Elfin Hill Road Reserve Foreshore Stabilisation

Concept Design Report

Gosford City Council

23 February 2015

Final

8A0467

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1 INTRODUCTION

1.1 Study Area and Background

Elfin Hill Road Reserve is situated on the eastern foreshore of Brisbane Water at Green Point. The reserve is utilised for passive recreation and dinghy launching, primarily by local residents. The Study Area extends from Elfin Hill Road in the south to the rock platform behind 313 Avoca Drive in the north (refer **Figure 1**). The reserve exhibits varying levels of active shoreline erosion and there are a number of ad-hoc seawalls present with varying degrees of structural integrity. Council intends to carry out foreshore stabilisation works along this section of the reserve.

This project is being commissioned in line with the *Coastal Zone Management Plan for Brisbane Water* which has the following overarching aims:

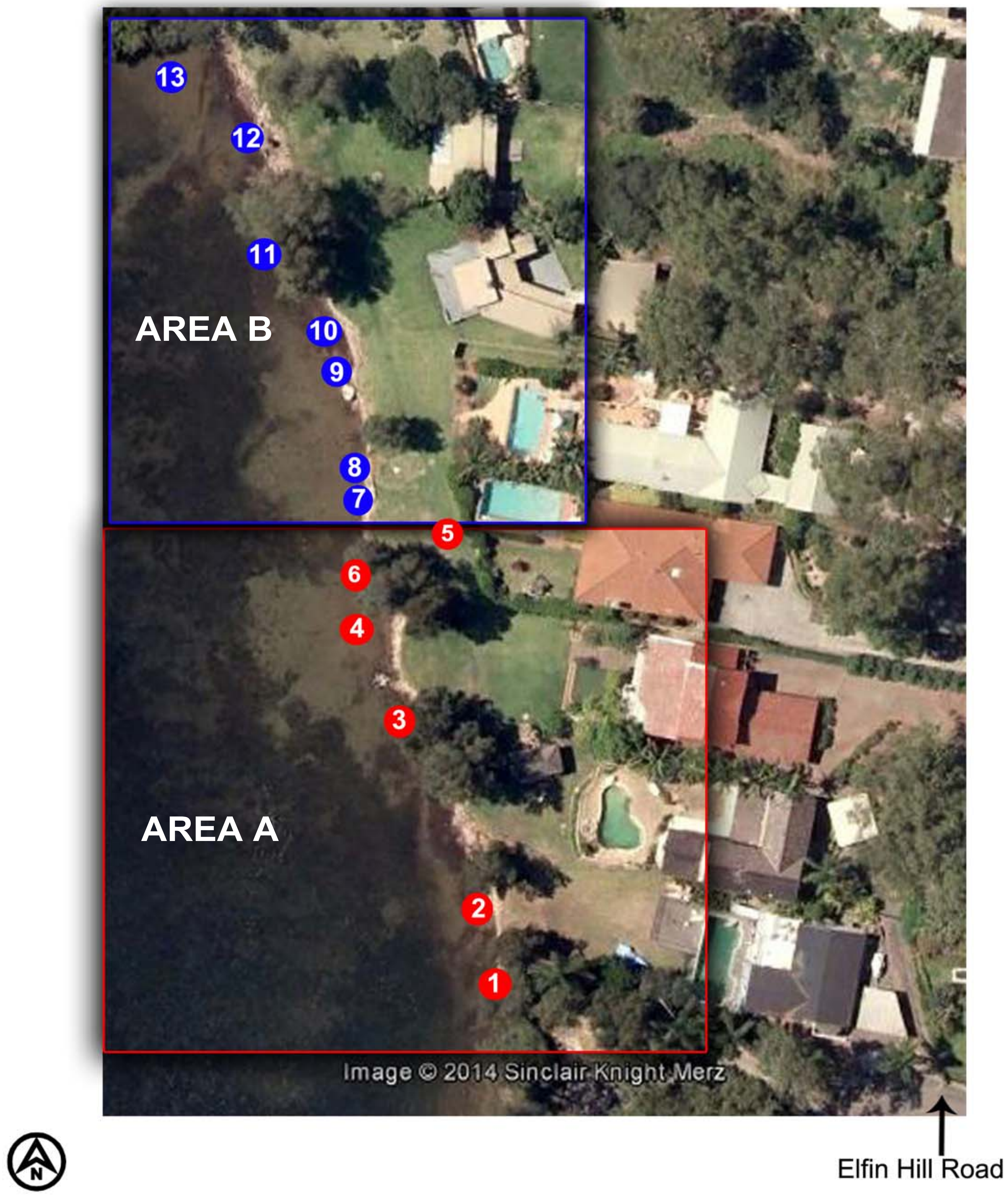
- Protect, rehabilitate and improve the natural estuarine environment;
- Manage the estuarine environment in the public interest to ensure its health and vitality;
- Improve the recreational amenity of estuarine waters and foreshores;
- Recognise and accommodate natural processes and climate change; and,
- Ensure ecologically sustainable development and use of resources.

1.2 Scope of Work

Gosford City Council (Council) engaged Haskoning Australia Pty Ltd (HKA) to carry out a concept design of foreshore stabilisation along Elfin Hill Road Reserve, Green Point. The following activities were completed as part of the project and are presented in this report:

- Inception meeting;
- Site survey;
- Site investigations;
- Collation and review of background information;
- Basis of Design; and,
- Conceptual options.

Detailed design, design drawings and environmental assessment is proposed to be completed at a later date and does not form part of this report.



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2 SITE DESCRIPTION AND INVESTIGATIONS

The site was inspected on the 28th of October 2014 with Warren Brown (Council), Robert Baker (Council), Ben Morgan (HKA) and Rick Plain (HKA). Following the site inspection, preliminary site investigations (sediment samples, a shallow test pit and dynamic cone penetrometers (DCPs)) were carried out by and Ben and Rick.

The site inspection involved observation of matters that included effectiveness of existing foreshore stabilisation methods, influence of trees on stability/instability, riparian vegetation as an indicator of possible recent instability/slumping, proximity and influence of storm water outlets, contribution of traffic to bank conditions, wave exposure, and typical tidal level fluctuations. The implementation of various conceptual options was discussed at the site inspection.

2.1 Site Description

Elfin Hill Road Reserve is situated on the eastern foreshore of Brisbane Water at Green Point. The Study Area extends around 125 m along the alignment of the foreshore from Elfin Hill Road in the south to the rock platform behind 313 Avoca Drive in the north (refer **Figure 1**). The reserve is between 15 to 25 m wide, grassed and relatively flat with levels ranging from 0.8 to 2.0 m AHD. The reserve exhibits varying levels of active shoreline erosion and there are a number of ad-hoc sea walls present with varying degrees of structural integrity.
The Study Area has been divided into Areas A and B, which are described below.

Area A is presented in **Figure 2** and comprises of the following:

- Brick and concrete rubble of various size;
- Aluminium ramps used as a private launching ramp and 2 wooden planks thought to be used as a dinghy skid by another resident;
- Remains of a vertical ‘piled’ timber seawall, discontinuous, eroded behind piles and in a state of disrepair;
- Casurinas exposed at seaward base;
- Open eroded foreshore, around a 0.5 m scarp;
- Several local pvc drainage lines exposed;
- One reinforced concrete storm water outlet terminated at a headwall approximately 5m landward of MSL. Concrete channel and gabion to prevent erosion of the shoreline. Gabion is damaged with contents scattered along foreshore and signs of erosion in drainage channel;
- 150 to 250 mm angular sandstone blocks;
- Mangroves established in sediments on the rock shelf south of the site, one mangrove approximately 3 m tall was uprooted.

Inventory of shoreline blocks and rock suggests approximately 50 sandstone blocks varying in size between 150 mm and 250 mm in this area may be suitable for reuse in the foreshore stabilisation works.

Area B is presented in **Figure 3** and comprises of the following:

- A sandstone block seawall comprising of approximately 200 mm to 300 mm square sandstone blocks mortared together on places, in reasonable condition. Signs of settlement and possible washout behind the wall;
- Access steps to the water constructed using bricks and concrete;
- Casurinas exposed at seaward base and two 100mm stumps indicating removal of casurinas;
- Remains of a log seawall, in poor condition;
- Open eroded foreshore, around a 0.5m scarp;
- Scalloped area on cleared shoreline thought to extend over rising main. Rising main not visible;
- Several local drainage lines exposed, two drainage lines have headwalls;
- Approximately 4 square meters of 20 to 50 mm gravel in front of one drainage outlet;
- 2 large 1.5 m diameter boulders;
- 2 large partly burnt stumps, dilapidated dinghy near the stumps;
- 200 to 300 mm angular sandstone blocks;
- Seaweed and debris deposits at the northern end of the site up to 300 mm deep;
- One dinghy stored on the grass at the northern end of the site;
- Mangroves established on rock shelf north of the site.

Inventory of shoreline blocks and rock suggests approximately 130 square sandstone blocks varying in size between 200 mm and 300 mm, approximately 80 angular sandstone blocks varying in size between 200 mm and 300 mm and 2 large 1.5 m diameter boulders may be suitable for reuse in the foreshore stabilisation works. Other material such as logs may be suitable for developing ecosystems.

AREA A

Casurinas exposed at based behind sandstone and concrete wall

Pipe terminated behind seawall and dilapidated gabion in foreground

Pipe terminated behind seawall and dilapidated gabion

Brick and concrete rubble along foreshore

Aluminium ramps, vertical logs wall and brick and concrete rubble

Casurinas exposed at base. Rockshelf at southern end of site visible in the right of the photograph

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AREA B

Seaweed and debris up to 300mm thick

Stumps

Mortared sandstone blockwork wall

Local access steps at high tide

Casurinas exposed at base

Scalloped area with 0.5m scarp. Rising main thought to lie underneath scalloped area

Large boulders and log wall to the left of the photograph. Log removed from wall visible behind boulder

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2.2 Preliminary Site Investigation

Four DCPs were carried out along the foreshore to provide input into foundation conditions for various foreshore treatments. The DCPs were carried out to depths between 0.8 m and 2.6 m below the surface and generally indicated looser or softer material for the upper 0.7 m to 0.9 m with denser or stiffer material below. Bedrock was noted as foreshore rock shelves adjacent to the north and south of the site. Inferred depth to bedrock across the site varied between 0.7 m and 2.6 m. The DCPs results and a location plan are provided in **Appendix A**.

Four sediment samples were also collected and analysed for particle size distribution (PSD). The sediment sample results indicated that the middle and southern end of the site comprises medium grained sand with silt and traces of gravel. The samples have less than 10% fines (silt and clay sized sediments) and less than 8% gravel. The northern end of the site comprises silty sand with gravel and the sample has 22% fines and 23% gravel. The PSD results are provided in **Appendix A**.

The grass reserve appears to be reclaimed land that was once likely to have been an extension of the existing intertidal foreshore. A shallow test pit was excavated in an area where subsidence and washout was thought to be occurring (around 3 metres from the foreshore). The test pit revealed good quality topsoil and grass with a thick well established root system. **Photograph 1** shows the test pit behind the existing sandstone block wall.

Photograph 1 – Shallow Test Pit behind the existing sandstone wall

It is understood investigation of acid sulphate soils (ASS) would be carried out at a later date as part of the environmental assessment.

2.3 Survey and Services

A detailed survey of the site was undertaken by Stephen Thorne and Associates on the 22nd of October 2014. The survey included site levels and the locations of visible services, trees and structures. A Dial Before You Dig request was submitted to assist in locating services. A council sewer main and a rising main were noted to run parallel to the foreshore through the reserve. Both mains lead to a pumping station at the southern end of the site with markers indicating their location.

The survey plan detailing these features is provided in **Appendix B**. Note that AHD refers to Australian Height Datum. Zero metres AHD approximates Mean Sea Level at present.

3 LITERATURE REVIEW

A literature review of has been undertaken for the site. The literature review includes Coastal Processes, Geological Setting and Flora and Fauna. These are discussed in more detail below.

3.1 Coastal Processes

Coastal Processes examines Wind, Climate Change, Water Level and Waves. These are examined in detail below and will govern the design of foreshore stabilisation options.

