<td>• Worker safety</td>
</tr>
</tbody>
</table>
5. SUMMARY AND RECOMMENDATIONS

5.1 Summary

This report is the culmination of the design process for the Nanumaga Coastal Protection works as part of the TCAP. It finalises the design narrative undertaken in the Concept Design Report (UNDP, 2020) and draws on extensive stakeholder consultation, site investigations and interviews with contractors working in the region. The basis of design, structure parameters and the project implementation framework is presented herein. A safety in design (SiD) investigation which presents a design and construction risk assessment is provided in appendix C for reference.

The Nanumaga Coastal Protection works can be summarised as follows:

- 665m of Berm Top Barrier (BTB) constructed on the western coast of Nanumaga. Constructed from buried geotextile mega containers (GMC) approximately 20m long, the BTB will raise the height of the storm berm by around 1500mm. The GMC will be filled and buried under 9,500m$^3$ of sediment sourced from the northern tip of Nanumaga located around 500m from the village centre. The BTB will be planted with local vegetation and a small rubble footpath will be built on the crest of the BTB alignment.

- A cellular concrete boat ramp will extend the recently constructed boat ramp from Nanumaga boat harbour to the Village centre. The ramp will be placed atop stacked geosynthetic containers (GSC) and will raise the berm in this location.

5.2 Recommendations

The following recommendations are included as the TCAP moves through the implementation stage:

- Any uncertainties or omissions within this Detailed Design Report and associated IFC drawings should be conveyed by the tenderers to UNDP during the ID phase of the procurement strategy.

- The submitted C-ESMP should address as a minimum the risks presented in Table 8 and those detailed in the ESIA (SPC, 2021a).

- A post-construction monitoring and maintenance strategy should be established with clear tasks, roles, training and budget allocated to GoT.

- Wherever possible a UNDP representative engineer should be present during the construction phase to ensure the coastal protection works are constructed as to the specifications presented.
6. REFERENCES


PCCSP, 2015. Current and future climate of Tuvalu

PSLM, 2019a. Tuvalu – Vaitupu 2019 Tide Predictions Calendar. Climate and Oceans Support Program in the Pacific. A Pacific Islands Program supported by the Australian Government and Australian Bureau of Meteorology. GPO Box 1289 Melbourne Victoria 3001 Australia

PSLM, 2019b. Tuvalu – Vaitupu 2019 Tide Predictions Calendar. Climate and Oceans Support Program in the Pacific. A Pacific Islands Program supported by the Australian Government and Australian Bureau of Meteorology. GPO Box 1289 Melbourne Victoria 3001 Australia


Appendix A: Nanumaga Coastal Protection IFC Drawings
GEOTECHNICAL PLACEMENT

1. THE GEOTECHNICAL PLACEMENT IS TO BE CONDUCTED IN A MANNER WHICH LIMITS THE EXTENT OF THE WORKS EXPOSED TO POSSIBLE DAMAGE FROM HIGH LEVELS OF WAVE ACTION AND STORMWATER.

2. THE WORKS SHALL BE COMPLETED IN A MANNER WHICH LIMITS THE EXTENT OF THE WORKS EXPOSED TO POSSIBLE DAMAGE FROM HIGH LEVELS OF WAVE ACTION AND STORMWATER AND ENSURE THAT IT DOES NOT ADVERSELY AFFECT AREAS ADEQUATE TO THE WORKS.

3. DEMOLITION AND EXCAVATION SHALL BE UNDERWAY IN A CAREFUL MANNER WITHIN A MINIMUM OF ONE-HALF AND WITH ALL POSSIBLE PRECAUTION TAKEN TO PREVENT DAMAGE TO PROPERTY AND INJURY TO PERSONNEL.

4. CARRY OUT ALL WORKS IN ACCORDANCE WITH THE APPROVED PROJECT DOCUMENTATION. RECORDS AND DATA AUTHORIZED ANY CHANGES MADE TO THE WORKS UNDER THE DOCUMENTATION IN ACCORDANCE WITH QUALITY PROCEDURES.

