Terara Shoalhaven Sand
C/- Ernest Panucci

Rehabilitation Management Plan - Proposed Expansion of Sand Dredging Operations at Terara Shoalhaven Sand, Pig Island, Terara, NSW

martens consulting engineers

ENVIRONMENTAL

WATER

WASTEWATER

GEOTECHNICAL

CIVIL

PROJECT MANAGEMENT

P1806743JR08V01
April 2019

Limitations Statement

The sole purpose of this report and the associated services performed by Martens & Associates Pty Ltd is to prepare a Rehabilitation Management Plan in accordance with the scope of services set out in the contract / quotation between Martens & Associates Pty Ltd and Terara Shoalhaven Sand C/- Ernest Panucci (hereafter known as the Client). The scope of works and services were defined by the requests of the Client, by the time and budgetary constraints imposed by the Client, and by the availability of access to the site.

Martens & Associates Pty Ltd derived the data in this report primarily from a number of sources which may include for example site inspections, correspondence regarding the proposal, examination of records in the public domain, interviews with individuals with information about the site or the project, and field explorations conducted on the dates indicated. The passage of time, manifestation of latent conditions or impacts of future events may require further examination / exploration of the site and subsequent data analyses, together with a re-evaluation of the findings, observations and conclusions expressed in this report.

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All enquiries regarding this project are to be directed to the Project Manager.

Executive Summary

Overview

This Rehabilitation Management Plan (RMP) has been prepared to support a development proposal to extend an existing sand extraction lease area in the river channel vicinity to the west and south west of Pig Island, on the lower Shoalhaven River, Nowra, NSW ('the site'). The assessment has been prepared in accordance with Secretary's Environmental Assessment Requirements (SEARs) ID No. 1234 (June 7, 2018) and will form part of an Environmental Impact Statement (EIS) covering all aspects of the proposal and subsequent environmental impacts.

The RMP aims to:

- Protect the environmental and ecological values of the river adjacent to, upstream and downstream of the proposed and existing extraction areas.
- Provide rehabilitation management strategies to rehabilitate riverine and habitat areas affected by the extraction processes.
- Recommend appropriate monitoring to determine changes to river stability and ecological processes.
- Propose a final landform which integrates well into the surrounding landscape.

Baseline River Assessment

An assessment of existing conditions of the Shoalhaven River surrounding Pig Island showed slumping and minor undercutting of the banks in the study area. Previous protection works generally appeared to successfully stabilise banks.

Most of the intertidal beach sections were unvegetated, although the western portion of the southern bank of Pig Island showed significant native vegetation regrowth. Pasture grass draped the majority of the erosion scarp. Small patches of endangered communities Coastal Saltmarsh and Swamp Oak Forest were observed on the southern and western banks of Pig Island.

Conceptual Final Landform

The final landform, after closure and decommissioning of dredging operations, is intended to be consistent with the surrounding topography and surrounding environment. Final land use shall be suitable for future land uses.

Rehabilitation and Stabilisation Plan

The following measures are recommended to be implemented, in accordance with the site Acid Sulfate Soils Management Plan, after completion of extraction works:

- Former dredged area to be left for a minimum of 10 years to allow for sediment replenishment.

- Regular periodic monitoring of water quality and river bank conditions.

- Implement appropriate bank stabilisation and / or bank revegetation works, where required.

Proposed management action schedules to manage environmental and ecological values of the study area and to implement this RMP, along with timeframes and responsibilities are provided in Attachment B.

Contents

1 Overview

1.1 Background

Martens and Associates have been engaged to prepare a Rehabilitation Management Plan (RMP) for a reach of the Lower Shoalhaven River, to support a proposal to expand the sand extraction area in the river channel vicinity to the west and south west of Pig Island.

This plan has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) No. 1234 (dated June 7, 2018) and will form part of an Environmental Impact Statement (EIS) covering all aspects of the proposal and subsequent environmental impacts.

1.2 Scope

This report provides the following:

- Scope of the report and SEARs.
- Baseline river assessment, including analysis of existing bank erosion and protection works.
- Final design landform on completion of works.
- Recommended rehabilitation works.
- Scheduled management actions.

1.3 Proposed Development

Shoalhaven Sands Pty Ltd (the Client), propose to extend the existing dredging footprint around the western and north western portion of the Shoalhaven River mid-channel bar known as Pig Island. The proposed dredging expansion will allow for the extraction of up to 100,000 tonnes of river sand per annum, over a 29 year period. Figure 1 (Attachment A) shows the proposed extraction areas.

Previous consent to extend the sand extraction lease area to the south of Pig Island was determined in 2014 (RA12/1001).

1.4 Statutory and Regulatory Requirements

The Secretary of the NSW Department of Planning and Environment (NSW DP&E) has consulted with relevant government agencies and has provided environmental assessment requirements (EAR) for the project (EAR 1234, 2018), as summarised in Table 1.

Table 1: Requirements from EAR1234.

Rehabilitation Management Plan Requirements	Section of Report
Natural Resources Access Regulator	
Watercourses, Wetlands and Riparian Land	
o The EIS should address the potential impacts of the project on all watercourses likely to be affected by the project, existing riparian vegetation and the rehabilitation of riparian land.	Sections 2.6, 2.7, and Schedules S04 and S05 (Attachment B)
Landform Rehabilitation Where significant modification to landform is proposed, the EIS must include:	
o Justification of the proposed final landform with regard to its impact on local and regional surface and groundwater systems;	Section 2.5
o A detailed description of how the site would be progressively rehabilitated and integrated into the surrounding landscape;	Sections 2.5 and 2.6
o Outline of proposed construction and restoration of topography and surface drainage features if affected by the project; and	Section 2.5 and 2.6
o An outline of the measures to be put in place to ensure that sufficient resources are available to implement the proposed rehabilitation.	Section 1.6
NSW Department of Planning & Environment – Resources & Geoscience Division	
o Clause13. Proposed rehabilitation procedures during, and after completion of, extraction operations, and proposed final use of site.	Sections 2.5 and 2.6
NSW EPA	
o Clause 3. Rehabilitation: Outline considerations of site maintenance, and proposed plans for the final condition of the site (ensuring its suitability for future uses).	Section 2.7 and Attachment B
NSW Department of Primary Industries – Fisheries	
o Clause 13. Outline of proposals for the progressive rehabilitation of the area including rehabilitation of existing exhausted extraction areas.	Section 2.6

1.5 Development Consent

This RMP has been prepared to support the EIS in accordance with the SEARs.

The proposed extraction operations will operate under Conditions of Consent provided with the determination. Rehabilitation and landscape related conditional requirements shall be incorporated into a revised RMP.

1.6 Financial Approach

The proposed rehabilitation process has been designed to be implemented as part of the extraction operations business model and plan, in conjunction with ongoing dredging operations. Timing of elements of the rehabilitation plan implementation in conjunction with ongoing excavation works will ensure that financial and material resources are available to fully complete the project.

1.7 Abbreviations

Abbreviations used in this report are summarised in **Table 2**.

Table 2: Abbreviations used in this RMP.

Abbreviation	Description
ASS	Acid sulfate soils
ASSMP	Acid Sulfate Soils Management Plan
EAR	Environmental assessment requirements
EIS	Environmental Impact Statement
LEP	Local Environmental Plan
NSW DP&E	NSW Department of Planning and Environment
RMP	Rehabilitation Management Plan
SEARs	Secretary's Environmental Assessment Requirements
SRWP	Shoreline Revegetation / Works Plan

2 Rehabilitation Management Plan

2.1 Scope

The RMP provides a range of environmental management strategies for protecting the long-term environmental and ecological values of areas of the Shoalhaven River in the vicinity of the proposed resource extraction works.

This RMP applies to the river bed and bank areas adjacent to the proposed and existing resource extraction areas, and areas on the mainland and Pig Island where land based activities related to the resource extraction take place.

2.2 General Objectives and Aims of the RMP

Environmental management objectives for the areas covered within this RMP include:

- Protection of the environmental and ecological values of the river adjacent to, upstream and downstream of the proposed and existing extraction areas.
- Rehabilitation of riverine vegetation and habitat areas affected by extraction processes, whilst ensuring that the works do not have an adverse impact on any previous and current revegetation works being conducted by Council downstream of the study area.
- Long-term monitoring of the extraction areas and adjacent river banks to determine changes (if any) to riverine vegetation communities, bank stability and water quality (including nutrients and salinity) and recommend corrective actions where required.
- Proposed final landform which integrates well into the surrounding landscape, restores topographic and surface water features, and is suitable for future uses.

2.3 Responsibilities

It will be the responsibility of the site operator to implement the actions required by the RMP. Reporting results should be provided to Council or other agencies, as required by Conditions of Consent.