Wind

The *Structural Design Actions - Wind Actions - AS 1170.2* (Standards Australia, 2002) specifies wind speed for engineering design. This wind speed is dependent on elevation, terrain, wind direction and topography amongst other factors. It is given as a peak 3 second gust for varying Average Reoccurrence Intervals (ARI). The 3 second peak gust velocity can be converted to an equivalent 1-hour duration using methods outlined in Coastal Engineering Manual (USACE, 2006). The 1 hour design wind speed for the NSW coast south of 30 degree latitude and 10 m above a water body is presented in **Table 1**. While these estimates take topographic effects such as hill slopes into account, they do not account for topographic effects caused by valley and water way orientation, which leads to funnelling of wind.

Table 1 - 1-hour Duration Design Wind Velocity (m/s) 10 m above a water body (AS 1170.2:2002)

Wind Direction	5-year ARI	100-year ARI
North	17	21.7
North East	17	21.7
East	17	21.7
South East	20.1	25.8
South	19.1	24.4
South West	20.1	25.8
West	21.2	27.2
North West	20.1	25.8

Climate Change

The possibility of global climate change accelerated by increasing concentrations of greenhouse gases, the so-called Greenhouse Effect, is now widely accepted by the scientific and engineering communities. This is predicted to cause globally averaged surface air temperatures to increase and sea levels to rise.

The *NSW Sea Level Rise Policy Statement* (DECCW 2009) was released in October 2009. It includes sea level rise (SLR) planning benchmarks of 0.4 m at 2050 and 0.9 m at 2100 (both relative to 1990), with the two benchmarks allowing for consideration of SLR over different timeframes. The policy was formally retracted by the State Government in September 2012, however, the NSW Chief Scientists and Engineer's Report states that the science behind sea level rise benchmarks in the 2009 *NSW Sea Level Rise Policy Statement* was adequate (Cardno, 2014).

A report on the *Potential Impacts of Climate Change on the Hunter, Central and Lower North Coast of NSW (*HCCREMS, 2010) accepted sea level rise levels of 0.4 m by 2050 and 0.9 m by 2100, which was proposed in the *NSW Sea Level Rise Policy Statement* (DECCW 2009).

At the Gosford City Council's Ordinary Council Meeting in August 2013, it was decided to adopt the sea level rise benchmarks set out in the *NSW Sea Level Rise Policy Statement* (DECCW 2009) of 0.4 m at 2050 and 0.9 m at 2100 relative to 1990 levels.

An analysis of water level data collected at Koolewong since July 1985 was undertaken by Cardno (2007). It determined an average water level increase for the site of around 2.2 mm/year during this period. At this rate, mean sea level (and other tidal planes) would have risen by 0.05 m since 1990.

In the *Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar 2013) and the *Draft Brisbane Water Foreshore Floodplain Risk Management Study* (Cardno 2014), Cardno have undertaken sensitivity analysis on flooding and include various sea level rise scenarios. The 100 year projected sea level rise scenarios used in their analysis were 0.18 m, 0.3 m, 0.55 m and 0.91 m. These values were obtained from the *Practical Consideration of Climate Change* Guidelines (DECC, 2007) an in consultation with Council and DECC.

Gosford LGA has adopted SLR planning benchmarks of 0.4 m by 2050. The design life of the foreshore stabilisation concept designs is 40 years, which approximately coincides with the SLR planning benchmark of 0.4 m at 2050.

Another potential outcome of climate change is an increase in the frequency and intensity of storm events, which can be assessed in the future as predictions become more definitive. Suitable conservatism can be incorporated in the design process to account for potential increases in design waves and water levels (say in the order of 10%), in addition to any sea level rise.

Water Level

Tidal information for the site has been obtained from the *Brisbane Water Estuary Processes Study* (Cardno Lawson Treloar 2008). A summary of the tidal planes relative to AHD is presented in **Table 2**.

Table 2 - Tidal Planes for Erina Creek (Cardno 2008)

Tidal Planes	Water Level (m)
High High Water Springs (HHWS)	0.63
Mean High Water Springs (MHWS)	0.39
Mean High Water (MHW)	0.34
Mean Tide Level (MTL)	0.08
Mean Low Water (MLW)	-0.18
Mean Low Water Springs (MLWS)	-0.23
Indian Springs Low Water (ISLW)	-0.4

Coastal water levels are elevated above predicted tide levels during storm events. Elevated water levels may lead to coastal inundation and intensify damage to the coastline and to coastal developments. The *Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar 2013) accesses the Design Water Level (DWL) for a range of locations in Brisbane Waters. DWL includes storm tide level, wind set up and sea setup. Variations in Mean Sea Level linearly increases or decreases DWL in the simulation. Simulations were undertaken for approximate 5-year and 100-year Average Reoccurrence Intervals (ARI). Two locations near Elfin Hill Road Reserve were assessed as part of this study. The locations were approximately 150 m north of the site and 150 m south of the site. Results from the Cardno Lawson Treloar simulation and additional design water levels allowing for 0.4 m of SLR by 2050 are presented in **Table 3.**

Table 3 - Predicted Design Water Level

Event	150m North of Elfin Hill Road Reserve (m AHD)	150m South of Elfin Hill Road Reserve (m AHD)
5-year ARI + 0m SLR	1.34	1.33
5-year ARI + 0.4m SLR	1.74	1.73
100-year ARI + 0m SLR	1.65	1.63
100-year ARI + 0.4m SLR	2.05	2.03

Waves

The wave climate at Green Point is limited to locally generated wind waves and boat wake. Wind waves at the site are limited by the available fetch (distance of water over which the wind blows). The longest fetch is close to 4 km to the west and north west. Wave modelling using the SWAN model was undertaken in the *Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar 2013). Predicted wave heights and periods at the site for approximate 5-year and 100-year ARI events are summarised in **Table 4.**

Table 4 - Predicted significant wave heights for Green Point (Cardno Lawson Treloar 2013)

Simulated Event	150m North of Elfin Hill Road Reserve		150m South of Elfin Hill Road Reserve	
	Wave Height (m)	Wave Period (sec)	Wave Height (m)	Wave Period (sec)
5-year ARI	0.83	3.4	0.74	3.2
100-year ARI	1.02	3.8	0.92	3.6

Wind-wave hindcasting calculations carried out by HKA based on procedures in the Coastal Engineering Manual (USACE, 2006) and using design wind velocities presented previously in **Table 1** are summarised in **Table 5.** The values are similar to those predicted in the *Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar 2013).

Table 5 - Wind-wave hindcasting calculations using methods in USACE (2006)

Simulated Event	Wave Height (m)	Wave Period (second)
5-year ARI	0.76	2.5
100-year ARI	1.03	2.8

Boat wake at the site is generated on a regular basis by the small craft that use the area. Other larger craft also generate wake on an infrequent basis. Boat wake at the site is estimated to have a maximum wave height of around 0.5 m.

Flood Planning

The *Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar 2013) outlines a Flood Planning Level (FPL). The flood planning level is the sum of the Design Water Level and wave run-up height. In this case, wave run-up height depends on the wave height, edge treatment types and edge treatment surface material. Cardno Lawson Treloar (2013) assess ten edge treatment types. These are:

- 1 in 20 Natural Slope - 1.5 m AHD crest
- 1 in 20 Natural Slope - 2.5 m AHD crest
- 1 in 10 Beach Face - 1.5 m AHD crest
- 1 in 10 Beach Face - 2.5 m AHD crest
- 1 in 5 Embankment - 1.5 m AHD crest
- 1 in 5 Embankment - 2.5 m AHD crest
- 1 in 2 Seawall - 1.5 m AHD crest
- 1 in 2 Seawall - 2.5 m AHD crest
- Vertical Wall - 1.5 m AHD crest
- Vertical Wall - 2.5 m AHD crest

The FPL is conservative and assumes the worst case scenario for each location. This assumes a smooth edge treatment surface and an edge treatment type that allows the highest wave run-up. The FPL for a 100-year ARI event and for SLR at 0.3 m, 0.4 m (interpolated), and 0.55 m is summarised in **Table 6**. At the locations presented in **Table 6**, the FPL assumes a smooth seawall with slope of 2H:1V and a crest level at 2.5 m AHD.

Table 6 - Flood Planning Level (Cardno Lawson Treloar 2013)

Simulated Event	150m North of Elfin Hill Road Reserve (m AHD)	150m South of Elfin Hill Road Reserve (m AHD)
100-year ARI + 0.3m SLR	2.93	2.88
100-year ARI + 0.4m SLR	**2.95**	**2.90**
100-year ARI + 0.55m SLR	2.97	2.92

The *Draft Brisbane Water Foreshore Floodplain Risk Management Study* (Cardno 2014) examines options for the management of flooding of the foreshore of Brisbane Water estuary. Despite the high FPL, the report concludes that across Elfin Hill Road Reserve, only wave energy dissipating foreshore design is required, which aims to reduce wave run-up. Levee banks are not required under the recommendations of the report.

3.2 Geological Setting

Geology

The *Gosford-Lake Macquarie 1:100 000 Geological Sheets 9131 & 9231* indicates the site is underlain by Terrigal Formation, part of the Narrabeen Group deposited during the Triassic Period. These deposits are described as interbedded laminate, shale and quartz to lithic quartz sandstone with minor red claystone.

The *Gosford-Lake Macquarie 1:100 000 Soil Landscape Series Sheets 9131 & 9231* indicates the terrestrial portion of the site is classified as Erina, an erosional landscape. The limitations noted on this group is of particular interest, which includes localised high soil erosion hazard, localised mass movement, foundation hazard and strongly acidic soils of low fertility. The map makes no reference to the aquatic landscape.

Acid Sulfate Soils

Acid Sulfate Soils (ASS) is the common name given to sediment and soil containing iron sulfide. The exposure of iron sulfides to air will result in oxidation and the generation of sulphuric acid. Acid leachate can strip metals such as aluminium and iron from the soil matrix and release them into water bodies. Elevated concentrations of these metals may potentially affect water quality and adversely affect aquatic organisms (disease or death) that inhabit the water body.

In 1995, the then Department of Land and Water Conservation (DLWC) published Acid Sulfate Soils Risk Maps for NSW coastal areas. The risk maps identify four risk classes (high, low and no known occurrence of ASS and disturbed terrain) based on the probability of ASS being present. Within each risk class, the depth to acid sulfate material, landform and environmental risks are documented.

The Gosford Acid Sulphate Soils Risk Map (1:25,000 scale, 1995 edition) indicates the site lies within an area of high probability of occurrence of ASS materials in bottom sediments below water level. The proposed construction methodology would not be expected to excavate below the MLWS level (-0.23 m AHD) which means that the material to be excavated is frequently exposed to oxygen and it is unlikely that acid sulfate conditions would be generated. The material that forms the reserve appears to be imported fill material and is not expected to be acid generating. Nevertheless, ASS investigations are recommended as part of the future environmental assessment.

3.3 Flora and Fauna

Coastal flora, in particular saltmarsh and mangroves, are valuable in developing ecosystems and stabilising estuary foreshores. The root systems of both species stabilise coastal foreshores and reduce the impact of waves and currents. Saltmarsh grows at a specific elevation, near the level of the Highest Astronomical Tide (HAT) (NSW DPI, Daly, 2013). Incorporating saltmarsh in a foreshore stabilisation design should allow for at least a 2m wide, relatively flat berm to allow saltmarsh to establish. Mangroves grow at lower elevations between Mean Sea Level (MSL) and Mean High Water (MHW) (NSW DPI, Stewart and Fairfull, 2008). Incorporating mangroves into a design should allow for a 3 to 6 m wide planting area.

4 BASIS OF DESIGN

4.1 Purpose

The foreshore stabilisation is required to address foreshore erosion along Elfin Hill Road Reserve. The design should aim to accommodate the following where possible:

- be of a soft treatment design;
- reinstate a natural, sloping foreshore with the aim of improving reserve amenity;
- provide access to the water and inter-tidal habitat;
- increase recreational amenity and safety;
- improve habitat value through the use of environmentally friendly seawall design;
- recycle existing material onsite where possible;
- minimise excavation and removal from site to reduce Acid Sulfate Soil risk;
- be applied elsewhere in the estuary where prevailing estuarine processes and bathymetry allow; and
- be adaptive for accommodating future sea level rise.

4.2 Guidelines, Standards and Project Documents

The following Guidelines, Standards and Project Documents were considered for the design of the foreshore stabilisation.