5. ALL DISCREPANCIES SHALL BE REFERRED TO THE UCN ENGINEER FOR RESOLUTION BEFORE PROCEEDING.

6. DURING THE CONSTRUCTION THE CONTRACTOR SHALL BE RESPONSIBLE FOR MAINTAINING THE WORKS INCLUDING ADJACENT STRUCTURES AND ROADS IN A STABLE CONDITION AND ENSURING NO PART IS OVERSTRESSED.

7. ALL DIMENSIONS ARE IN METRES AND ALL LEVELS IN METRES RELATIVE TO CHART DATUM.

8. ABBREVIATIONS TO BE USED IN WORKS IN THE WORKS EXTENDED TO A WRISTbands AND Datums USED IN WORKS IN THE WORKS EXTENDED TO A WRISTbands AND Datums USED IN WORKS IN THE WORKS EXTENDED TO A WRISTbands AND Datums USED IN WORKS IN THE WORKS.

9. CATCHMENT BASED DATA ON MODEL (ME) PROVIDED BY FSSB (2019).

10. ELEVATED TERRAFLY TO BE HIGHEST POINT OF RECLAMATION TO ALLOW OVERFLOW FROM MAJOR EVENTS TO BE COMPLETE THE RECLAMATION. REFER DESIGN REPORT FOR DETAILS.

11. ALL DIMENSIONS RELATING TO EXISTING WORKS, GROUNDS AND EXCAVATED LEVELS, OR ITEMS SUPPLIED BY OTHERS, SHALL BE VERIFIED BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF ANY FABRICATION AND EXCAVATION WORKS. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THEIR ACCURACY.

12. ALL PROPRIETARY ITEMS SHALL BE Installed STRICTLY IN ACCORDANCE WITH THE MANUFACTURER’S INSTRUCTIONS AND SUPPLIED INSTRUCTIONS.

13. THE CONTRACTOR SHALL BE RESPONSIBLE FOR TEMPORARY SITE CLEANUP AND GENERAL MAINTENANCE OF THE AREA DURING CONSTRUCTION.

14. THE CONTRACTOR SHALL RECORD PHOTOGRAPHIC EVIDENCE OF ALL EXCAVATIONS PRIOR TO ANY BACKFILLING.

EXCAVATION AND FILL WORKS

1. THE UNFINISHED DRAWING SUPPERSHALL BE ADVISED WHEN DEMOLITION, EXCAVATION AND FILL WORKS ARE TO COMMENCE.

2. THE EXCAVATION ALIGNMENT AND BATTER SHALL BE IN ACCORDANCE WITH THE LEVELS AND HS SLOPES SHOWN ON THE DRAWINGS.

3. CAVES MUST BE TAKEN WITH EXCAVATION BATTERS TO ENSURE THEY ARE NOT SPEEDING ROAD AND SITE ACCESS.

4. APPROVED WORKS MUST BE BUILT BY THE CONTRACTOR UNDER THE SUPERVISION FROM THE SUPPLIER IN RESPONSE TO THE REMOVAL OF TREES, OR COVERING OF LOCAL GARDENING OR INFRASTRUCTURE BY EXCAVATION BATTERS.

5. COVERING OF THE USE OF TOP BARRIERS MUST BE IN ACCORDANCE WITH THE ALIGNMENT LEVELS AND HS SLOPES OF THOSE SPECIFIED IN THE DRAWINGS. ANY PROPOSED CHANGES TO THE DESIGN MUST BE PROPOSED TO THE UNFINISHED ENGINEER PRIOR TO CONSTRUCTION.

6. STOCKPILING OF SAND SHALL BE LIMITED TO THE EXTREMELY EXTREME FOR CONTINUITY OF THE WORKS.

FILL MATERIAL

1. ALL FILL MATERIALS ARE NON-COMPOUND MATERIALS COMPRISING HARD, DENSE AND DURABLE INERT MATERIALS WHICH WILL BE SELF-FORM ORGANIC AND DURABLE MATERIAL.