2.4 Baseline River Assessment

2.4.1 Martens & Associates (2019a)

Martens & Associates undertook a site inspection to prepare a River Stability Assessment (2019a) for the site, which provides a baseline assessment for existing river conditions and informs potential required management actions to be implemented under the RMP. An assessment of the river indicated the following:

- The banks of the river and of Pig Island showed considerable evidence of existing slumping and minor undercutting in the study area.
- Conditions of the banks of the river on the south side of Pig Island were relatively poor where bank protection works have not been implemented.
- Bank and toe protection works were evident on both river banks of the lower Shoalhaven. Where in place, protection works generally appeared to be successfully stabilising banks. In some parts where only minor toe protection was implemented, river banks were experiencing failure due to lack of riparian vegetation and other erosional forces.

Existing bank conditions and bank protection works are provided in Figures 2 and 3 (Attachment A).

The site is mapped as containing Class 2 and 3 acid sulfate soils (ASS) in accordance with the Shoalhaven Local Environmental Plan (LEP) 2014, (MA, 2019c). The existing Acid Sulfate Soils Management Plan (ASSMP) must be taken into account throughout rehabilitation works.

2.4.2 P Dalmazzo (2017)

A site inspection of Pig Island was undertaken by Peter Dalmazzo (3 February, 2017), for preparation of the draft Shoreline Revegetation / Works Plan (SRWP) (refer to Section 2.6.1). His observations are summarised as:

- The sandy intertidal beach width varied generally between 6 – 10 m, and up to 17 m at the western tip of Pig Island. Some areas of the shoreline were benched, between 0.25 to 1 m high. Slumping and undercutting were observed along some sections of the bank.

- Most of the intertidal beach sections on Pig Island were unvegetated. Vegetated sections included areas of Grey Mangrove, reeds and weeds, and Swamp Oak and wattles. Pasture grass draped the majority of the erosion scarp. Small patches of endangered communities Coastal Saltmarsh and Swamp Oak Forest were observed near the island's shoreline. The western portion of the shoreline showed significant regrowth of native vegetation, including Swamp Oaks.

2.5 Conceptual Final Landform

The final rehabilitated landform for land-based activities is intended to blend with the existing surrounding environment and maintain the natural topography of the area.

Closure and decommissioning of the sand dredging project would involve removal of the dredge and associated equipment, and any processing area buildings and infrastructure which are unfit for re-purpose. The site's finished contours will be established as close as possible to pre-dredging operations and the surrounding topography, and appropriate stormwater designs will be implemented to mitigate potential impacts to surface and groundwater.

The final land use shall be suitable for future uses.

2.6 Rehabilitation and Stabilisation Plan

2.6.1 Shoreline Revegetation / Works Plan

The draft SRWP was prepared for the Client as required by condition 32 of RA12/1001 (Dalmazzo, 2017), and covers the southern shoreline of Pig Island, extending from the western tip for approximately 1 km to the east. The draft SRWP has been provided as Attachment C.

The SRWP's objectives include:

1. To install structures that can slow the erosion of the shoreline;
2. To vegetate the shoreline with local native plant species;
3. To remove weeds from the shoreline; and
4. To retain the amenity of the area for bait collection by recreational fishers.

Site inspection observations are provided in Section 2.4.2.

Table 1 of the draft report provides a schedule of works, including a nominated timeframe, and responsibility for the action. Actions include weed removal from the intertidal beach and shoreline, revegetation works, bank stabilisation works (install sand sausage in some areas suffering slumping and undercutting), and monitoring and maintenance of identified management works.

A maintenance, monitoring and reporting schedule is provided in Table 3 of the draft report, and clarifies ongoing rehabilitation management actions.

SRWP management actions (Tables 1 and 3) are provided as Schedules S03 and S04 (Attachment B) of this report. The full draft report is provided as Attachment C.

2.6.2 Recommended Rehabilitation and Stabilisation Measures

Following resource extraction works, and in accordance with the site ASSMP, it is recommended that the following measures be implemented:

- Exhausted resource extraction areas are to be left for a minimum of 10 years following completion of dredging works to allow for these areas to be replenished (i.e. sediment to accumulate) via typical river flows and larger flood events.
- 'Edges' of exhausted resource extraction areas are to be allowed to revegetate (where depth is adequate to do so) in order to stabilise the sides of the dredge hole created by dredging.
- Water quality in exhausted resource extraction areas should be periodically monitored (refer to Section 2.7.1, and Schedule S01, Attachment B). Significant changes in water quality outside of expected river ranges should be further investigated to determine cause and responsibility. Remediation measures should be developed by the applicant if responsibility is with the operator.
- Annually monitor river bank conditions for a period of 2 years (or in accordance with consent conditions) in the vicinity of, and upstream and downstream of the extraction area. Refer to Sections 2.7.2 and 2.7.3, and Schedules S02, S03 and S04 (Attachment B) for further details.

- If works have impacted on river bank stability or riverine vegetation, these areas are to be remediated. Remedial works may include the following:

    - Bank stabilisation works – typically involves either bank regrading or placement of rock at the base and sides of the bank to prevent erosion. This may also include use of reno mattresses or gabions, revetments, retaining structures (rock wall) and / or groynes.

    - Bank revegetation works – typically involves the planting of riparian vegetation including mangroves along the banks of the river to assist in the stabilisation of banks. Dalmazzo (2017) notes, however, that mangroves would not be planted in some intertidal beach and shallow subtidal areas where squirt worm populations would be affected.

    - Vegetation maintenance works – to ensure plantings are established and survive, appropriate maintenance measures shall be undertaken (refer to Schedules S03 and S04, Attachment B).

Any bank stabilisation or revegetation works should be compatible with existing bank stabilisation and revegetation works being conducted by Council. Refer to Sections 2.7.2 and 2.7.3, and Schedules S02, S03 and S04 (Attachment B), and the draft SRWP (Attachment C) for further details.

2.7 Proposed Rehabilitation Management Actions and Objectives

Proposed management action schedules to manage environmental and ecological values of the study area and to implement this RMP, along with timeframes and responsibilities are provided in Attachment B.

2.7.1 Schedule S01: Water Quality Control

Objective 1. Ensure river water quality has not been adversely affected by extraction works.

Objective 2. Establish water monitoring points to enable water monitoring to be conducted throughout rehabilitation works.

Water quality shall be monitored quarterly through the rehabilitation phase, and continue for two years after cessation of dredging activities

(or as conditioned by consent). Schedule S01 (Attachment B) outlines tasks to be completed as part of water quality control. Water quality targets shall be in compliance with Shoalhaven River Estuary Management Plan (March 2008), the NSW Interim Water Quality Objectives and ANZECC (2000) guidelines.

2.7.2 Schedule S02: River Bank Erosion and Riverine Vegetation Management

Objective 1. Establish condition of existing river banks and vegetation as baseline assessment for implementation of rehabilitation works.

Objective 2. On-going monitoring of river bank stability and riverine vegetation to manage any potential impacts upstream and downstream of extraction areas.

2.7.3 Schedules S03 and S04: Implementation of Management Actions: Draft Shoreline Revegetation / Works Plan (Dalmazzo, 2017)

Objective 1. To stabilise and manage shoreline erosion.

Objective 2. To manage shoreline revegetation and weed control.

Management actions, responsibilities and timeframes from Tables 1 and 3 of the draft Plan (Dalmazzo, 2017) are provided in Schedules S03 and S04 (Attachment B). Further information is provided in Section 2.6.1, and the full draft report is provided in Attachment C.

River bank erosion and riverine vegetation on the mainland and Pig Island shall be monitored through recommended means outlined in Schedules S02, S03 and S04 (Attachment B).

3 References

Dalmazzo, P. (2017) *Draft Shoreline Revegetation / Works Plan – Pig Island, Terara*.

Landcom (2004) *Managing Urban Stormwater – Soils and Construction.*

Martens & Associates (2019c) *Acid Sulfate Soils Assessment: Proposed Expansion of Sand Dredging Operations at Terara Shoalhaven Sand, Pig Island, Terara, NSW* (ref P1806743JR02V01).

Martens & Associates (2019b) *Land Resource Assessment: Proposed Expansion of Sand Dredging Operations at Terara Shoalhaven Sand, Pig Island, Terara, NSW* (ref P1806743JR07V01).

Martens & Associates (2019a) *River Stability Assessment: Proposed Expansion of Sand Dredging Operations at Terara Shoalhaven Sand, Pig Island, Terara, NSW* (ref P1806743JR01V01).

Martens & Associates (2012a) *River Impact Assessment – Proposed Expansion of Sand Extraction Area; Pig Island Lower Shoalhaven River, NSW* (ref P1103077JR01V03).

Martens & Associates (2012b) *Supplementary Environmental Details – Proposed Expansion of Sand Extraction Area; Pig Island Lower Shoalhaven River, NSW* (ref P1103077JR04V02).

NSW Natural Resources Access Regulator (2018) *Secretary's Environmental Assessment Requirements (SEARs ID No 1234) – Project Extension to Terara Shoalhaven Sand Quarry, Shoalhaven LGA* (ref. V18/314#40 & OUT 18/8776).