Guidelines and Standards

Australian Standards AS1170.2 – 2002, Structural Design Actions - Wind Actions.

Australian Standard AS 2758.6 -2008, Aggregated and rock engineering purposes, Part 6: Guidelines for the specification of armourstone.

Australian Standard AS 4997-2005, Guidelines for the Design of Maritime Structures.

Coastal Engineering Manual (CEM) prepared by US Army Corps of Engineers in 2002 .

Coastline Management Manual (CMM) prepared by the New South Wales Government in 1990.

Environmental Engineering for Coastal Shore Protection prepared by USACE.

Environmentally Friendly Seawalls Guide prepared by DECC.

Foreshore Stabilisation and Rehabilitation Guideline prepared by Lake Macquarie City Council.

Primfact 746 Mangroves prepared by NSW Department of Primary Industries in 2008.

Primfact 1256 Saltmarsh prepared by NSW Department of Primary Industries in 2013.
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The Rock Manual prepared by CIRIA.

Shore Protection Manual (SPM) prepared by US Army Corps of Engineers in 1984.

Technical Design Guide for Cantilever Retaining Walls by Koppers.

<u>Project Documents</u>
Brisbane Water Estuary Processes Study Hydraulic Processes prepared by Cardno Lawson Treloar 2007.

Brisbane Water Estuary Processes Study prepared by Cardno Lawson Treloar 2008.

Brisbane Water Foreshore Flood Study prepared by Cardno Lawson Treloar 2013.

Draft Brisbane Water Foreshore Floodplain Risk Management Study prepared by Cardno 2014.

Captain Cook Reserve Foreshore Stabilisation Design Report prepared by Royal Haskoning DHV 2014.

4.3 Design life

A design life of nominally 40 years has been selected for the rock and concrete components of the foreshore treatments. Design life around the sewer rising main could be increased by localised works such as concrete encasement.

4.4 Survey

The design of the foreshore is based on survey undertaken by Stephen Thorn & Associates in October 2014, covering around 10 m both sides of the waterline along the foreshore within the Study Area. All levels are reduced to the Australian Height Datum.

4.5 Geometry

The design has regards to the following geometric constraints:

- Existing shoreline profiles;
- Existing structure (eg.seawalls, fences and buildings);
- Existing trees and other vegetation; and
- Minimise excavation to limit ASS risk.

4.6 Site Investigations

DCPs have been carried out to assess the suitability of founding various foreshore treatments. Sediment samples have been collected and analysed for particle size grading to provide input into the design of natural sloping foreshore areas, filter design and constructability.

4.7 Coastal Processes

From the *Brisbane Water Foreshore Flood Study* (Cardno Lawson Treloar 2013), a deep water design wave height of 1.02 m and a wave period of 3.8 seconds has been adopted for the site and the DWL for a 100-year ARI storm event including 0.4 m of sea level rise is 2.05 m AHD.

Based on the DWL and foreshore level of 0.2 m AHD (refer to survey in **Appendix B**), the maximum water depth at the site would be 1.85 m. The breaking wave height for this water depth is around 1.11 m, assuming a breaker index of 0.6 which is appropriate for shallow waters (USACE, 2006). Therefore, it is reasonable to expect that wave height of up to 1.02 m could propagate to the site. This value has been adopted as the design significant wave height.

4.8 Rock Hydrodynamic Stability (Sizing and Grading)

The hydrodynamic stability of the rock used was assessed in accordance with the Hudson equation in CEM (USACE, 2006). An igneous and sandstone rock with densities of 2.65 t/m^3 and 2.3 t/m^3 respectively, and a natural angle of repose of 42 degrees has been assumed.

4.9 Geotechnical Stability

Conventional low height design profiles have been used that would not be subject to a geotechnical stability analysis.

4.10 Saltmarsh and Mangroves

The selection and planting level of saltmarsh and mangrove species would be in conjunction with Council and consider existing saltmarsh and mangrove species and levels in the area.

5 CONCEPT DESIGN

5.1 Failure Modes of Revetment Designs

Failure modes of revetments for the foreshore stabilisation works were considered for the design. A structure is deemed to have failed if damage has occurred that results in structure performance and functionality below the minimum anticipated by design (USACE 2006). Failure may occur for one or more of the following reasons (USACE 2006):

- Design failure: when the structure as a whole, or individual structure components, cannot withstand load conditions within the design criteria;
- Load exceedance failure: when anticipated design load conditions are exceeded;
- Construction failure: due to incorrect or poor construction or materials; and
- Deterioration failure: from structure deterioration and/or poor maintenance.

Possible failure modes for revetment designs are summarised in **Figures 4** to **7.** These failure modes have been considered as part of the design process for this project, as described in **Table 7**.

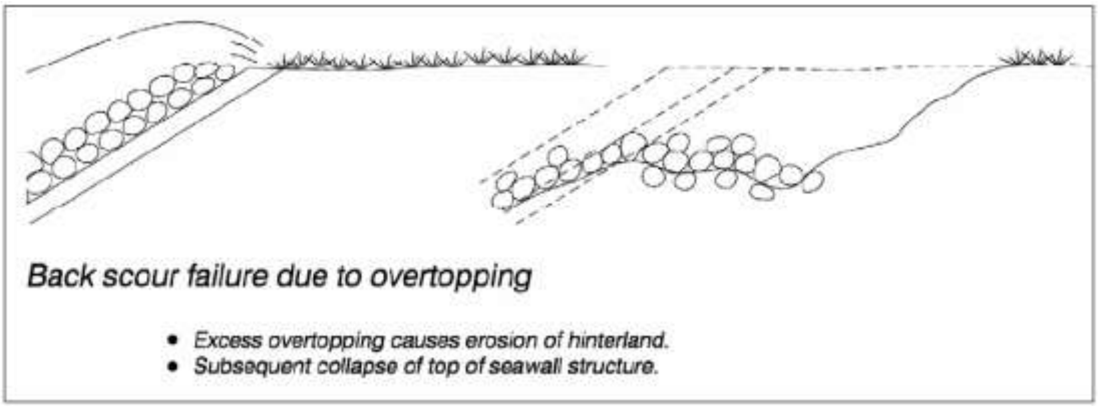


Figure 4: Scour due to overtopping (USACE 2006)

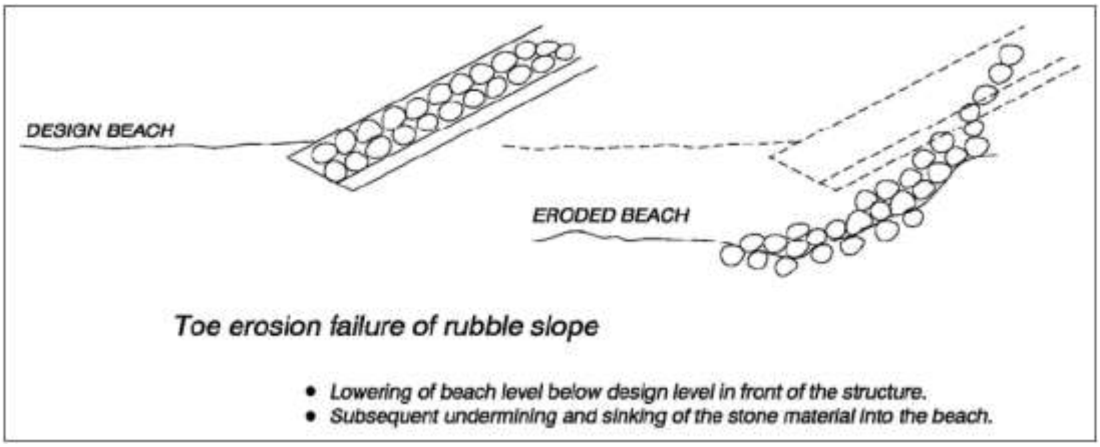


Figure 5: Toe erosion failure of rubble slope (USACE 2006)

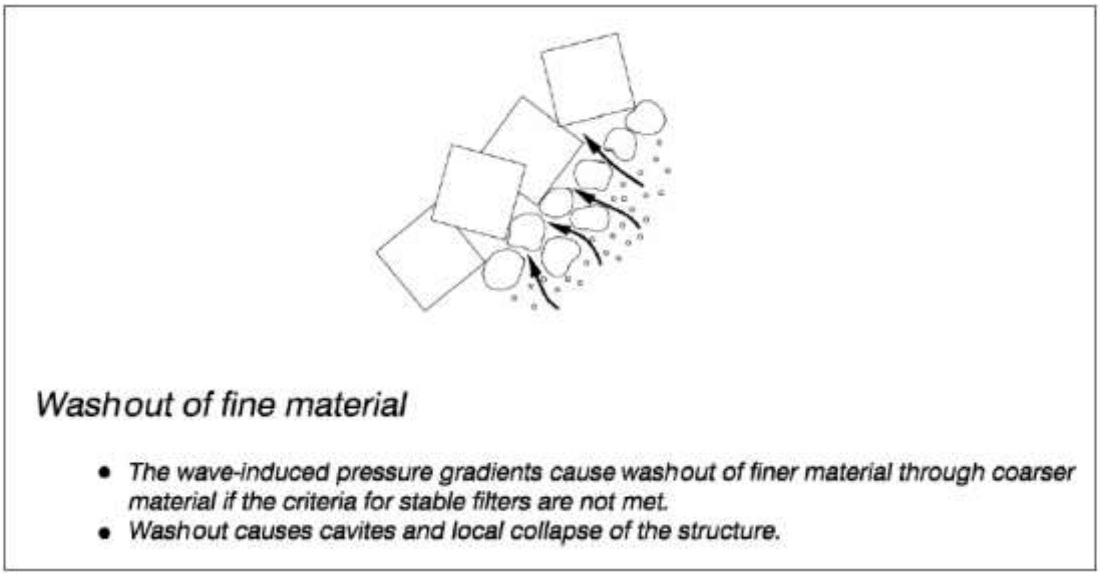


Figure 6: Washout of underlayer material (USACE 2006)

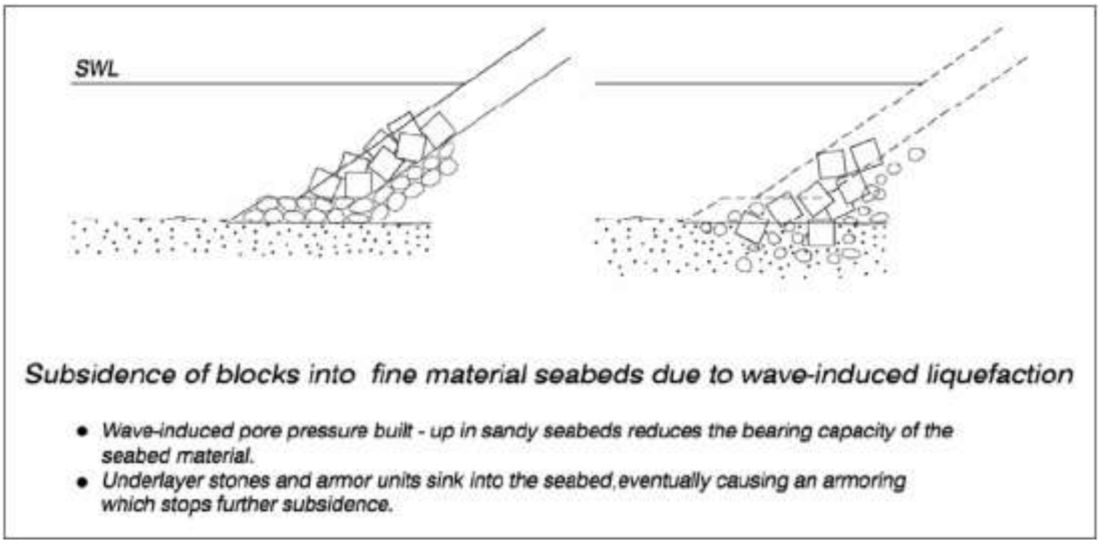


Figure 7: Block subsidence due to liquefaction (USACE 2006)

Table 7 - Design features addressing possible failure modes of revetments

Possible Failure Mode	Design features addressing failure mode
Scour due to overtopping	High crest level relative to prevailing wave climate and water levels such that overtopping would be limited to rare water level or wave events
Toe erosion failure of rubble slope	Construct toe to design scour level. Alternatively Layer of large rock placed at toe of seawall to provide additional protection against scour; if toe erosion were to occur, this rock layer could settle to a level below the MLWS level of -0.23 m AHD without compromising the structural integrity of the seawall

Possible Failure Mode	Design features addressing failure mode
Washout of underlayer material	Incorporation of a gravel layer or suitable geotextile filter between the bed and revetment to minimise washout of fine material
Block subsidence due to liquefaction	Gravel between the bed and revetment and / or possibly a geotextile filter would minimise wave-induced pore pressures in the seabed, which in any case would be low because of the mild wave climate at the site

5.2 Concept Design Options

The concept designs have been developed in accordance with the Basis of Design and informed by the walkover assessment in collaboration with Council, the site investigations, and previous foreshore stabilisation options developed by HKA. The concept designs are presented on a series of design sketches provided in **Appendix C**.