2. ORCHIDS OF FILL MATERIALS SHALL COMPLY WITH THE FOLLOWING PROPERTIES:

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MATERIAL</th>
<th>PROPERTIES</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>300mm MAJOR</td>
<td>28% PASSING 30mm SIEVE</td>
</tr>
<tr>
<td>B</td>
<td>100mm MAJOR</td>
<td>28% PASSING 20mm SIEVE</td>
</tr>
</tbody>
</table>

GEOTECHNICAL (Mega) CONTAINERS

1. PLACEMENT OF THE CONTAINERS SHALL BE IN ACCORDANCE WITH THE FOLLOWING TOLERANCES:

- A TOLERANCE OF ±1M ALONG THE BOUND OF INDIVIDUAL CONTAINERS.
- A MAXIMUM OF ±0.5M HORIZONTAL OFFSET BETWEEN THE ERROR OF ADVANCED GEOMETRIC BAND CONTAINERS.
- A MAXIMUM OF ±0.5M VERTICAL OFFSET BETWEEN ADJACENT GEOMETRIC BAND CONTAINERS.

2. CONTAINERS SHALL BE FILLED USING TYPE VIII MATERIAL.

3. CONTAINERS SHALL BE FILLED AND BEAD-associated WITH THAT PROCESSED BY THE MANUFACTURER AND IN ACCORDANCE WITH THE CONSTRUCTION PROCEDURE.

4. The FILL MATERIALS SHALL BE HYDRODYNAMICALLY STABLE AND SHALL ACHIEVE CONTAINER DIMENSIONS WITHIN THE RANGE SPECIFIED.

<table>
<thead>
<tr>
<th>CONTAINER</th>
<th>TYPE</th>
<th>WEIGHT (kg)</th>
<th>LENGTH (m)</th>
<th>WIDTH (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>500</td>
<td>20,000</td>
<td>3,100</td>
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</tbody>
</table>

5. THE CONTAINERS SHALL BE PLACED ON A GEOTECHNICAL TO PREVENT THE LOSS OF FILL MATERIALS THROUGH THE STRUCTURE. IN ACCORDANCE WITH THE DRAINAGES AND THIS SPECIFICATION.

6. THE CONTAINERS SHOULD BE PLACED USING SELF-FORMING FILL PLACEMENT EQUIPMENT, IN ACCORDANCE WITH THE MANUFACTURER’S RECOMMENDATIONS.

7. THE AMOUNT OF HANDLING SHALL BE MINIMUM TO ENSURE THE GEOMETRIC BAND CONTAINER RETAINS ITS FORM AND SHAPE, AND TO REDUCE THE STRAINS PUT ON THE GEOMETRIC BAND CONTAINERS. THE GEOMETRIC BAND CONTAINERS SHALL BE LOADED IN SUCH A WAY AS TO MINIMIZE THE EXPOSURE OF THE ON-SITE SITE BULK MATERIAL.

8. THE CONTAINERS SHALL BE PLACED IN A STRETCHER BAND-LOAD TO ENSURE EFFECTIVE INTERLOCK AND STABILITY.

9. IF VERSATILE TAPPING AT THE GEOMETRIC BAND CONTAINERS IS REQUIRED DURING PLACEMENT, A MINIMUM BAND COVER OF 500MM IS REQUIRED OVER THE GEOMETRIC BAND CONTAINERS.

REINSTATEMENT, SITE DESTRUCTION AND CLEANUP

1. EXCEPT TO THE EXTENT THAT THE SITE HAS BEEN REPAIRED AND UPGRADED IN ACCORDANCE WITH THE WORKS, THE SITE SHALL BE REPAIRED TO ITS PRE-CLEAN CONDITION AND ANY STRUCTURED DAMAGES DURING THE COURSE OF THE WORKS.