NSW Planning & Environment (2018) *Planning Secretary's Environmental Assessment Requirements – Terara Shoalhaven Sand (EAR 1234).*

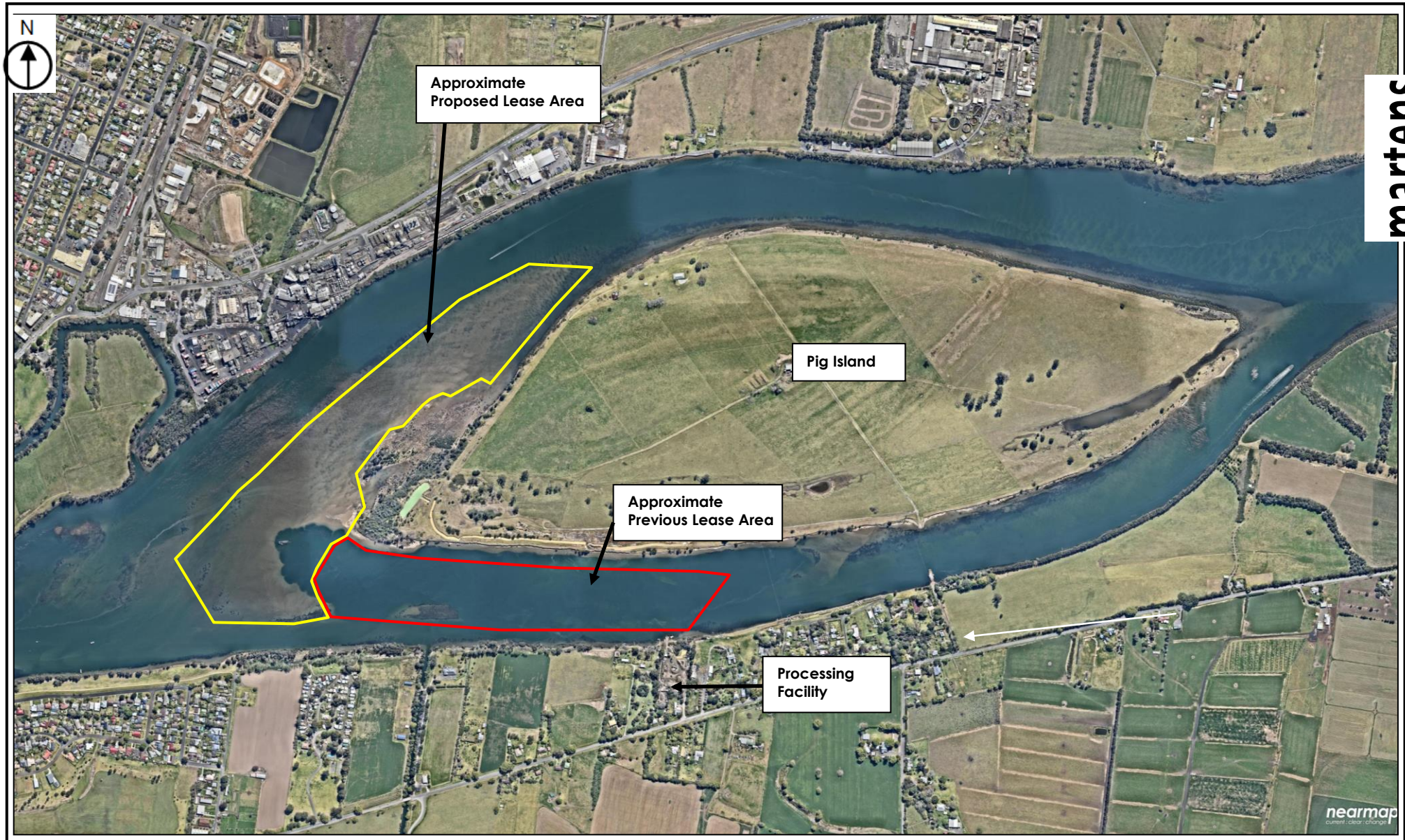
NSW Public Works (April 1990), *Lower Shoalhaven River Flood Study.*

Umwelt (Australia) Pty Ltd (2005) *Shoalhaven River Estuary Data Compilation Study.*

Umwelt (Australia) Pty Ltd (2006) *Shoalhaven River Estuary Management Plan.*

Webb, McKeown and Associates (2008) *Lower Shoalhaven River: Floodplain Risk Management Study.*

4 Attachment A - Figures



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Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	CS	**Approximate Extents of the Previous and Proposed Dredge Lease Areas Pig Island, Shoalhaven River, NSW** Image Source: Nearmap (2018)	Drawing No: **Figure 1**
Approved:	BM		
Date:	April 2019		
Scale:	Not to Scale		Job No: P1806743

KEY
- Erosion – Bank failure (mass slump)
- Erosion – Bank undercutting

Martens & Associates Pty Ltd ABN 85 070 240 890		**Environment | Water | Wastewater | Geotechnical | Civil | Management**	
Drawn:	CS	**River Bank Conditions (2018 and 2011)** **Lower Shoalhaven River and Pig Island, NSW** Image Source: Nearmap (2018)	Drawing No: **Figure 2**
Approved:	BM		
Date:	April 2019		
Scale:	Not to Scale		Job No: P1806743

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KEY
- Levee (Shoalhaven River Levee IDs P1L1, P1L2 and P2L1)
- Gabion baskets and bank toe protection work
- Rockwall
- Sand sausage

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Environment | Water | Wastewater | Geotechnical | Civil | Management

Drawn:	CS
Approved:	BM
Date:	April 2019
Scale:	Not to Scale

Existing Bank Protection Works
Lower Shoalhaven River and Pig Island, NSW
Image Source: Nearmap (2018)

Drawing No:
Figure 3

Job No: P1806743

5 Attachment B – Site Rehabilitation Management Plan Schedules

Description of Schedule	Timing	Schedule Number S01 Affected Areas
River Water Quality	Operational and Rehabilitation Phases	River

Item	Actions / Requirements	Responsible Agent	Location/Area	Frequency
Monitoring Locations	Water quality monitoring locations shall be nominated to enable compliance assessment.	Site Owner / Operator	Monitoring locations	As required, or as conditioned by consent
Number of Monitoring Locations	A minimum of 3 site monitoring locations will need to be determined, or as conditioned by consent	Environmental Consultant	Monitoring locations	-
Monitoring Parameters	River water quality parameters to be monitored include: TN, TKN, Total ammonia N, NOx, TP, BOD_5, TSS, pH and EC	Environmental Consultant	Monitoring locations	-
Monitoring Frequency	Surface water samples to be collected in order that compliance can be assessed	Environmental Consultant	Monitoring locations	Quarterly
Reporting	Monitoring and compliance shall be documented.	Environmental Consultant	-	Annual report to be submitted to Council, OEH and NRAR

Description of Schedule	Timing	Schedule Number S02 Affected Areas
River Stability and Riverine Vegetation	Operation, Post-operation	River, Pig Island, Mainland

Item	Actions / Requirements	Responsible Agent	Location/Area	Frequency
Photographic Register	Photographs of river banks and shoals to be taken to form register	Environmental Consultant	River upstream and downstream of resource extraction areas.	Photos taken 6 monthly for 2 years. Annual report to be submitted to Council.
Hydrological Survey	Hydrological survey of the riverbed and banks within the dredge locality	Environmental Consultant	Within dredge area, and river upstream and downstream of resource extraction areas.	At 5 years and 10 years, after completion of extraction activities. Inclusion in report to be submitted to Council
Bank Erosion Pins	Bank Erosion Pins to be established to determine rate of erosion.	Environmental Consultant	River upstream and downstream of resource extraction areas.	Prior to extraction works
Assessment of river bank conditions	Assessment of river and bank conditions using photographs, aerial imagery and site inspections, and other specialist consultant reports as required	Environmental Consultant	River upstream and downstream of resource extraction areas.	Annual report to be submitted to Council, for 2 years after cessation of extraction operations (or as conditioned by consent)
Reporting	Monitoring and compliance shall documented.	Environmental Consultant	-	Annual report to be submitted to Council

Description of Schedule	Timing	Schedule Number S03 Affected Areas
Table 1, draft Shoreline Revegetation / Works Plan (Dalmazzo, 2017)	Operation, Post-operation	River, Pig Island, Mainland

Table 1. Management Plan Schedule of Works; unless otherwise stated, timeframes refer to period from date of approval of this plan