Variations of two designs from the *Captain Cook Reserve Foreshore Stabilisation Design Report* (RHDHV 2014) and three additional foreshore treatment design options have been recommended for Elfin Hill Road Reserve. These include:

- Rock Treatment (refer **Cross Section 3, Appendix C**);
- Saltmarsh Treatment (refer **Cross Section 2, Appendix C**);
- Mangrove Treatment (refer **Cross Section 1, Appendix C**);
- Rock Pools (refer **Cross Section 5, Appendix C**); and,
- Dinghy Skid (refer **Cross Section 4, Appendix C**).

The site is constrained to a narrow Council reserve with multiple casurina stands on the existing embankment and close proximity to property boundaries. Due to these constraints, design options that reduced the width of the reserve were not recommended. Therefore, the Beach and Saltmarsh Walkthrough Treatments from the *Captain Cook Reserve Foreshore Stabilisation Design Report* (RHDHV 2014) have not been considered further. In addition, the existing foreshore has receded landward of the MHWM and it is envisaged to reclaim the foreshore to at least this area where possible. Reclamation will also assist in protecting the rising main.

The concept designs are discussed in more detail below.

Rock Treatment

- Minimum two layers of sandstone rock around 400 mm diameter at a slope of 1 in 2.0 to 1.5 respectively
- Founded by rock bedding layer underlain by geotextile to prevent migration of fines
- Grasses expected to partially grow over crest of treatment
- Treatment positioned relative to alignment of existing foreshore to minimise cut
- Pack geotextile material and gravel around exposed casurina roots
- Comparative cost estimate $700/ linear metre

Saltmarsh Berm

- Similar design to Rock Treatment with incorporation of at least 2 m wide saltmarsh berm built out from existing foreshore alignment, to a planting level of around 0.7m AHD (to be confirmed)
- Option for shoreline reclamation where significant scalloping has occurred, particularly where rising main is at risk of damage
- Treatment positioned seaward of existing foreshore to minimise cut
- *Sarcocornia quinqueflora* thought to be native to area, advice from Council to be sort
- Comparative cost estimate $930/ linear metre

Mangrove Treatment

- Create shoreline rubble mound protection similar to the Rock Treatment
- Construct offshore rubble mound 3 to 6 m from the toe of the shoreline rubble mound protection using 350-400 mm diameter rock recycled from onsite
- Plant area between the shoreline rubble mound protection and offshore rubble mound with mangroves
- Treatment positioned seaward of existing foreshore to minimise cut
- Comparative cost estimate $730/ linear metre

Rock Pools

- Similar to rock treatment but with the incorporation of sandstone blocks founded on bedrock 1 to 2 m offshore of shoreline rock protection. May be grouted to bedrock and between blocks if water is to be retained at lower tide levels
- Comparative cost estimate $420/ linear metre

Dinghy Skid

- Sandstone rock fill founded on or near bedrock to minimise settlement
- Concrete slab poured over rock fill
- Sandstone blocks at toe of ramp to minimise scour
- Treated hardwood slat approximately 50 mm x 25 mm bolted to concrete slab to provide a feature to prevent slipping on the ramp and minimise damage to dinghies using the ramp
- Comparative cost estimate $5,600 per dinghy skid

Suggested locations for implementation of these concept designs are presented in **Figure 1, Appendix C**. The Rock Pool Treatment location is seen to be somewhat fixed due to the proximity of bedrock required for founding sandstone blocks and creating pools of water. Similarly, the Mangrove Treatment locations would be somewhat limited to the site fringes as they generally do not succeed in areas where views of local residents are impacted. The locations and alignment of the Saltmarsh Treatment have been determined based on the MHWM. The Saltmarsh Treatment is interchangeable with the Rock Treatment if preferred by Council. The Rock Treatment may be implemented across the whole site, however, this treatment alone has restricted environmental benefit relative to the other options. The Dinghy Skid is seen as a low maintenance and durable option for the expected wave climate and geological site conditions if it doesn’t cut into the existing reserve, and suitably accommodated by the other foreshore treatments.

Based on 100 year design water level and wave run-up values, the *Draft Brisbane Water Foreshore Floodplain Risk Management Study* (Cardno 2014) concludes that wave energy dissipating foreshore design is required at the site, but levee banks are not required. The proposed designs would provide energy dissipation and stabilise the eroding foreshore, however may not prevent extreme coastal inundation on some of the lower lying properties nearby. However, the designs are of a softer engineering nature and could be raised to reduce local inundation impacts and accommodate future sea level rise.

6 REFERENCES

Australian Standard AS 2758.6 -2008, Aggregated and rock engineering purposes, Part 6: Guidelines for the specification of armourstone.

CIRIA (2007), The Rock Manual, The use of rock in hydraulic engineering

Coastal Engineering Research Centre (1984), Shore Protection Manual

Cardno Lawson Treloar (2007) Brisbane Water Estuary Processes Study Hydraulic Processes, prepared for Gosford City Council, 2007

Cardno Lawson Treloar (2008), *Brisbane Water Estuary Processes Study*, prepared for Gosford City Council and Department of Environment and Climate Change, 6 March 2008

Cardno Lawson Treloar (2013), *Brisbane Water Foreshore Flood Study,* prepared for Gosford City Council and Department of Environment and Climate Change, July 2013

Cardno (2014), *Draft Brisbane Water Foreshore Floodplain Risk Management Study,* prepared for Gosford City Council, August 2014

DECCW (2010a), *Flood Risk Management Guide – Incorporating Sea Level Rise Benchmarks in Flood Risk Assessments, Department* of Environment, Climate Change and Water NSW

Department of Conservation and Land Management (1993). *Gosford-Lake Macquarie 1:100 000 Soil Landscape Series Sheets 9131-9231*, C.L. Murphy and P.J. Tille

Department of Environment and Climate Change [DECC] (2009). *Environmental Friendly Seawalls – A guide to Improving the Environmental Value of Seawalls and Seawall-lined Foreshores in Estuaries.* Sydney Metropolitan Catchment Management Authority and DECC, June 2009.

Department of Environment, Climate Change and Water NSW [DECCW] (2009), *NSW Sea Level Rise Policy Statement*, DECCW 2009/708, October, ISBN 978-1-74232-464-7

Gosford City Council, *Ordinary Council Meeting Tuesday, 20 August 2013.*

Gosford-Lake Macquarie 1:100 000 Geological Sheets 9131 & 9231, provisional edition, Geological Survey of New South Wales, Sydney

Hunter and Central Coastal Regional Environmental Management Strategy [HCCREMS] (2010). *Potential Impacts of Climate Change on the Hunter, Central and Lower North Coast of NSW.*

Intergovernmental Panel on Climate Change [IPCC] (2001a), *Summary for Policymakers, A Report of Working Group I of the Intergovernmental Panel on Climate Change*

Intergovernmental Panel on Climate Change [IPCC] (2001b), *Technical Summary, A report accepted by Working Group I of the IPCC but not approved in detail*, Co-ordinating Lead Authors DL Albritton (USA) and LG Meira Filho (Brazil)

Intergovernmental Panel on Climate Change [IPCC] (2007), "Summary for Policymakers", in *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, S Solomon, D Qin, M Manning, Z Chen, M Marquis, KB Averyt, M Tignor and HL Miller (editors), Cambridge University Press, Cambridge, United Kingdom and New York, USA

Manly Hydraulics Laboratory [MHL] (2004), *DIPNR Brisbane Water Estuary Tidal Data Collection,* NSW Department of Commerce- Manly Hydraulics Laboratory, February-May 2004

NSW Department of Primary Industries (2013), *Coastal Saltmarsh Primefact 1256*, Trevor Daly, March 2013

NSW Department of Primary Industries (2008), *Mangroves Primefact 746*, Mark Stewart and Sarah Fairfull, May 2008

Royal Haskoning DHV (2014), *Captain Cook Reserve Foreshore Stabilisation Design Report,* prepared for Gosford City Council, June 2014

US Army Corp of Engineers [USACE] (2006) EM 1100-2-1100 (Part II) *Coastal Engineering Manual Part II*, 1 June 2006 (Change 2)

APPENDIX A
Site Investigations (DCPs and PSDs)

Geotechnical Explanatory Notes

Introduction

These notes have been produced to supplement the geotechnical aspects of the report and appendices. In particular, the notes provide specific details relating to geotechnical logging and interpretation of borehole logs, test pit logs and in situ tests presented as part of the appendices.

Geotechnical fieldwork, interpretation and reporting has been carried out by a suitably qualified engineer or scientist. The reliability of the geotechnical information provided in the logs and penetration tests will depend to some extent on the frequency and method of excavation and penetration testing. Large variation may occur in the subsurface geological conditions and records from excavations or penetration tests may vary significantly from other locations across the site.

Description and Classification Methods

The methods of description and classification of soils and rocks in this report is based on *Australian Standard AS1726: Geotechnical Site Investigation*. Field descriptions and classifications are based on visual and tactile assessment. Where appropriate, laboratory data and penetration testing have been used to verify field descriptions and classifications.

Penetration Testing

Penetration testing is used to determine soil consistency or density. Commonly implemented penetration tests include:

DCP – Dynamic Cone Penetrometer tests are carried out by driving a 16mm rod into the ground using a 9kg hammer and recording the number of blows per 100mm. Two similar tests are commonly used: the cone penetrometer utilises a 20mm diameter cone end driven into the ground with the hammer dropping from a height of 510mm (AS1289, Test F3.2), while the Perth Sand Penetrometer utilises a 16mm flat end driven into the ground with the hammer dropping from a height of 600mm (AS1289, Test F3.3).

SPT – Standard Penetration Tests are carried out by driving a 50mm diameter split sample tube 450mm into the ground using a 63kg weight falling from a height of 760mm (AS1289, Test F3.1). These tests are normally carried out in boreholes. Blows per 150mm are recorded and the 'N' value is taken as the number of blows for the last 300mm.