3. UPON COMPLETION OF THE WORKS, REMOVAL, AND DISPOSAL, OFFER SITE OF ALL SUPPLIES, SPILLS, EMBRACE OR EXCESS MATERIAL, AND FOR THE FINAL CLEANING UP OF ALL AREAS COVERED BY THE CONTRACT SHALL BE LEFT CLEAN AND TIDY UPON COMPLETION.
**LONGITUDINAL SECTION GB01**

<table>
<thead>
<tr>
<th>CHAINAGE</th>
<th>DEPTH TO EXISTING (m)</th>
<th>CONTROL S.O.P</th>
<th>EXISTING SURFACE</th>
<th>LOCALLY TRIM EXISTING SURFACE TO ENSURE PATH TO MEGA BAG CLEARANCE</th>
<th>MIN. 300mm CLEARANCE</th>
<th>MEGA CONTAINER</th>
<th>CORAL FILL PATH</th>
<th>TOP OF BERM</th>
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</tbody>
</table>

**Notes:**
- CONTROL S.O.P: Control Surface Over Point
- EXISTING SURFACE: Depth to Existing Surface
- DEPTH TO EXISTING (m): Depth to Existing Surface in meters
- LOCALLY TRIM EXISTING SURFACE: Locally trim existing surface to ensure path to mega bag clearance
- MIN. 300mm CLEARANCE: Minimum 300mm clearance
- MEGA CONTAINER: MEGA container placement
- CORAL FILL PATH: Coral fill path
- TOP OF BERM: Top of berm

**Scale:**
- PLAN SCALE 1:250
- GENERAL ARRANGEMENT PLAN AND LONGITUDINAL SECTION SHEET 2
LOCALLY STEEPEN BATTERS IN THIS AREA TO LIMIT BACKFILLING INTO EXISTING CISTERN;

STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

EXISTING FRC CELLULAR CONCRETE RAMP TO BE RETAINED;

EXISTING ACCESS PATH (COMPACTED FILL);

MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03;

LOCATE BETWEEN THE PATHS.

STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

EXISTING FRC CELLULAR CONCRETE RAMP TO BE RETAINED;

EXISTING ACCESS PATH (COMPACTED FILL);

MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

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MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

300mm MINIMUM DEEP KEY. OVER EXCAVATE TO ENSURE 300mm COVER FROM SAND CONTAINER TO UNDERSIDE OF PATH.

LOCATE BETWEEN THE PATHS.

STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

EXISTING FRC CELLULAR CONCRETE RAMP TO BE RETAINED;

EXISTING ACCESS PATH (COMPACTED FILL);

MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

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MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

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PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

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STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

EXISTING FRC CELLULAR CONCRETE RAMP TO BE RETAINED;

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MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

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EXISTING FRC CELLULAR CONCRETE RAMP TO BE RETAINED;

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PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

EXISTING FRC CELLULAR CONCRETE RAMP TO BE RETAINED;

EXISTING ACCESS PATH (COMPACTED FILL);

MATCH PROPOSED ACCESS PATH TO EXISTING PATH;

PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

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PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.

STACKED GEOTEXTILE SAND CONTAINERS (KEYED IN);

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PROVIDE PATH CONNECTION FROM CELLULAR CONCRETE RAMP TO EXISTING PATH;

PROPOSED CELLULAR CONCRETE RAMP TO CONNECT WITH EXISTING CELLULAR RAMP. REFER TO SECTION C3 SHEET 06-03.
CONTROL GB02 SOUTHERN BTB

1 GENERAL EARTHWORKS

1A.1 EXCAVATION OF 20 Screening and Stockpile 155 m³

1A.2 USING EXCAVATED SCREEN AT LOCALLY SOURCED BEACH SAND 105 m³

2 IMPORTED MATERIAL

2A.1 CRUSHED CORAL fill OR TURF AT CROSS SECTIONAL AREA (CALC) 380 m³

2A.2 TIMBER RETAINING BEAMS (400mm x 400mm, TOTAL LENGTH 5634m) X 4 4 x Each 564 m 1853 m³

2B.1 TIMBER RETAINING BEAMS (400mm x 400mm, TOTAL LENGTH 5634m) X 4 4 x Each 564 m 1853 m³

2B.2 TIMBER RETAINING BEAMS (400mm x 400mm, TOTAL LENGTH 5634m) X 4 4 x Each 564 m 1853 m³

2C.1 MEGA CONTAINER 300m³ X 4 12 m 1200 m³

2D.1 MEGA CONTAINER 300m³ X 4 12 m 1200 m³

NOTE:
1. ALL VOLUMES ARE IN-SITU CUBIC METRES
2. NO ALLOWANCE HAS BEEN MADE FOR STRIPPED SURFACE.