Action	Timeframe	Responsibility
Action 1 - Remove plants of Spiny Rush from the intertidal beach (mechanical or poisoning)	initial removal within 3 months; follow-up weeding at 6 months	Shoalhaven Sands/contractor
Action 2 - Remove plants of Lantana from shoreline, such as on the high bank at western end of island (mechanical or poisoning)	initial removal within 3 months; follow-up weeding at 6 months	Shoalhaven Sands/contractor
Action 3 - Establish staging plan based on consultation with suppliers of plants	Within 1 month	Shoalhaven Sands/contractor
Action 4 - In areas where there are no existing native trees as shown in Figure 13, plant Swamp Oaks *Casuarina glauca* as set out in Table 2 and Figure 14	within 2 months of stock becoming available for each stage	Shoalhaven Sands/contractor
Action 5 - Any plants used for revegetation of native plant communities on the site should preferably be grown from local parent stock and long-stem plants preferred	as required	Shoalhaven Sands/contractor
Action 6 – The planted vegetation is to be maintained according to the maintenance schedule set out in Table 3 to ensure plantings are established and survive	for 6 months after completion of each stage	Shoalhaven Sands/contractor
Action 7 - install sand sausage (as described in Attachment 1) to areas suffering slumping and undercutting as suggested in Figure 13	within 12 months	Shoalhaven Sands/contractor
Action 6 - Monitor and report on progress as set out in Table 3	after completion of each stage	Shoalhaven Sands/contractor

Description of Schedule	Timing	Schedule Number S04 Affected Areas
Table 3, draft Shoreline Revegetation / Works Plan (Dalmazzo, 2017)	Operation, Post-operation	River, Pig Island, Mainland

Table 3. Maintenance, Monitoring and Reporting Schedule

Phase	Item	Time Post Planting	Responsibility
1. Maintenance	water plants (if necessary)	Weekly for one month after completion of each stage	Shoalhaven Sands/contractor
2. Maintenance	mechanically remove or spot spray weeds with poison (if necessary)	At 1 month then 6 months after completion of each stage	Shoalhaven Sands/contractor
3. Maintenance	replace dead plants (if necessary)	At 1 month then 6 months after completion of each stage	Shoalhaven Sands/contractor
4. Monitoring	inspect and photograph plants and sand sausage	6 months after completion of each stage	Shoalhaven Sands/contractor
5. Reporting	supply results of inspection to Shoalhaven City Council	Within 7 months of completion of each stage	Shoalhaven Sands/contractor

6 Attachment C – Draft Shoreline Revegetation / Works Plan (Dalmazzo, 2017)

DRAFT

Shoreline Revegetation/Works Plan

Pig Island

Terrara

PREPARED FOR: SHOALHAVEN SANDS PTY LTD

PREPARED BY: PETER DALMAZZO

DATE: DRAFT 22 AUGUST 2017

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CONTENTS

ATTACHMENTS

1 INTRODUCTION

1.1 Background

Peter Dalmazzo was commissioned by Shoalhaven Sands Pty Ltd to prepare this shoreline revegetation/works plan for the shoreline of Pig Island adjacent to a part of the Shoalhaven River estuary over which approval has been granted for sand extraction. The plan is required by condition 32 of the consent for RA12/1001.

1.2 Location & Setting

The site is located on the shoreline of Pig Island in the Shoalhaven River estuary, approximately 1.5 kilometres downstream of the Princes Highway bridge at Nowra (Figures 1 and 2). This plan covers the shoreline on the southwestern part of the island as shown in Figure 3. The area extends along the southern shoreline from the western end of Pig Island for approximately one kilometre to the east, approximately as far as the eastern extent of the adjacent open filter drain located on the southern part of Pig Island.

1.3 Constraints

During preparation of this plan, representations were made by members of Shoalhaven Riverwatch about potential effects of foreshore revegetation on squirt worm populations on the unvegetated sand of the intertidal beach and adjacent shallow subtidal area. The squirt worms at this site are considered to be an important bait resource by recreational fishers. It was decided that this plan would not involve planting of mangroves as that would significantly modify the intertidal habitat at the site and destroy its value as a bait collection area.

2 OBJECTIVES OF THIS PLAN

1. To install structures that can slow erosion of the shoreline.

2. To vegetate the shoreline with local native plant species.

3. To remove weeds from the shoreline.

4. To retain the amenity of the area for bait collection by recreational fishers.

Figure 1. Location of the site in regional context.
Source: © Land and Property Information Panorama Avenue Bathurst NSW 2795 www.lpi.nsw.gov.au

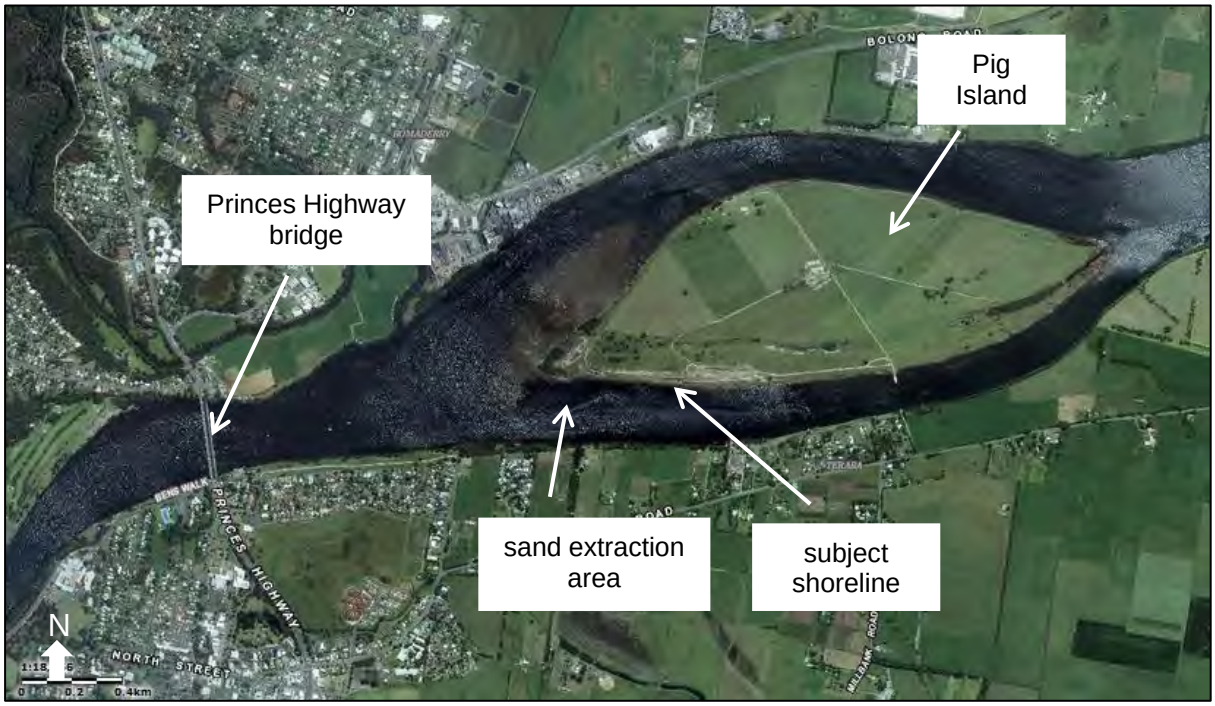

Figure 2. Air photograph of the site and surrounding features.
Source: © Land and Property Information Panorama Avenue Bathurst NSW 2795 www.lpi.nsw.gov.au

Figure 3. Area of shoreline to which this plan applies (adjacent to yellow dashed line) and two endangered ecological communities.

3 DESCRIPTION OF THE SITE

The character of the site is shown in Figures 4 to 12. The ecology of the area was described by Dalmazzo (2012) and geomorphology by Martens & Associates (2011).

The site was inspected on Friday 3 February 2017 between 9:50 am and 11:20 am AEDT around low tide. The shoreline had a sandy intertidal beach that generally varied in width from approximately 6 to 10 metres at low tide, though at the western spit of the island there was a wider section up to 17 metres. The high tide strand line was at the toe of a steep erosion scarp that was up to 3 metres tall from toe to the top of the high bank. Some sections of shoreline had a bench several metres wide about 0.25 to 1 metre above the intertidal sandy beach, landward of which the ground again stepped up steeply to the top of the high bank. There was slumping of some sections of river bank.

Most of the intertidal beach was unvegetated sand. However there was some Eelgrass *Zostera muelleri* in the shallow subtidal sand. There were a few Grey Mangroves *Avicennia marina* scattered in intertidal areas and other intertidal areas had Common Reed *Phragmites australis*, possibly where there were outflows of subterranean freshwater. A few clumps of the weed Spiny Rush *Juncus acutus* were scattered near the top of the intertidal beach. Above high tide level there were a few areas with native trees including Swamp Oak *Casuarina glauca* and wattles *Acacia* sp.. The erosion scarp was draped with the introduced pasture grass Kikuyu *Pennisetum clandestinum*. On top of the high bank there was mostly Kikuyu but, particularly at the western part of the shoreline, there was significant regrowth of native Swamp Oak vegetation. There were also weeds such as *Lantana camara* on the high bank at the western tip of the island.

Bioturbation was evident on the beach. On the lower intertidal sandy beach and the shallow subtidal unvegetated sand there were numerous mucous-lined burrows of polychaete Squirt Worms *Australonereis ehlersi*. There were some areas of beach with outcropping, heavy clay soil and these areas appeared to be favoured by Semaphore Crabs *Heloecius cordiformis* at mid- to upper-tide level.

Small patches of two endangered ecological communities (Coastal Saltmarsh and Swamp Oak Forest) were present at the site as shown on Figure 3.