Sampling

Sampling is carried out during drilling or test pitting to allow for visual and tactile assessment and to allow for laboratory testing (if required). Sampling methods include:

- U_{50} - Undisturbed Sample Tube (50mm)
- B – Bulk Sample (>10kg sample size)
- D – Disturbed Sample
- W – Water Sample
- SPT – SPT Sample
- S – Surface Sample
- PID – Photoionisation detector reading in ppm

Laboratory Testing

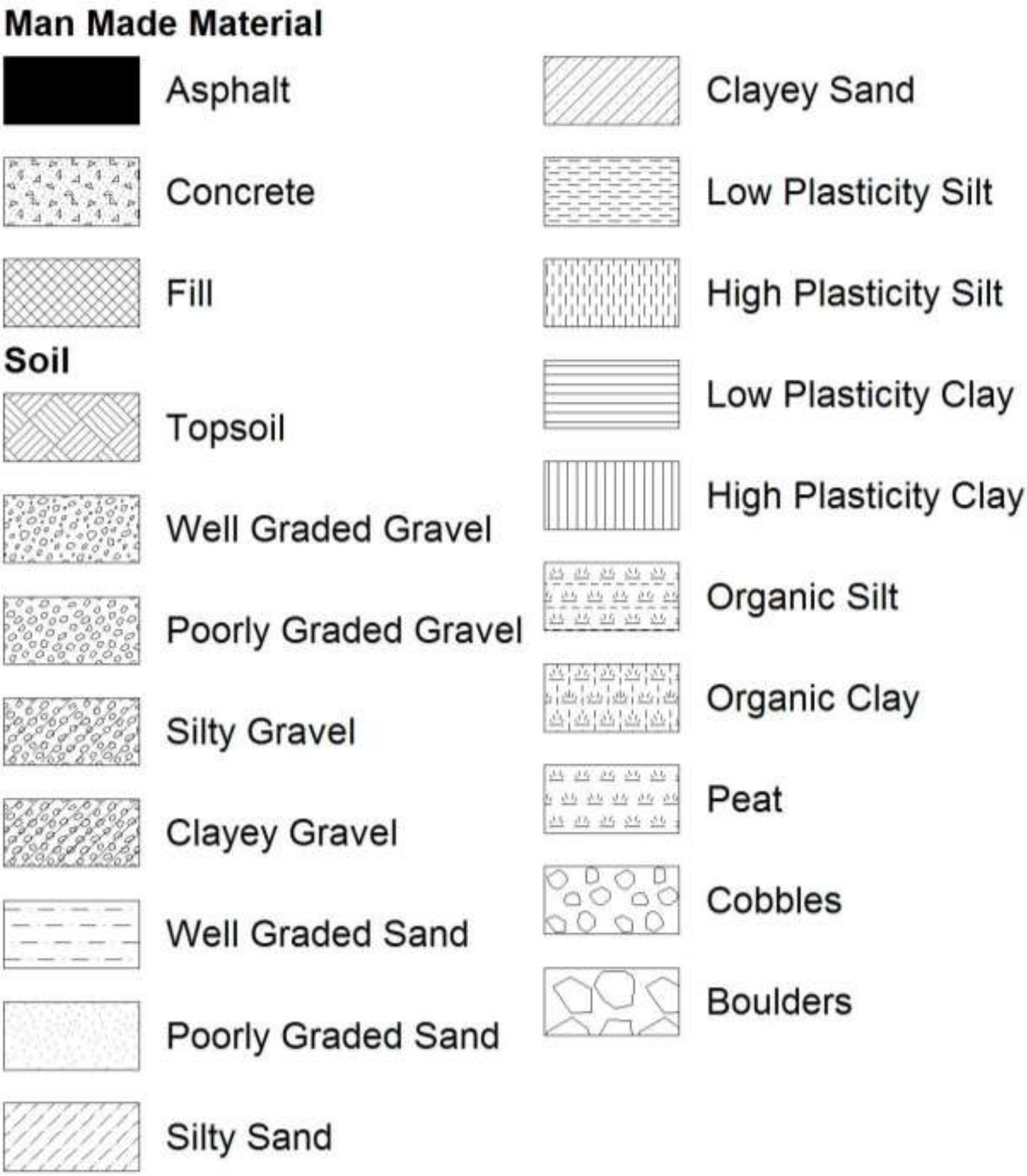
Laboratory Testing is carried out by a NATA accredited laboratory in accordance with *Australian Standard 1289 – Methods of Testing Soil for Engineering Purposes*.

Groundwater

There are several problems associated with measuring the water level in boreholes. Perched water tables above impermeable layers may lead to an erroneous indication of the true water level in underlying strata. Also, water levels may fluctuate with changing climatic conditions, some drilling methods do not enable the presence of groundwater to be detected and in low permeability soils where groundwater flow is slow, water may not enter the hole in the time it is left open. Despite the problems, the level of groundwater is often important for design and the following symbols may be used to indicate the presence of groundwater on site.

- ▼ - Standing water level
- GNO - Groundwater Not Observed
- GNE - Groundwater Not Encountered
- ├– - Groundwater inflow/seepage
- –┤ - Groundwater outflow/loss

Graphic Symbols for Soil



Soil Classification

Particle size and descriptive terms

Name	Subdivision	Size
Boulders	N/A	>200mm
Cobbles	N/A	63 mm to 200 mm
Gravel	Coarse Medium Fine	20 mm to 63 mm 6 mm to 20 mm 2.36 mm to 6 mm
Sand	Coarse Medium Fine	0.6 mm to 2.36 mm 0.2 mm to 0.6 mm 0.075 mm to 0.2 mm

Soil classification is conducted on material nominally finer than 63mm. The proportion of boulders and cobbles is recorded along with the packing characteristics as follows:

- Clast supported - clasts touching, with or without the presence of a soil matrix, and
- Matrix supported - clasts supported in a soil matrix.

Minor Component

The primary soil name is modified to include minor components as follows:

Modifier	Percentage of minor component
Omit, or use 'trace'	Fine soil in primarily coarse material: ≤5% Coarse soil in primarily fines material: ≤15%
Describe as 'with clay/silt/sand/ gravel' as applicable	Fine soil in primarily coarse material: 5-12% Coarse soil in primarily fines material: 15-30%
Prefix soil as 'silty/clayey/sandy/ gravelly'' as applicable	Fine soil in primarily coarse material: >12% Coarse soil in primarily fines material: >30%

Moisture Condition

Condition	Symbol	Guide
Dry	D	Cohesive soils are hard and friable or powdery. Granular soils are cohesionless and free running.
Moist	M	Soil feels cool and darkened in places. Cohesive soils can be remoulded. Granular soils tend to cohere.
Wet	W	Soil feels cool, darkened in colour. Free water forms on hands when handled. Cohesive soils are weakened. Granular soils tend to cohere.

Cohesive Soils

Cohesive refers to soil behaviour. Cohesive soils are classified based on strength (consistency).

Consistency

Term	Symbol	Field Guide to Consistency	Undrained Shear Strength, S_u (kPa)
Very Soft	VS	Extrudes between fingers when squeezed in hand.	<12
Soft	S	Can be remoulded by light finger pressure. Easily penetrated by thumb 30-40mm.	12-25
Firm	F	Can be remoulded by strong finger pressure. Penetrated by thumb 20-30mm with moderate effort.	25-50
Stiff	St	Cannot be remoulded by fingers. Can be indented by thumb.	50-100
Very Stiff	VSt	Can be intended by thumb nail.	100-200
Hard	H	Difficult to indent with thumb nail.	>200

Cohesionless Soil

Cohesionless refers to soil behaviour. Cohesionless soils are classified based of relative density.

Density

Term	Symbol	Field Guide to Consistency	Density Index %
Very Loose	VL	Very easily shovelled, almost no resistance.	≤15
Loose	L	Low resistance to shovelling.	15-35
Medium Dense	MD	Considerable resistance to shovelling.	35-65
Dense	D	Requires handpick for excavation.	65-85
Very Dense	VD	Requires power tool for excavation.	>85

Origin

Residual Soil	Weathered in-situ
Aeolian Soil	Deposited by wind
Alluvial Soil	Deposited by streams and rivers
Colluvial Soil	Deposited on slopes
Lacustrine Soil	Deposited by lakes
Marine Soil	Deposited in ocean basins, bays, beaches and estuaries
Fill	Man-made. May be significantly more variable between tested locations than naturally occurring soils.

Royal HaskoningDHV
Enhancing Society Together

Guide to the Description Identification and Classification of Soil (AS 1726)

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60mm and basing fractions on estimated mass)					GROUP SYMBOLS	PRIMARY NAME
COARSE GRAINED SOILS (more than half of material less than 63mm is larger than 0.075 mm)	GRAVELS More than half of the coarse fraction is larger than 2.36mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength.		GW	GRAVEL
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength.		GP	GRAVEL
		GRAVELS WITH FINES (Appreciable amount of fines)	Excess of non-plastic fines, zero to medium dry strength.		GM	SILTY GRAVEL
			Excess of plastic fines, medium to high dry strength.		GC	CLAYEY GRAVEL
	SANDS More than half of the coarse fraction is smaller than 2.36mm	CLEAN SANDS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength.		SW	SAND
			Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength.		SP	SAND
		SANDS WITH FINES (Appreciable amount of fines)	Excess of non-plastic fines, zero to medium dry strength.		SM	SILTY SAND
			Excess of plastic fines, medium to high dry strength.		SC	CLAYEY SAND
		DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
FINE GRAINED SOILS (more than half of material less than 63mm is smaller than 0.075 mm)	SILTS AND CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
		Medium to High	None	Medium	CL	CLAY
		Low to Medium	Slow to very slow	Low	OL	ORGANIC SILT
	SILTS AND CLAYS Liquid limit greater than 50	Low to Medium	Slow to very slow	Low to Medium	MH	SILT
		High	None	High	CH	CLAY
		Medium to High	None	Low to Medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS		Identified by colour, odour, spongy feel and generally by fibrosous texture.			Pt	Peat

Figure 1 - DCP and Surface Sample Location Plan

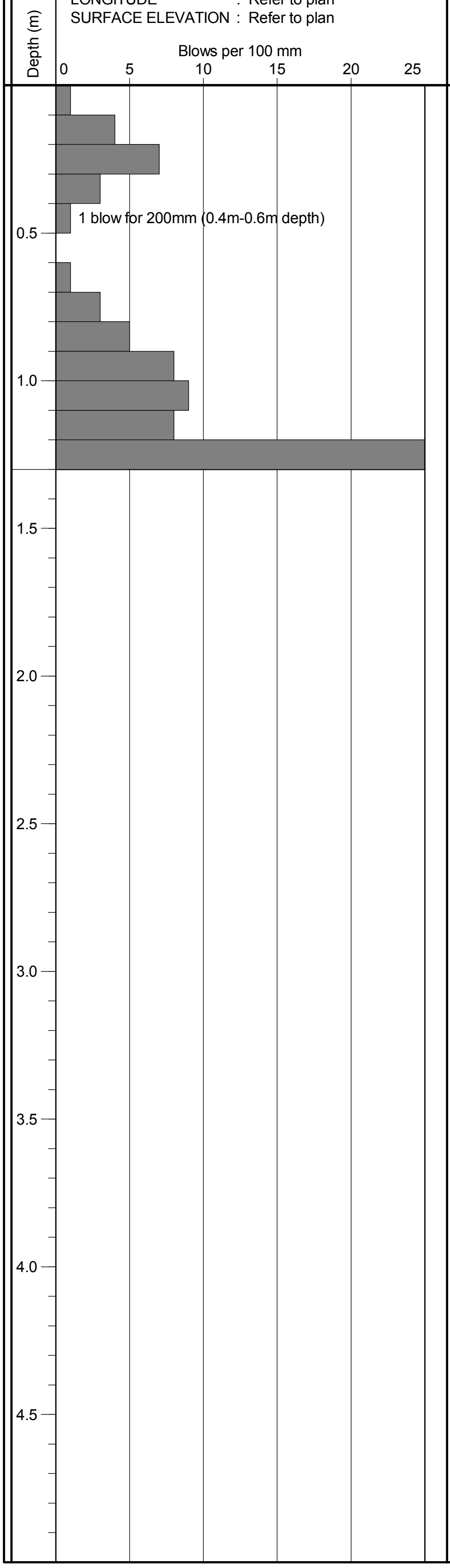
DYNAMIC CONE PENETROMETER LOG

PROJECT : Elfin Hill Road Reserve
CLIENT : Gosford City Council
FILE / JOB NO : 8A0467
METHODOLOGY : AS1289.6.3.2

SHEET : 1 OF 2

TEST: BH1

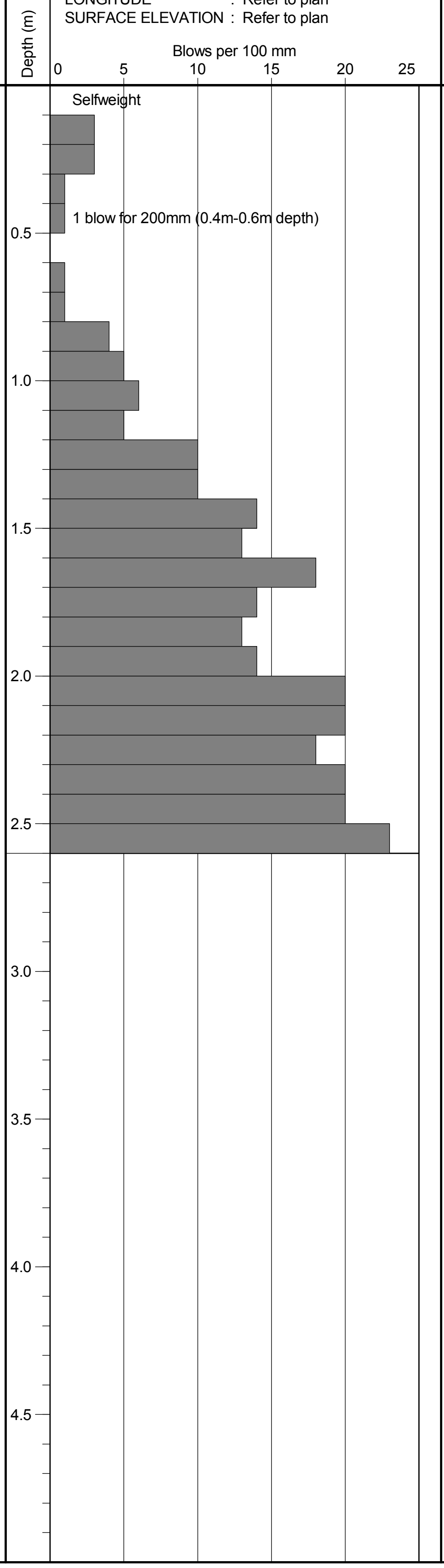
LOGGED : BM / RP 28/10/2014
CHECKED : SJB 3/11/2014
LATITUDE : Refer to plan
LONGITUDE : Refer to plan
SURFACE ELEVATION : Refer to plan



Comments
Refusal Reached (25 blows over one interval).