SITE VOLUMES PLAN

SCALE 1: 1,000

CONTROL GB02 SOUTHERN BTB

1 GENERAL EARTHWORKS

1A.1 EXCAVATION OF 20m x SCREENING AND STOCKPILE 555 m³

1A.2 USING EXCAVATED SCREEN AT LOCALLY SOURCED BEACH SAND 380 m³

2 IMPORTED MATERIAL

2A.1 CRUSHED CORAL fill OR TURF AT CROSS SECTIONAL AREA (CALC) 380 m³

2A.2 TIMBER RETAINING BEAMS (400mm x 400mm, TOTAL LENGTH 5634m) X 4 4 x Each 564 m 1853 m³

2B.1 TIMBER RETAINING BEAMS (400mm x 400mm, TOTAL LENGTH 5634m) X 4 4 x Each 564 m 1853 m³

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NOTE:
1. ALL VOLUMES ARE IN-SITU CUBIC METRES
2. NO ALLOWANCE HAS BEEN MADE FOR STRIPPED SURFACE.

EARTHWORK VOLUME MOVEMENT PLAN

TUVALU COASTAL ADAPTATION PROJECT (TCAP), NANUMAGA

P19012

P19012-AG-CV-05-01

UNFINISHED DRAWING
VILLAGE CENTRE - TYPICAL LONGITUDINAL SECTION CELLULAR RAMP

SCALE 1: 50

GENERAL FILL SOURCED FROM THIS SITE

CELLULAR BLOCKS REFER DETAIL CL SHEET 06-03

MATCH PROPOSED CELLULAR CONCRETE BLOCKS TO EXISTING (MINIMISE OVERLAP) REFER SECTION C2 SHEET 06-03

APPROXIMATE TOP OF BATTER BLUFF RAMP TO MATCH AT THIS POINT

EXISTING ACCESS PATH

2.5m³ SAND CONTAINERS REFER DETAILS SHEET 06-03

PROPOSED CONCRETE CELLULAR BLOCKS PLACE SHORT BAG AS REQUIRED

2.0m CROSS SECTION LENGTH

MIN 100mm LAYER OF CLEAN BEACH FILL ON TOP OF GSC

300mm U-PIN (TYPICAL)

GENERAL FILL SOURCED FROM THIS SITE

SCALE 1: 25

VILLAGE CENTRE - RAMP CRESCENT DETAIL

SCALE 1: 25

PROPOSED CONCRETE CELLULAR BLOCKS REFER DETAIL C1 SHEET 06-03

PLACE SHORT BAG AS REQUIRED

2.0m CROSS SECTION LENGTH

300mm U-PIN (TYPICAL)

GENERAL FILL SOURCED FROM THIS SITE

SCALE 1: 15

VILLAGE CENTRE - SECTION CELLULAR RAMP

SCALE 1: 50

GENERAL FILL SOURCED FROM THIS SITE

300mm U-PIN (TYPICAL)

PROPOSED CONCRETE CELLULAR BLOCKS REFER DETAIL C1 SHEET 06-03

PLACE SHORT BAG AS REQUIRED

2.0m CROSS SECTION LENGTH

300mm U-PIN (TYPICAL)

GENERAL FILL SOURCED FROM THIS SITE
GEOTEXTILE SAND CONTAINER DETAIL
SCALE 1:20

M7
- 1800mm
600mm

TOTAL BAG LENGTH (LONGITUDINALLY) = 2.5m
ASSUMED AREA OF BAG SHOWN 1.05m²
BAG VOLUME 2.5m³

TUBULAR GEOTEXTILE ENCASEMENT
(PREFABRICATED UNIT)