Figure 4. View northward from water with large part of subject shoreline visible. Most of the trees in the background were more than one hundred metres beyond the shoreline and are not part of the subject site.

Figure 5. Some sections of shoreline dropped sharply from the top of the bank down to the sandy intertidal beach. Swamp Oak trees were present in some areas.

Figure 6. Some sections of shoreline had a low-level bench above the intertidal sandy beach, beyond which the land again stepped up to the top of the bank. There were Swamp Oaks and Wattles present and clumps of the weed Spiny Rush *Juncus acutus* were scattered near the top of the beach.

Figure 7. There was slumping of some section of river bank due to undercutting at the toe.

Figure 8. Some intertidal areas had Grey Mangroves *Avicennia marina*.

Figure 9. Some intertidal areas hade Common Reed *Phragmites australis*, possibly where there were outflows of subterranean freshwater.

Figure 10. There were some areas of beach with outcropping heavy clay soil. These areas appeared to be favoured by Semaphore Crabs *Heloecius cordiformis* polychaete worms such as Squirt Worms *Australonereis ehlersi*.

Figure 11. The western part of the shoreline had significant regrowth of native vegetation, mostly Swamp Oaks. Replanting would not be required in this area.

Figure 12. The western tip of the island is subjected to westerly wind chop at high tide. Sand sausage protection should be installed at the toe of the bank to slow erosion. There were also weeds such as *Lantana camara* that should be removed and replaced with Swamp Oaks.

4 MANAGEMENT ACTIONS/IMPLEMENTATION

Table 1 sets out the actions that are to be carried out to implement this plan, along with timeframes and responsibilities. Growing of seedlings (preferably from local parent stock) can take some time and staging of the works by dividing the shoreline into appropriate length sections may be necessary depending on contractors' ability to provide plants.

To slow erosion of the shoreline, at sections of shoreline where undercutting and slumping is apparent, a sand sausage should be installed at the toe of the erosion scarp/high water level. The sand sausage is one long continuous sandbag placed along the toe of the bank and constructed on-site with removable frames, geotextile fabric and a sewing machine. A methodology developed by Shoalhaven Riverwatch involves filling the sausage from sand on-site, sewing it in place and then removing the frame to the next section. The sausage prevents wave action from eroding the bank as well as trapping sediment from eroding banks. Unlike sandbags, it is not moved during flood events due to its length, flexibility and weight (Attachment 1 - Shoalhaven Landcare Association Inc., 2017). Areas where consideration should be given to installing sand sausage are shown on Figure 13. These areas are mostly where there is slumping of the high bank, but also, at the western tip of the island which is subjected to westerly wind chop at high tide, sand sausage protection should be installed at the toe of the bank to slow erosion.

Revegetation of the shoreline with local native tree species will help reduce erosion because tree roots bind together the sandy soils. The vegetation will also provide some habitat for native animals. On the Shoalhaven River floodplain, Swamp Oak *Casuarina glauca* is often the only tree species present in remnant stands of the endangered ecological community Swamp Oak Forest on Coastal Floodplains. It is therefore considered appropriate that this species be used for revegetation of the shoreline at the subject site. Areas where revegetation should be undertaken are shown on Figure 13. The number, type, location and spacing of plants are set out in Table 2 and illustrated in Figure 14. Revegetation would not be required in those areas where Swamp Oaks are already growing but should be planted where Lantana is removed.

The main weeds to be dealt with at the site are Spiny Rush *Juncus acutus* and Lantana *Lantana camara*. If long-stem plants are used for revegetation, Kikuyu does not require treatment as it will eventually be shaded out by the mature Swamp Oaks. Spiny Rush and Lantana plants should be mechanically removed or poisoned.

Table 1. Management Plan Schedule of Works; unless otherwise stated, timeframes refer to period from date of approval of this plan

Action	Timeframe	Responsibility
Action 1 - Remove plants of Spiny Rush from the intertidal beach (mechanical or poisoning)	initial removal within 3 months; follow-up weeding at 6 months	Shoalhaven Sands/contractor
Action 2 - Remove plants of Lantana from shoreline, such as on the high bank at western end of island (mechanical or poisoning)	initial removal within 3 months; follow-up weeding at 6 months	Shoalhaven Sands/contractor
Action 3 - Establish staging plan based on consultation with suppliers of plants	Within 1 month	Shoalhaven Sands/contractor
Action 4 - In areas where there are no existing native trees as shown in Figure 13, plant Swamp Oaks *Casuarina glauca* as set out in Table 2 and Figure 14	within 2 months of stock becoming available for each stage	Shoalhaven Sands/contractor
Action 5 - Any plants used for revegetation of native plant communities on the site should preferably be grown from local parent stock and long-stem plants preferred	as required	Shoalhaven Sands/contractor
Action 6 – The planted vegetation is to be maintained according to the maintenance schedule set out in Table 3 to ensure plantings are established and survive	for 6 months after completion of each stage	Shoalhaven Sands/contractor
Action 7 - install sand sausage (as described in Attachment 1) to areas suffering slumping and undercutting as suggested in Figure 13	within 12 months	Shoalhaven Sands/contractor
Action 6 - Monitor and report on progress as set out in Table 3	after completion of each stage	Shoalhaven Sands/contractor

Figure 13. Area of shoreline where installation of sand sausage should be considered (red lines) and where Swamp Oaks should be planted (yellow lines).

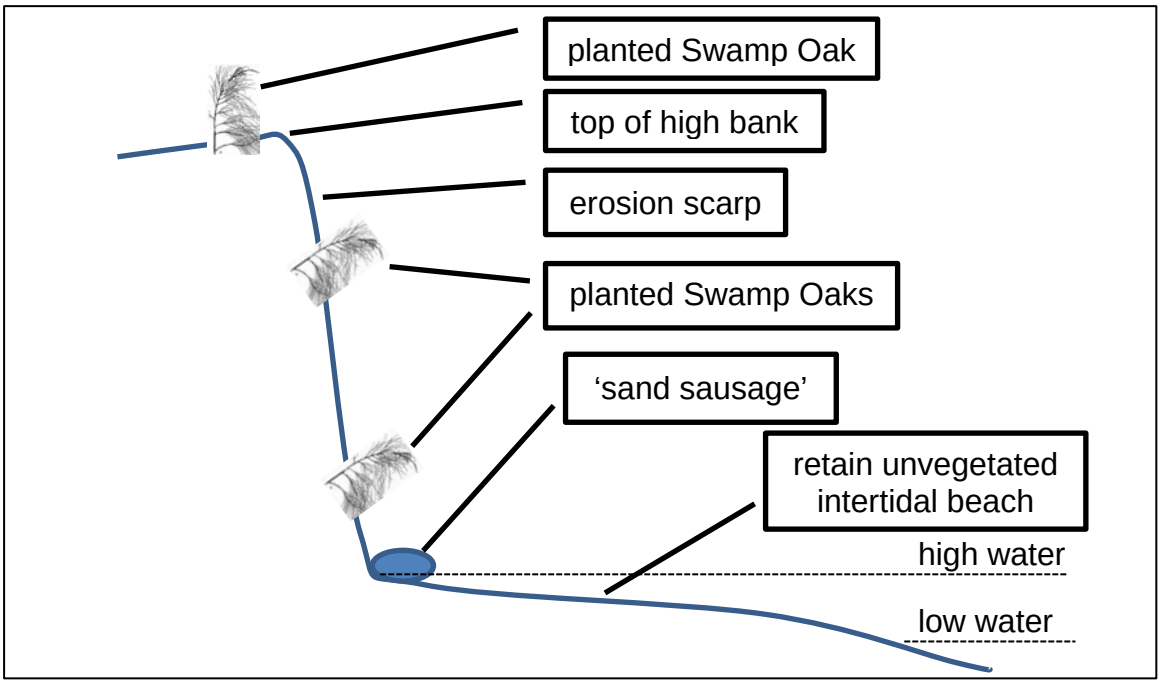

Figure 14. Stylised cross section of shoreline showing general arrangement of shoreline protection and revegetation.

Table 2. Planting Guide for Swamp Oaks

Species	Swamp Oak *Casuarina glauca*
Stock	tubestock seedlings or long-stem plants
Planting Arrangement	at top of bank within one metre landward of erosion scarp and in face of erosion scarp at least one metre above toe
Planting Density	one plant per square metre; a minimum of two rows must be planted in the face of the erosion scarp and the minimum planting density must be one metre spacing with offset rows to ensure adequate coverage is achieved
Planting techniques	see Attachment 2 by The Australian Plants Society NSW Ltd (2010) -

5 MAINTENANCE, MONITORING & REPORTING

If standard tube stock seedlings are used rather than long-stem plants, they will require maintenance as set out in Table 3. If long-stem plants are used then the root ball will be below the root zone of most weeds and competition from weed roots will be minimal. Therefore following planting and initial watering, generally little further maintenance will be required (Attachment 2 by The Australian Plants Society NSW Ltd, 2010) and items 1 and 2 in Table 3 will not be required.