TEST: BH2

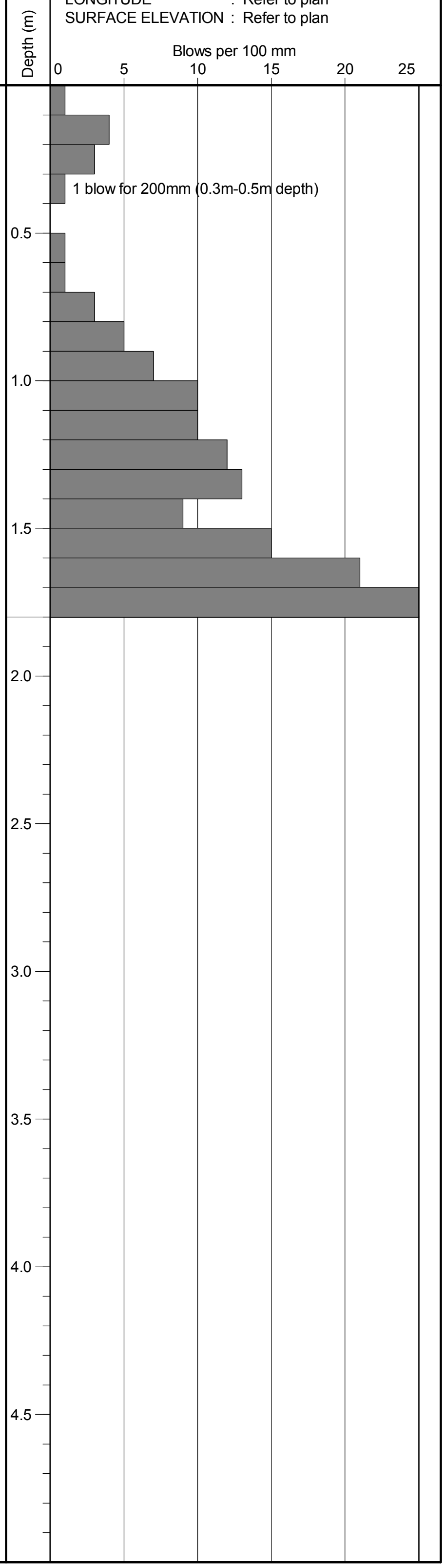
LOGGED : BM / RP 28/10/2014
CHECKED : SJB 3/11/2014
LATITUDE : Refer to plan
LONGITUDE : Refer to plan
SURFACE ELEVATION : Refer to plan



Comments
Target Depth Reached.

TEST: BH3

LOGGED : BM / RP 28/10/2014
CHECKED : SJB 3/11/2014
LATITUDE : Refer to plan
LONGITUDE : Refer to plan
SURFACE ELEVATION : Refer to plan



Comments
Refusal Reached (25 blows over one interval).

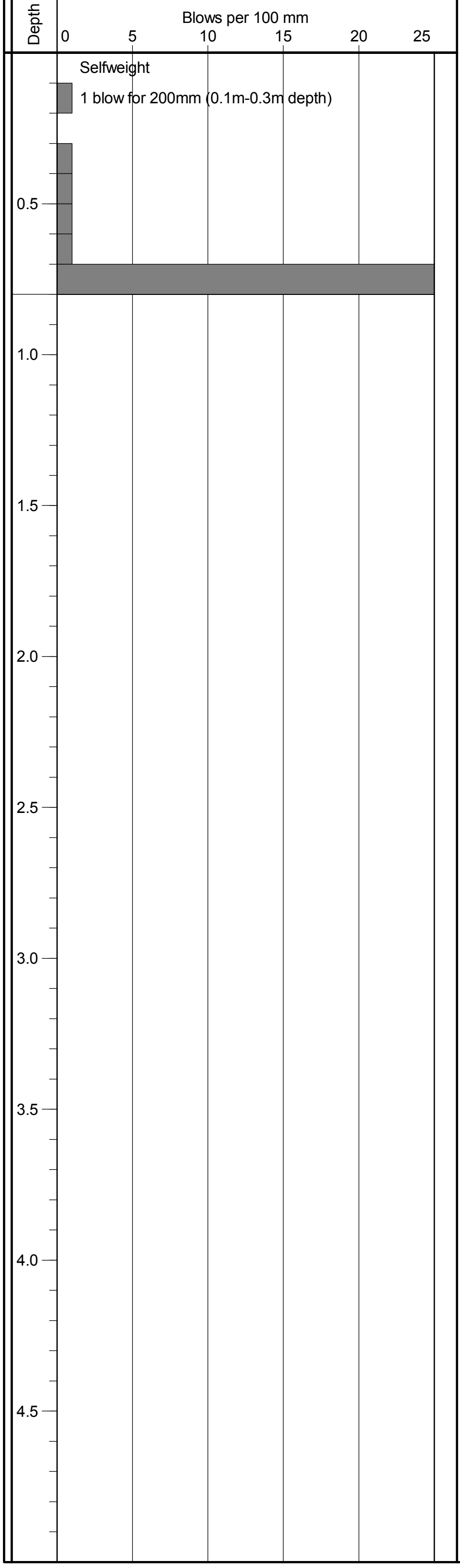
DYNAMIC CONE PENETROMETER LOG

PROJECT : Elfin Hill Road Reserve
CLIENT : Gosford City Council
FILE / JOB NO : 8A0467
METHODOLOGY : AS1289.6.3.2

SHEET : 2 OF 2

TEST: BH4

LOGGED : BM / RP 28/10/2014
CHECKED : SJB 3/11/2014
LATITUDE : Refer to plan
LONGITUDE : Refer to plan
SURFACE ELEVATION : Refer to plan



Comments
Refusal Reached (25 blows over one interval).

Certificate of Analysis

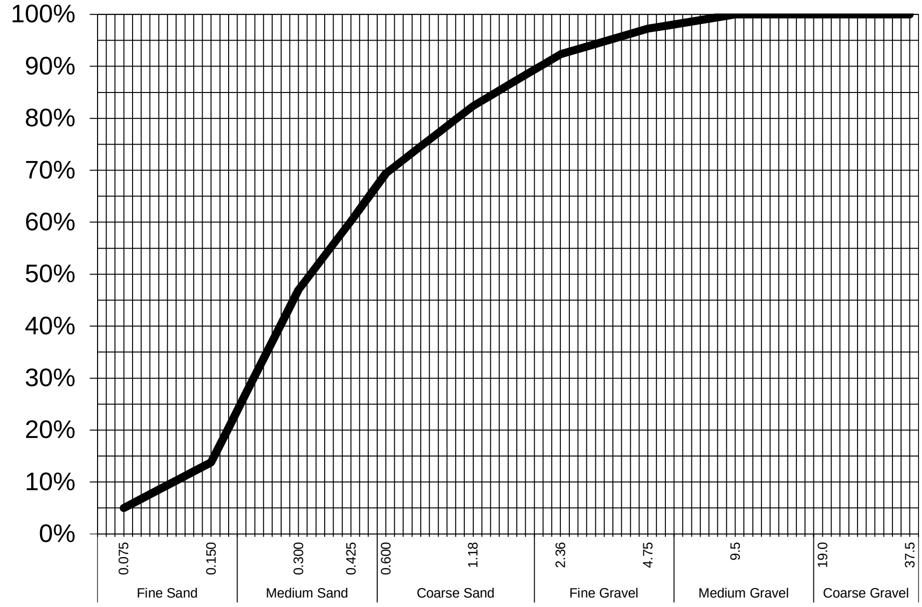
ALS Laboratory Group Pty Ltd
5/585 Maitland Road
Mayfield West, NSW 2304
pH 02 4014 2500
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Ben Morgan	**DATE REPORTED:**	7-Nov-2014
COMPANY:	Haskoning Australia- Royal Haskoning	**DATE RECEIVED:**	29-Oct-2014
ADDRESS:	Suite 505 100 Walker Street North Sydney, 2060	**REPORT NO:**	ES1423739-001 / PSD
PROJECT:	Elfin Hill Road Reserve	**SAMPLE ID:**	DCP 1

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	97%
2.36	92%
1.18	82%
0.600	69%
0.425	60%
0.300	47%
0.150	14%
0.075	5%

Samples analysed as received.

Median Particle Size (mm)*	0.328

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 3-Nov-14

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

NATA Accreditation: 825 Site: Newcastle
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Laboratory Supervisor, Newcastle
Authorised Signatory

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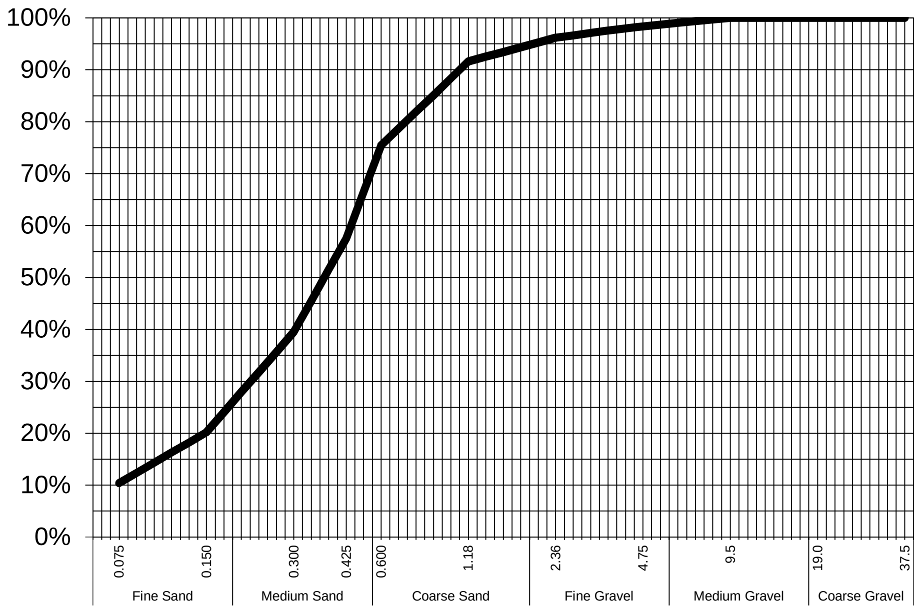
Newcastle, NSW

CLIENT:	Ben Morgan	**DATE REPORTED:**	7-Nov-2014
COMPANY:	Haskoning Australia- Royal Haskoning	**DATE RECEIVED:**	29-Oct-2014
ADDRESS:	Suite 505 100 Walker Street North Sydney, 2060	**REPORT NO:**	ES1423739-002 / PSD
PROJECT:	Elfin Hill Road Reserve	**SAMPLE ID:**	DCP 2

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	98%
2.36	96%
1.18	92%
0.600	75%
0.425	58%
0.300	40%
0.150	20%
0.075	10%

Samples analysed as received.