GEOROCK OR APPROVED EQUIVALENT

ALIGNMENT OF BERM AS SHOWN ON PLANS

TYPICAL SECTION AND DETAILS
SHEET 3

UNFINISHED DRAWING

CELLULAR MATTRESS DETAILS

- LANDWARD SLOPE: 1V:9H, 10.0m LONG x 30m WIDE
- CREST: 2.0m LONG x 20m WIDE
- SEAWARD SLOPE: 1V:9H, 6.5m LONG x 30m WIDE
- TRANSVERSE ROW OF (SHORT) PINS: 1 PIN EVERY 3m BLOCK AT EACH END OF EACH SECTION.
- LONGITUDINAL ROW OF (SHORT) PINS: 4 PINS FOR SEAWARD AND LANDWARD SLOPE SECTIONS, 2 PINS FOR RAMP CREST.

GENERALLY THE SUPPLY AND INSTALLATION OF THE 'FLEXMAT' SHALL BE AS PER THE MANUFACTURERS (MARECON) 'INFORMATION DOCUMENT FOR ONSHORE AND COASTAL APPLICATIONS'. REFER ALSO TO NOTES SHEET 02-01.

CELLULAR RAMP SECTION - MATCH TO EXISTING BLOCKS

CELLULAR RAMP SECTION - EDGE DETAIL

ELEVATE EXISTING BLOCKS AS PER MANUFACTURERS INSTRUCTIONS TO ALLOW PLACEMENT OF NEW SKIRT

PLACE END SKIRT ABOVE EXISTING BLOCKS

UNFINISHED DRAWING
### Channel F011

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Legend:
- **EXISTING SURFACE**
- **DESIGN FSL**
- **EXCAVATION FOR KEY**
- **PATHWAY**
- **FILL**
- **MEGA CONTAINER**
- **EXCAVATION FOR KEY**
### CHANNEL FO01

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### EXISTING SURFACE

- Offset (-LHS/+RHS)

### EXCAVATION FOR KEY

- Offset (-LHS/+RHS)
**LEGEND**

- EXISTING SURFACE
- DESIGN FSL
- EXCAVATION FOR KEY
- PATHWAY
- FILLING
- MEGA CONTAINER
- EXCAVATION FOR KEY

**Dimensions:**

- **SCALE 1:100 AT ORIGINAL SIZE**
- **OFFSET (-LHS/+RHS)**
- **EXISTING SURFACE**
- **CHANNEL FD01**
- **FD01 DATUM**
- **CH 160**
- **CH 140**
- **CH 120**
- **CH 220**
- **CH 200**
- **CH 180**

**Locations:**

- **Gold Coast Highway, Burleigh Heads, QLD, 4220, Australia**
- **+61 (0) 412 393 703**
- **www.bluecoastconsulting.com.au**

**Survey Provided by:**

- **HORIZONTAL DATUM: UTM-WGS84 / UTSM60S EPSG32760**
- **VERTICAL DATUM: CHART DATUM (CD) TGZ**

**Scale:**

- **SCALE 1:25 AT ORIGINAL SIZE**
- **1 in 3.0**

**Offsets:**

- **0.25m**
- **0.5m**
- **0.75m**
- **1.0m**
- **1.25m**

**Values:**

- **-11.79**
- **-11.16**
- **-10.59**
- **-10.41**
- **-10.56**
- **-11.07**
- **-11.79**
- **-11.07**
- **-11.79**
- **-11.76**
- **-11.70**
- **-11.76**
- **-11.70**

**Channel FD01:**

- **DATUM 4.0**
- **DATUM 5.0**

**Notes:**

- **UNFINISHED DRAWING**

**Project:**

- **TUVALU COASTAL ADAPTATION PROJECT (TCAP), NAMUAGA**

**Issued For:**

- **MLC**
- **AW**

**Appendix:**

- **JL**
- **AW**

**References:**

- **1/1874**
- **control gb02**
- **site cross sections**
- **sheet 2**

**Document:**

- **P19012-AG-CV-07-05**