Table 3. Maintenance, Monitoring and Reporting Schedule

Phase	Item	Time Post Planting	Responsibility
1. Maintenance	water plants (if necessary)	Weekly for one month after completion of each stage	Shoalhaven Sands/contractor
2. Maintenance	mechanically remove or spot spray weeds with poison (if necessary)	At 1 month then 6 months after completion of each stage	Shoalhaven Sands/contractor
3. Maintenance	replace dead plants (if necessary)	At 1 month then 6 months after completion of each stage	Shoalhaven Sands/contractor
4. Monitoring	inspect and photograph plants and sand sausage	6 months after completion of each stage	Shoalhaven Sands/contractor
5. Reporting	supply results of inspection to Shoalhaven City Council	Within 7 months of completion of each stage	Shoalhaven Sands/contractor

6 REFERENCES

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ATTACHMENTS

3. SHOALHAVEN SAND SAUSAGE
4. LONG-STEM PLANTING GUIDE

Sand Sausages on the Shoalhaven River

Shoalhaven Landcare Association Inc.

Shoalhaven Riverwatch - Battling bank erosion, one long sausage at a time

The issue

The beauty of the Shoalhaven River attracts large numbers of recreational river users. But increased activities have degraded the river banks due to a number of factors. To maintain the beauty and health of the Shoalhaven River, Shoalhaven Riverwatch has undertaken riverbank restoration using different techniques since 1980. Sandbagging combined with replanting shoreline vegetation in many areas has proved cost effective. Unfortunately, sandbagging is a slow and labour intensive method.

Is there another way?

The solution

Shoalhaven Riverwatch, led by Peter Jirgens, designed an alternative to individual sandbags - the low cost **Shoalhaven Sand Sausage.** The Sausage is one long continuous sandbag placed along the toe of the bank, and constructed on-site with removable frames, geotextile fabric and a sewing machine. Volunteers fill the sausage from sand or mud on-site, sew it in place and then remove the frame to the next section.

The Sausage prevents wave action from eroding the bank as well as trapping sediment from eroding banks. Over time, additional Sausages can be added on top of the earlier Sausage to further build up a stable riverbank. The Sausage is also inexpensive to construct, costing only 1/5 of the cost of conventional sandbagging. Unlike sandbags, it is not moved during flood events due to its length, flexibility and weight.

The impact

The impact of the Shoalhaven Sand Sausage has been immediate – 100 metres of the riverbank are protected against erosion in hours, whereas once it would have taken days. Riverwatch has been successfully using the Sausage at a number of tidal sites on the Shoalhaven River. Bank stabilisation has multiple benefits for the river, improving fish habitat, improving water quality as well as protecting riparian vegetation and valuable farmland.

The effective impact of the Shoalhaven Sand Sausage and other Riverwatch activities has seen an increase in volunteers who are enthusiastic to be involved in immediate outcomes as well as the opportunity to work alongside like-minded volunteers. A sense of pride and comradeship encourages the volunteers.

Monitoring of Sausage sites shows a build-up of sediment on both sides of the Sausage, even during flood events. This demonstrates the effectiveness of the Sausage which, coupled with its construction efficiency, proves that it is a valuable tool to restore riverbanks.

Key facts

- Innovative new design for riverbank erosion control
- The work is done in hours, and not days
- Time and cost effective
- Increase in volunteer numbers
- www.riverwatch.org.au

Project Partners

This activity is part of the Local Landcare Coordinators Initiative

NSW GOVERNMENT Local Land Services

The Local Landcare Coordinators initiative is funded by the NSW Government, and is supported through the partnership of Local Land Services and Landcare NSW.

Landcare New South Wales

The **Long-stem Planting** Guide

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This guide has been compiled by members of The Australian Plants Society Central Coast Group and Gosford City Council and is funded by NSW Environmental Trust.
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Design by Marjo Patari, Gosford City Council.
Photos on front cover: long-stem planting along Ettalong Creek, long-stem planting, long-stem root ball, long-stem seedling about to be planted. Back cover: coastal area, Patonga Beach; riparian area, Umina; saline area, Yarrawa; rainforest area, Katandra Reserve, Holgate.
Printed on recycled paper, April 2010

Contents

Long-stem planting...

Development of the long-stem planting method in Australia has seen an increase in the survival rates of seedlings planted in many different environments. The advantages of this method, such as no post-planting watering, increased growth rates and higher survival rates, have made a positive contribution to many rehabilitation projects and seen individuals and groups obtain successful outcomes in areas that were considered a challenge.

Within Katandra Reserve (Holgate, NSW) the long-stem planting method has been trialled on rainforest species, resulting in significantly greater growth rates in seedlings of some species planted using the technique (Chalmers *et al*. 2007). Furthermore, native riparian species planted using this method in the Hunter Valley (NSW) showed greater survival rates (20-50 per cent better, depending on the species) compared with standard planting methods on river banks and demonstrated that native plants could indeed be reintroduced on to river banks where previous efforts had been unsuccessful (Hicks *et al*. 1999). Within saline environments survival and growth rates of long-stem planting has been exceptional (Hicks 2003) and, recently, the long-stem planting method has been used in a sand dune environment with great success for both survival and growth rates (Bakewell *et al*. 2009).

What is long-stem planting ?

The long-stem planting method is an innovative way of planting that can result in higher survival and growth rates with minimal post-planting care. Using the long-stem method, seedlings are grown in pots for 10-18 months, so that they develop long woody stems. These seedlings are then planted with about three-quarters of their length below the soil surface, approximately 1 metre deep, which results in much of the woody stem being covered with soil.

The deep planting protects the roots from substantial changes in soil temperature, allows the plant access to deeper soil moisture and reduces competition from weeds. Once planted, the seedling develops roots from the buried stem and leaf nodes. This promotes the development of a robust root network which gives the seedling a greater chance of survival.

The long-stem planting method has challenged two long-held horticultural principles:

1. Large plants should not be grown in small containers as they will become root bound, thereby hindering the future growth of the plant.

The long-stem method uses plants that are relatively tall for the size of the pot they are grown in. This is achieved through the use of standard pots. In addition, slow-release fertilisers are placed in the centre of the pot so that the plant does not need to grow extended roots in search of further nutrients. This prevents the plant from becoming root bound in the pot and allows for the development of healthy roots when planted in the ground.

2. Stems of seedlings should not be planted below the surface of the soil as this subjects them to fungal attack and disease.

The long-stem planting method appears to challenge this long-held horticultural belief since most of the seedling's woody stem is planted underground, yet survival rates of these seedlings have been higher than that of those planted using traditional methods. While this has been observed during both scientific and field trials, further research is needed to determine why the stems of long-stem plants are not prone to disease and fungal attack.

Field trials using the long-stem method have included a variety of native species to demonstrate that seedlings can not only be grown successfully when these two traditional principles are not followed, but can have survival and growth rates that exceed those planted using traditional planting methods. It would appear that most, if not all, hard tissue plants are suitable for use in long-stem planting (Hicks 2010, pers. com.,nd).

Gmelina leichhardtii

How the long-stem method was developed

The long-stem planting method was pioneered by Bill Hicks for use on river banks in the Hunter Valley. Bill wanted to establish native species on river banks instead of willows (*Salix* spp) as was the recommended practice at the time. The spread of willows had become an environmental problem, impacting on the ecology of river systems and wetlands in much of temperate Australia. Willows affect the flow of water and reduce biodiversity. Willow species are now listed by the Australian Government as Weeds of National Significance (1998), and are no longer recommended for planting.

The riparian environment presents challenges for the planting of natives using traditional planting methods as the seedlings are continuously affected by changes in water levels, river flow, and processes of erosion and sedimentation. Once the long-stem planting method had been developed and tested, Bill conducted workshops throughout New South Wales, Victoria and South Australia to educate communities about the use of the method and its value in revegetating cleared, disturbed and hostile natural areas. Individuals and groups have since conducted scientific field experiments to examine the effectiveness of the method in a range of habitats, including rainforest, sand dunes and saline sites. The Australian Plants Society Central Coast Group have used the method for a number of years at their Bushcare site in Katandra Reserve. With assistance from Bill Hicks the method was altered slightly to suit:

- the local rainforest conditions at Katandra;
- the number of plants required each year; and
- the tools and materials available to the Bushcare group.

The long-stem method has now been used throughout Australia and overseas, including revegetation projects in New Mexico.

Clockwise from top left:
Equipment and seedlings ready for planting, long-stem seedlings ready for planting with bottles of water, materials needed for potting.

Step-by-step guide to long-stem planting

The long-stem planting technique contains a number of steps which are considered to be important to the overall success of the method. However, once you have tried the technique you may be able to make changes in order to suit your site's particular needs.