Median Particle Size (mm)*	0.373

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 3-Nov-14

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand and fines

Test Method: AS1289.3.6.1

NATA Accreditation: 825 Site: Newcastle
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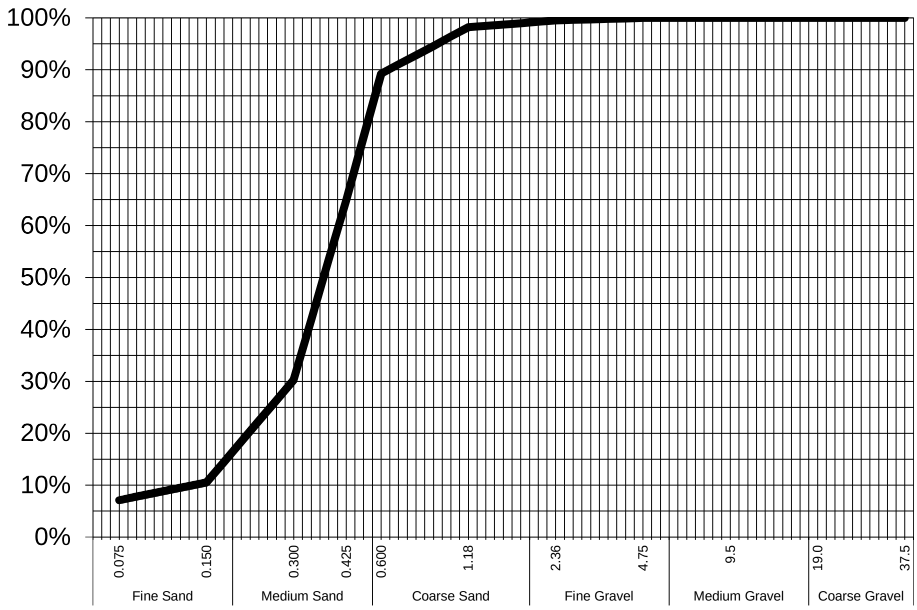
Newcastle, NSW

CLIENT:	Ben Morgan	**DATE REPORTED:**	7-Nov-2014
COMPANY:	Haskoning Australia- Royal Haskoning	**DATE RECEIVED:**	29-Oct-2014
ADDRESS:	Suite 505 100 Walker Street North Sydney, 2060	**REPORT NO:**	ES1423739-003 / PSD
PROJECT:	Elfin Hill Road Reserve	**SAMPLE ID:**	DCP 3

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	100%
4.75	100%
2.36	100%
1.18	98%
0.600	89%
0.425	65%
0.300	30%
0.150	11%
0.075	7%

Samples analysed as received.

Median Particle Size (mm)*	0.371

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 3-Nov-14

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand

Test Method: AS1289.3.6.1

NATA Accreditation: 825 Site: Newcastle
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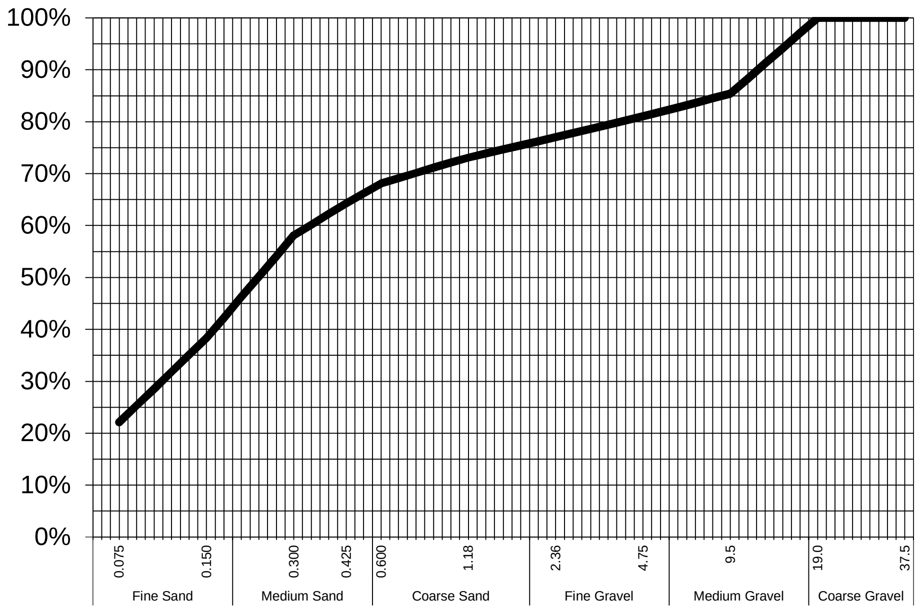
fax 02 4968 0349
samples.newcastle@alsenviro.com

ALS Environmental

Newcastle, NSW

CLIENT:	Ben Morgan	**DATE REPORTED:**	7-Nov-2014
COMPANY:	Haskoning Australia- Royal Haskoning	**DATE RECEIVED:**	29-Oct-2014
ADDRESS:	Suite 505 100 Walker Street North Sydney, 2060	**REPORT NO:**	ES1423739-004 / PSD
PROJECT:	Elfin Hill Road Reserve	**SAMPLE ID:**	DCP 4

Particle Size Distribution



Particle Size (mm)	Percent Passing
19.0	100%
9.5	85%
4.75	81%
2.36	77%
1.18	73%
0.600	68%
0.425	64%
0.300	58%
0.150	38%
0.075	22%

Samples analysed as received.

Median Particle Size (mm)*	0.239

Median Particle Size is not covered under the current scope of ALS's NATA accreditation.

Sample Comments:

Analysed: 3-Nov-14

Loss on Pretreatment NA

Limit of Reporting: 1%

Sample Description: Sand, gravel, shell and fines

Test Method: AS1289.3.6.1

NATA Accreditation: 825 Site: Newcastle
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APPENDIX B
Survey

CAUTIONS :

1) THIS SURVEY HAS BEEN PREPARED FOR THE PURPOSE OF DETAIL & CONTOUR ONLY. THE LOCATION OF ANY FENCING OR STRUCTURE IN RELATION TO THE BOUNDARIES HAS NOT NECESSARILY BEEN EXACTLY DETERMINED.
2) UTILITY SERVICES SHOWN HAVE BEEN LOCATED BY SURVEY WHERE THEY ARE VISIBLE AND APPARENT. HOWEVER , THE APPROXIMATE POSITION OF UNDERGROUND SERVICES MAY HAVE ALSO BEEN PLOTTED FROM UTILITY AUTHORITY PLANS, AND THIS PLAN MUST BE READ IN CONJUNCTION WITH THE RELEVANT UTILITY AUTHORITY PLANS.
3) THE LOCATION OF SERVICES ARE TO BE VERIFIED BY OBTAINING CURRENT INFORMATION FROM "DIAL BEFORE YOU DIG" (PHONE 1100) PRIOR TO DESIGN/CONSTRUCTION WORKS. ALTERNATIVELY, THE EXACT LOCATION OF SERVICES SHOULD BE DETERMINED BY FIELD SURVEY IN CONSULTATION WITH THE SERVICE AUTHORITIES WHERE DEEMED NECESSARY.

www.dialbeforeyoudig.com.au
DIAL 1100 BEFORE YOU DIG

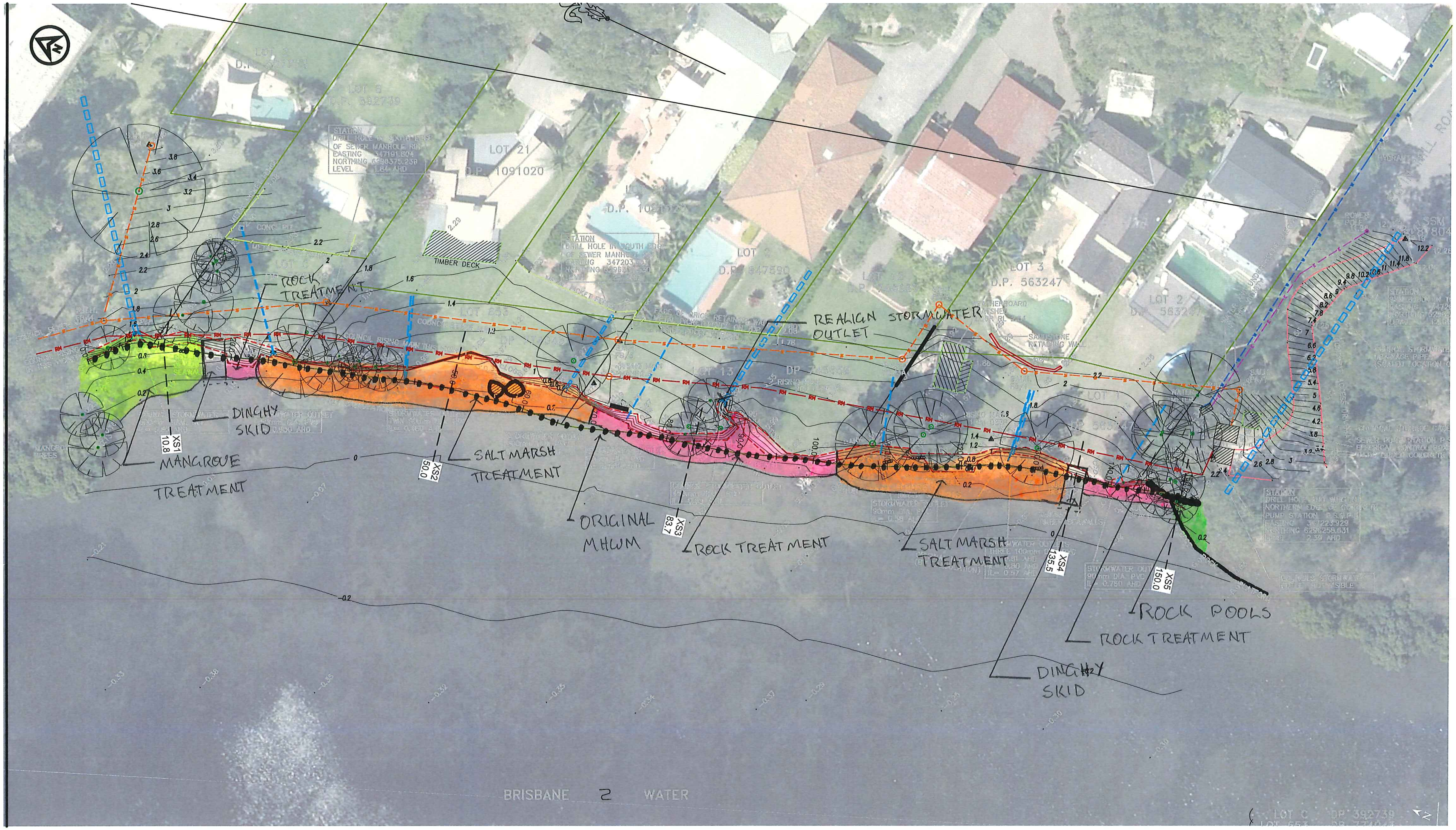
200mm CONTOURS

CAD FILE: 7044_DETAIL.dwg
THIS PLOT: 22-10-2014 09:39
REFERENCE: 7044

SCALE: 1:250 @ A1 SHEET	STEPHEN THORNE AND ASSOCIATES PTY LTD	DETAIL AND CONTOUR SURVEY OVER FORSHORE RESERVE ELFIN HILL ROAD RESERVE, GREEN POINT	ORIGIN OF LEVELS SSM 87804 RL 12.185 AHD	amendments	PLAN NUMBER	ISSUE
DATUM: Australian Height Datum — DATE 22/10/2014	CONSULTING SURVEYORS 48 MANN STREET, GOSFORD. 2250 Phone (02)4323-1255 Facsimile (02)4324-2226 P.O. BOX 1315 GOSFORD NSW 2250 A.C.N. 057 514 860 A.B.N. 51 057 514 860		SCALE OF METRES 1:250 (5 0 5 10 15 20 25)		7044	A
					SHEET 1 OF 1 SHEETS	

APPENDIX C
Concept Design Sketches

FIGURE 1
STUDY AREA



AUSTRALIAN HEIGHT DATUM

NOT FOR CONSTRUCTION

5 0 5 10 15 20 25m
1:250 (A1) 1:500 (A3)

SAVED: 31-Oct-14 PLOTTED: 15-Dec-14 \\HKA-SERVER\Public\CURRENT JOBS\8A0467_BOX - Elfin Hill Road Reserve Foreshore Stabilisation\E11 Drawings\Figures\8A0467-Fig 1.dwg