Tools and materials suggested/required for plantings are:

- **seedlings or seeds** for revegetation projects, local provenance seeds or seedlings are recommended as they will provide a range of ecological benefits including providing habitat for local fauna, and maintaining local genetic integrity.
- **pots** use standard 50 mm square-cornered pots.
- **potting mix** use a good quality mix for natives. Large pieces can be sieved from the mix and used at the bottom of the pot to stop the mix from escaping.
- **trace elements** for native plants (e.g. Micromax^{R}).
- **slow-release fertilisers** suitable for native plants. Two types are required: a 5-6 month slow-release fertiliser; and an 8-9 month slow-release fertiliser.
- **potting racks** to hold the pots off the ground or bench while the seedlings are growing in your 'nursery'.
- **seaweed solution** use half-strength seaweed solution in a bucket of water to fully immerse the potted seedlings. This is recommended just before planting.
- **tools for planting** shovel, post hole digger or auger, or water lance.
- **water for planting** if a water supply is not available and the water needs to be carried to the site, the use of as little as 2 litres per plant has been successful, but more can be used if the sub-soil is dry.

Top left and right: half-fill pot and create a depression/hole for the fertiliser and seedling.

Centre left: place the fertilisers in the hole.

Centre right: select seedling.

Bottom: place potted seedling in rack.

How to grow the long-stem seedlings

1. Use seedlings that have been grown in seed-raising trays using conventional methods, or collect the seedlings from a suitable location. Within Katandra Reserve, for example, small seedlings were collected from pathways and fallen logs in the rainforest, where there was little chance the seedlings would survive to become adult trees. Collecting seedlings from the natural environment ensures that you have the strongest seedlings which have survived where others have died. These stronger seedlings transplant more successfully. Collecting seedlings from the natural environment also allows you to choose from a greater variety of species which may be representative of all layers of the forest canopy. Conditions apply to the collection of plant material in reserves and national parks. Please check with your local authorities prior to collecting seeds or seedlings.
2. Thoroughly mix the trace elements through the potting mix (5 ml of trace elements per 7.5 litres of potting mix).
3. Half fill the pots with the prepared potting mix, placing the larger sieved pieces at the bottom.
4. Create a depression deep enough to hold the slow-release fertiliser. This depression can be made with a pen or stick with a diameter of approximately 1.5 cm. Place the fertilisers in the well (half a teaspoon of 8-9 month slow-release fertiliser, then quarter of a teaspoon of 5-6 month slow-release fertiliser). Gently place the seedling in the pot, taking care not to damage the fine hair roots. Carefully fill with potting mix and tap the bottom of the pot to settle the potting mix and improve contact between the potting mix and the roots. Top up the rest of the pot with potting mix. Water the seedling thoroughly and add more potting mix if necessary.
5. Place the pots on 'potting racks' so that they do not have direct contact with the ground or table. The potting racks provide a space between the bottom of the pots and the ground/table that result in the roots being 'air pruned'. This means that when the roots reach the outside of the pot they dry off (aerial pruning) and stop growing. This allows the roots to spread out into the surrounding soil and form a strong network when the seedling is planted.

Top left: dig hole with auger.

Top right: pour 1 litre of water into the hole and allow to drain before placing the seedling.

Centre: gently backfill the hole using water to settle the soil and eliminate air pockets. Then build up dish-shaped depression.

Bottom: add remaining water.

6. Select a suitable place for the seedlings to grow in your nursery. Choose the location to suit the species you are growing. Generally a sunlit position is recommended to encourage strong stem and leaf growth.
7. Water seedlings regularly and rotate the pots periodically to ensure all plants get an equal amount of water and sunlight.
8. Seedlings can take between 10 and 18 months to reach a suitable height for long stem planting. Seedlings should reach 1 metre during this time, however this would depend on the plant species' natural growth habit.
9. Soak the seedlings (still in their pots) the night before planting in a half-strength seaweed solution to ensure the root ball is thoroughly wet. This saturates the potting mix and assists in stimulating root development once planted.

How to plant using the long-stem method

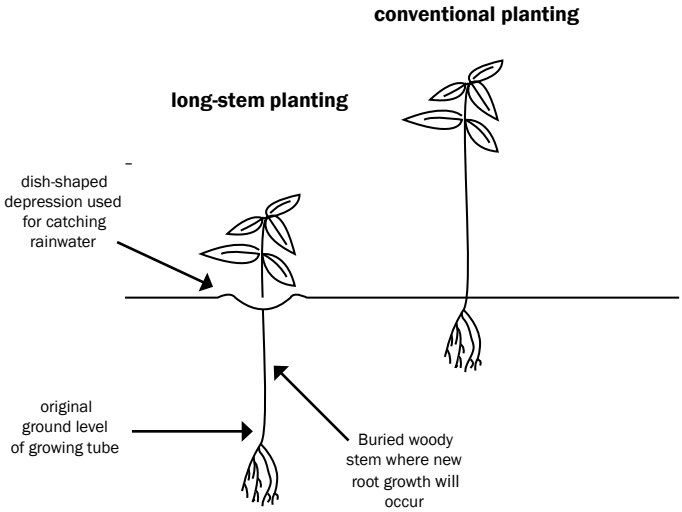
1. Dig holes that are deep enough to allow three-quarters of the plant to be buried. The use of power tools such as a soil auger in heavy clay may result in smooth walls in the hole, these may need to be roughened slightly to allow the roots to penetrate the smooth walls more easily.
2. Pour approximately 1 litre of water into the hole and allow it to soak in.
3. Prune side branches or large leaves from the lower portion of the stem that impede placement of the seedling in the hole when planting.
4. Place the plant in the hole and backfill carefully using soil and water alternately to ensure that no air pockets are left. This is important to prevent the roots from drying out.
5. Create a dish-shaped depression around the stem of the plant and add the remaining water. The depression will assist in catching any rain.
6. Generally no further maintenance is required. Since the root ball will be below the root zone of most weeds, competition from weed roots will be minimal. In moist environments, vine growth may need to be controlled.

Clockwise from top left: long-stem seedling before planting, close-up of roots developed from buried part of stem with a white line marking ground level, demonstration of original ground level and growth of roots from buried stem.

The original Bill Hicks method of long-stem planting differs slightly from the step-by-step method described above as he had a supply of water at his planting sites. The original method sourced water from the nearby stream using a water pump and then a water lance was used to dig the hole and thoroughly wet the soil. In soils prone to collapse, such as sand, a tube was used to support the hole around the lance. The plant was then placed into the tube and the plastic tube carefully removed. Water from the stream was used to water the seedlings in.

This original method of long-stem planting came out of a need to plant the seedling deep enough into the river bank so they would not be washed out during flooding in the riparian environment. While doing this Bill realised that the survival and growth rates were enhanced.

Bill grew plants from seed he collected from local sources. Shortly after germination seedlings were planted out into separate pots using the long-stem method and grown for the 10-18 month term as described above.



Above: Jessica planting a seedling at Katandra Reserve, Holgate, in 2004.

Below: Jessica next to the same plant to her left in 2009. Notice the general regeneration of the site due to long-stem planting.

General benefits

The benefits of the long-stem planting method are significant and include advantages which are of great assistance to bush regenerators and others interested in plant survival.

Firstly, the long-stem method creates an older, stronger seedling for planting. This is due to the consistent nutrients, air pruning and longer nursery period. If the seedling is also sourced from the natural environment through collection it has the added advantage of having survived the natural culling process of its local environment. This produces a much stronger plant than an ordinary seedling and increases its survival rate.

Another notable benefit is that the deeply-planted root ball is insulated from the substantial changes in soil temperature and moisture compared with traditional plantings where the plant roots are close to the soil surface.

In drier and saline environments, planting more deeply allows the root ball to be further away from the hot, dry or damaging salt-encrusted topsoils which increases the seedling's chances of survival.

Newly planted long-stem seedlings are also more stable in the ground than those planted using traditional methods. Deeper planting means that seedlings are better able to withstand soil erosion due to wind such as on sand dunes, or the effects of moving water such as flood conditions in riparian zones. The development of a deep root system allows the plant to bind greater amounts of soil, which is also why these plants are so stable in the ground.

Another benefit is the relatively small quantities of water required when planting, and that no further watering is required post-planting. This benefit is important on sites with limited water.

An unexpected benefit of long-stem planting has been the reduced loss from vandalism as it is more difficult to pull up a deeply-planted root ball (Hicks 2010, pers. com.,nd) and seedlings can survive trampling by people walking through planted areas (Bakewell et al. 2009).

Above: A long stem seedling two months after planting, along a creek bank at Umina Beach.

Below: the same seedlings three years later.

Finally, competition with shallow-rooted weeds is less likely to occur when seedlings are planted using the long stem method. The deeply-planted root ball accesses nutrients and soil moisture that is beyond the reach of shallow-rooted weed species. Given the reduced level of competition with shallow-rooted species, and that no follow-up watering is required, the after-planting care is minimised.

Riparian environment

As part of the original trials in the Hunter Valley, Bill Hicks grew seedlings to a height of up to 1.5 m and then planted 70-90 per cent of the plant below the soil surface. These trials revealed that three of the four species used exhibited greater growth rates using the long stem method. Bill showed that native plants could be reintroduced into riparian environments using the long-stem planting method where previous plantings trials had not been effective.