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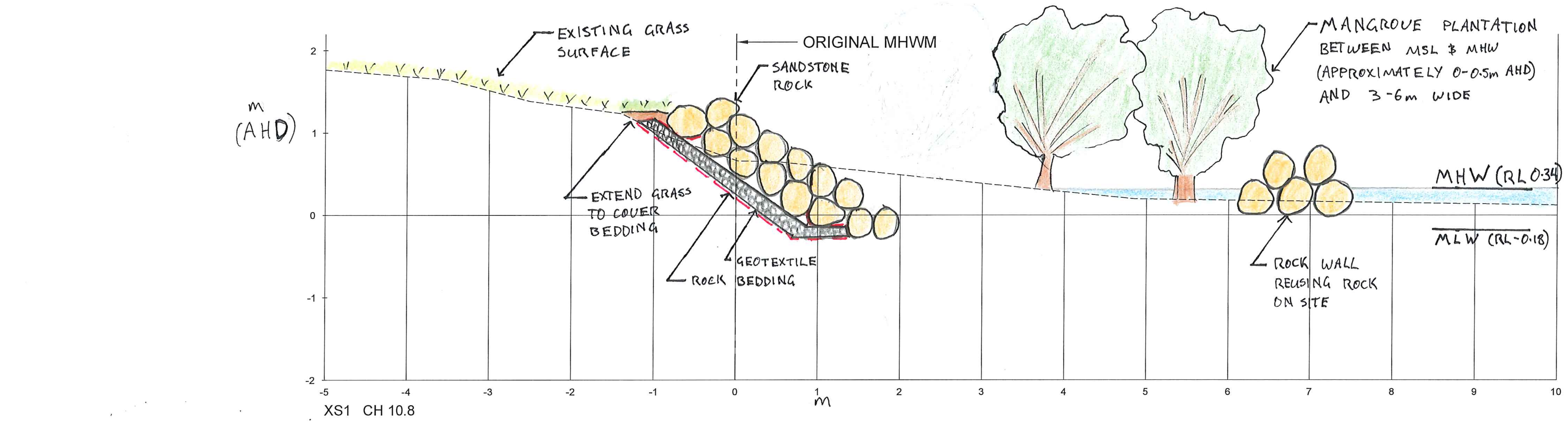
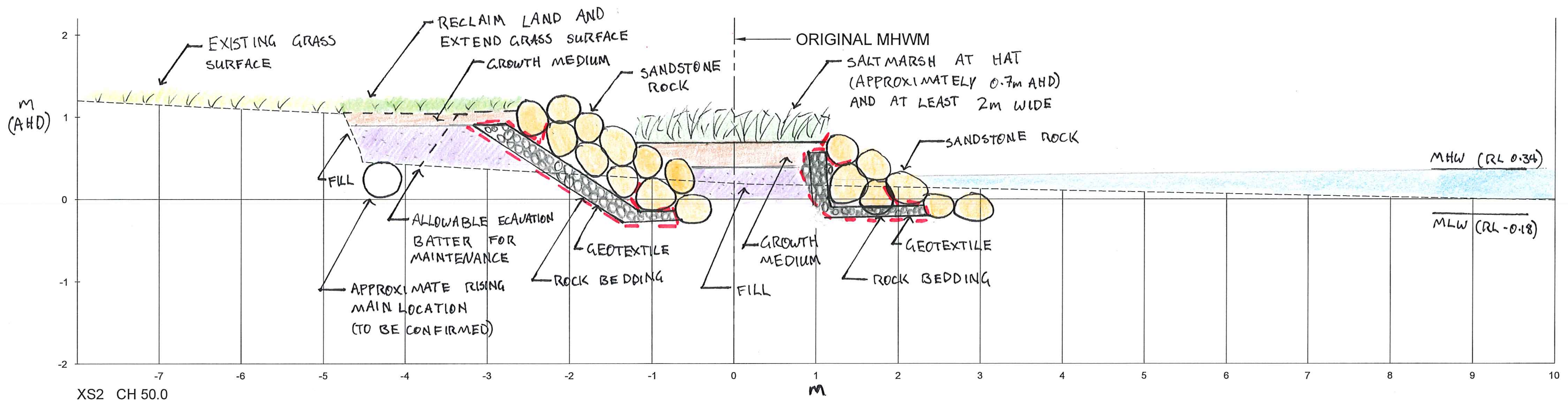


MANGROVE TREATMENT



SALTMARSH TREATMENT

AUSTRALIAN HEIGHT DATUM

NOT FOR CONSTRUCTION

500 0 500 1000 1500 2000 2500mm
1:25 (A1) 1:50 (A3)

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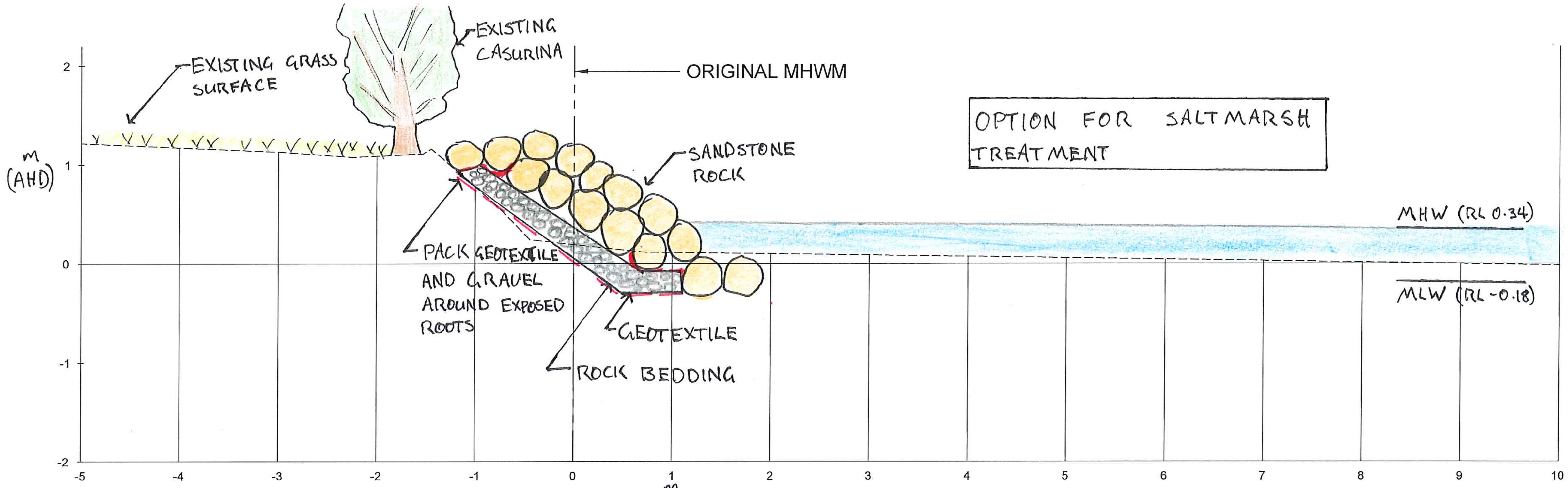
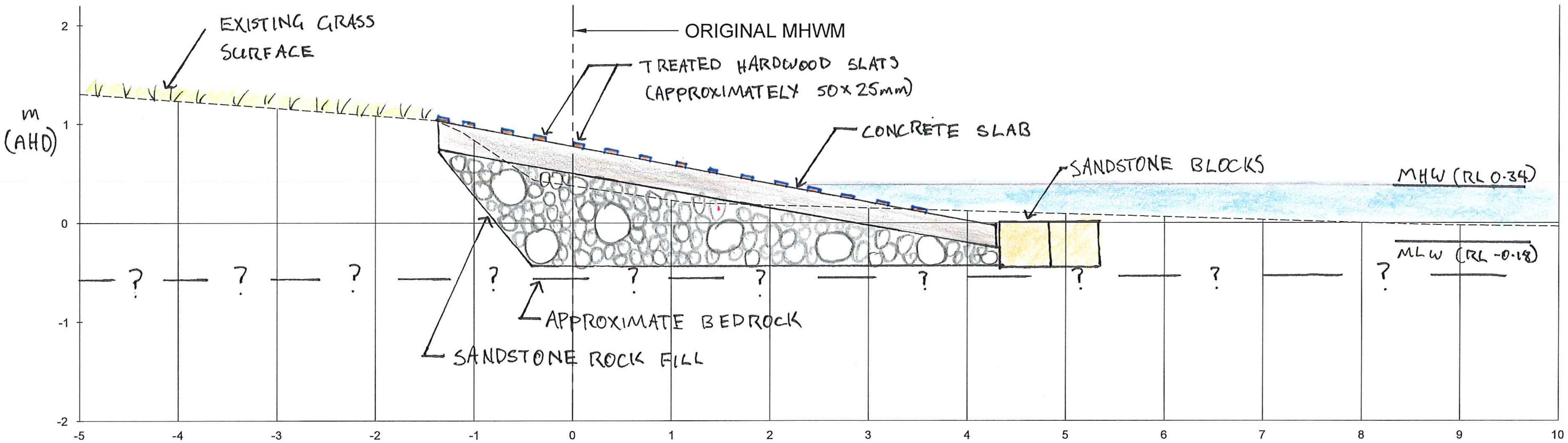


XS3 CH 83.7

ROCK TREATMENT



XS4 CH 135.5

DINGY SKID

AUSTRALIAN HEIGHT DATUM

NOT FOR CONSTRUCTION

500 0 500 1000 1500 2000 2500mm
1:25 (A1) 1:50 (A3)

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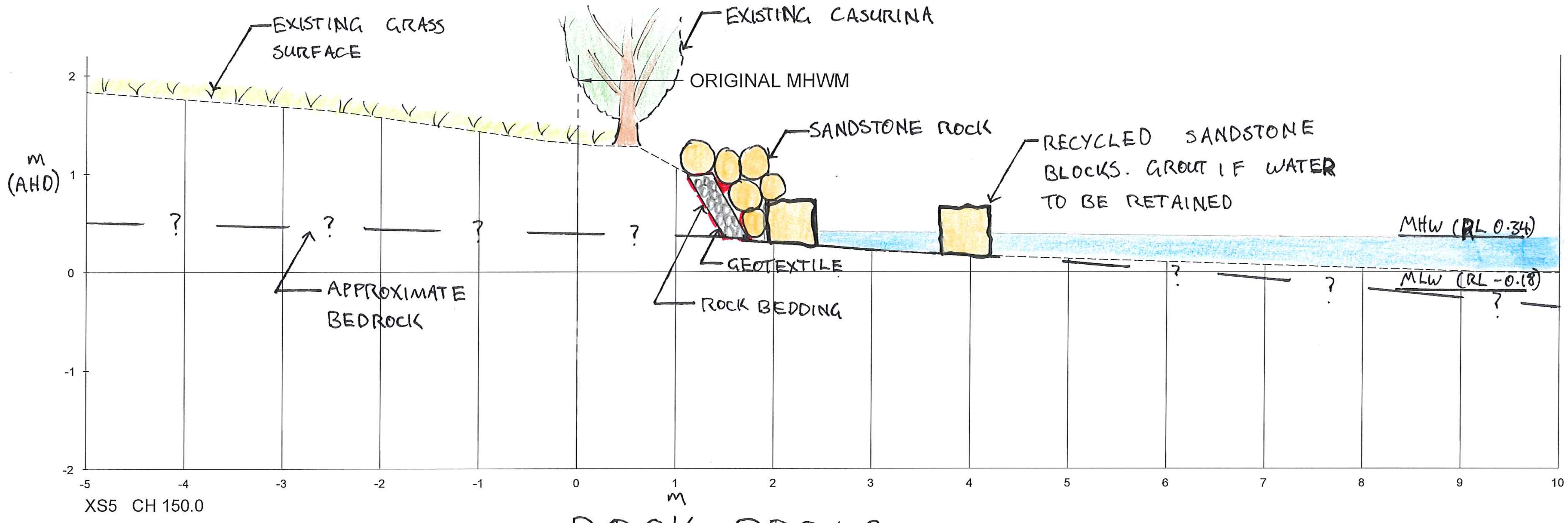

ROCK POOLS

AUSTRALIAN HEIGHT DATUM

NOT FOR CONSTRUCTION

500 0 500 1000 1500 2000 2500mm
1:25 (A1) 1:50 (A3)