One of the main benefits of using the long-stem method within the riparian context is that the roots of seedlings are planted more deeply into the river bank therefore, the seedling is not washed away during a flood event. Long-stem planting also allows the root ball to be protected from extremes of temperature, including frosts and drying out that can damage plants which are planted using traditional methods.

Additionally, the restoration of riparian areas with native plants results in environmental benefits that cannot be achieved with exotic species. These benefits should not be overlooked. The use of native plants improves local biodiversity and does not impact negatively on the health of river systems.

Melaleuca quinquenervia.

Top: Newly planted White Beech (*Gmelina leichhardtii*) long-stem seedling.

Below: Katandra Reserve, Holgate, where long-stem planting has been trialled.

Rainforest environment

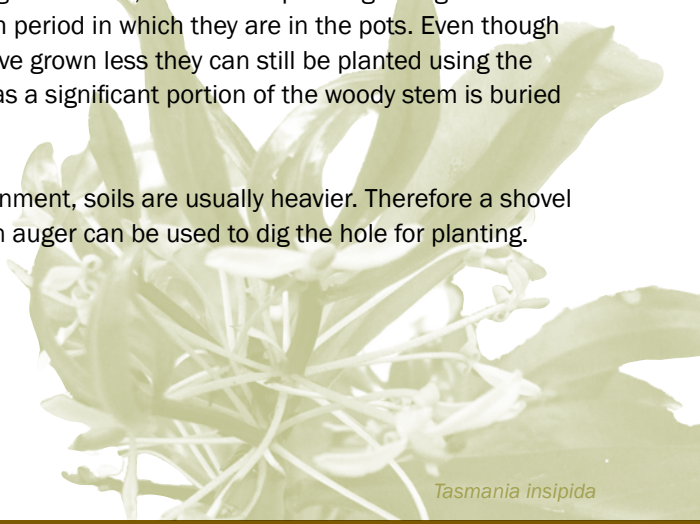
Research conducted in the rainforest at Katandra Reserve has indicated that some species show significantly greater growth rates when planted as long-stem seedlings (Chalmers et al. 2007). During these trials it was found that the growth of Cheese Tree, *Glochidion ferdinandi*, was significantly greater when planted using the long-stem method as opposed to traditional planting, while for Scentless Rosewood, *Synoum glandulosum*, the growth rate remained the same.

These trials at Katandra Reserve from 2002 to 2009 were conducted during an extended dry period. It is not known how long-stem planting would perform during a period of prolonged wet conditions. Field trials using a larger number of rainforest species are currently being undertaken to further study long-stem planting within rainforest environments.

Due to the great height of rainforest trees and the short seed 'shelf life' of many rainforest species it is often easier to collect seedlings from the forest floor in this environment. Collection of seedlings also provides benefits such as greater species selection and the harvesting of stronger individuals which have survived the germination process in forest conditions.

Rainforest species that are grown using the long-stem method show pronounced differences in growth habit, with some species growing to less than 1 metre in the 18-24 month period in which they are in the pots. Even though these species appear to have grown less they can still be planted using the long stem method as long as a significant portion of the woody stem is buried at planting.

Within the rainforest environment, soils are usually heavier. Therefore a shovel or a manual or petrol-driven auger can be used to dig the hole for planting.



Tasmania insipida

Top: Acacia long-stem seedling planted in a sand dune at Patonga Beach.

Below: Establishment of long-stem seedlings in the sand dune at Patonga Beach.

Coastal environment

It has been shown that in coastal areas long-stem planting of native sand dune plant species has been successful without the need for protective planting sleeves or follow-up watering. Seedlings planted in dune areas using the long-stem method experienced greater survival and growth rates than tube stock planted using the traditional planting method.

At Patonga Beach (Central Coast, NSW) the long-stem planting method has been used in trials of Coastal Wattle, *Acacia longifolia* var. *sophorae*, to restore the beach dune area. Results of these trials concluded that the long-stem method produced higher survival rates compared with plants using a traditional planting method (79 per cent compared with 53 per cent). Greater growth was also recorded in the long stem seedlings (19 cm mean stem growth as compared to 8 cm for the traditional method) (Bakewell et al. 2009). Also, long-stem seedlings survived trampling and breaking of stems and shoots due to human impact in the planted areas.

Long-stem plants in sand dunes benefit from having reliable soil moisture, limited root competition, and stable soil temperatures. The likelihood of the root ball being exposed in dunes as a result of sand movement is reduced when the long-stem planting method is used.

The advantages of using the long-stem planting method in this environment include the elimination of the need to build structures around the seedlings to protect them and the need for post-planting irrigation. This can significantly reduce the costs associated with regeneration work and the amount of follow-up maintenance required at the site.

In sandy environments, digging deep holes can usually be done with shovels or other hand tools.

Spinifex sp.

Top: Two and a half year old long stem seedlings planted in a high saline area near Muswellbrook (Yarrawa) continue to show significant growth.

Below: Long stem plantings in the saline environment.

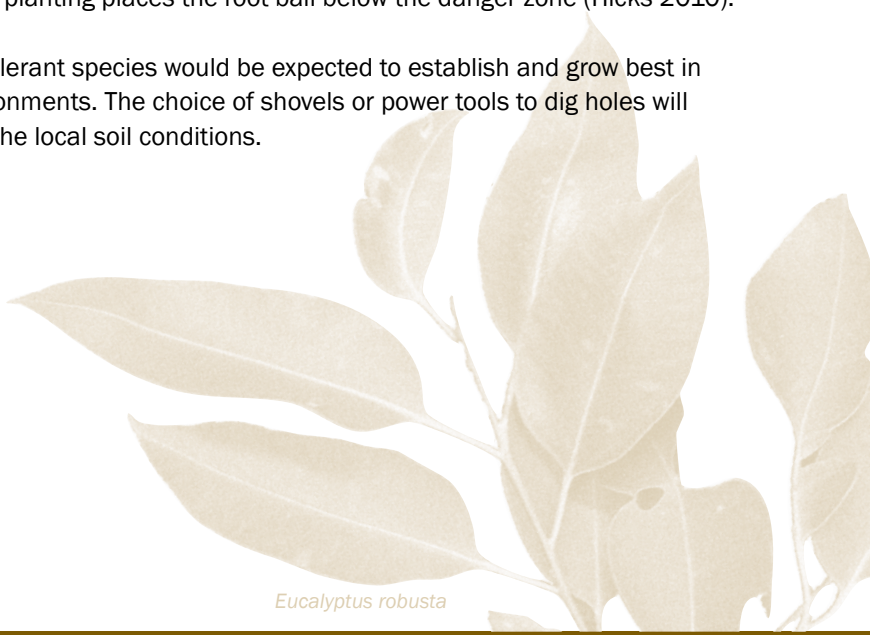
Saline environment

There has been great success in the use of long-stem planting within saline environments. After conducting trials within salt-affected lands in the Upper Hunter, Bill Hicks concluded that survival and growth rates of long-stem plantings had been outstanding (Hicks 2003). During these trials Bill planted 2,500 salt-tolerant seedlings. The trees survived a record drought, above-average temperatures and frosts as well as high salinity levels (Hicks 2003). It appears from these trials that virtually any native salt-tolerant species is suitable for long-stem planting.

The Hunter-Central Rivers Catchment Management Authority at Muswellbrook, NSW, has also used long stem planting at their saline site. Fresh water was used to water the seedlings in. At this site it was found that long-stem planting worked better on drier saline sites than wet saline ones and further research is needed to understand why.

The main benefit of this method in a saline environment is that the root system is planted below the salt-encrusted top layer of the soil. Soil salinity suppresses plant growth and creates a hot, dry and uninhabitable environment. As in other areas, deep planting places the root ball below the danger zone (Hicks 2010).

Local salt-tolerant species would be expected to establish and grow best in saline environments. The choice of shovels or power tools to dig holes will depend on the local soil conditions.



Eucalyptus robusta

Resources required

The actual cost and resource requirements for long-stem planting in comparison with traditional methods will vary between projects and site locations. The level of maintenance will be influenced by the environment being planted. The following table lists the resources that need to be considered when making comparisons between the two methods.

While long stem seedlings are kept for a longer time in the nursery, the advantages of reduced pre-planting site preparation, reduced cost of plant protection, reduced need for post-planting weed control and improved survival and growth rates are considered to be significant.

Resource	Long-stem method	Traditional method
Site preparation including soil preparation and ground cover weed control	Not usually needed. May be required for large plantings	Weed control and ripping may be required
Plant sleeves or other materials to protect against wind and frost	Not usually needed. Can be useful to protect from browsing animals	Required in some locations
Post-planting maintenance such as watering, weed control, fertilising, and mulching	Not usually needed	Weed control and watering usually required
Use of power tools/ equipment to dig holes	May be required in some environments	Usually not required for small scale projects, but may be used for larger projects to save time
Length of time to dig holes	Usually longer for long stem planting	Usually shorter for traditional method
Length of time that potted seedlings require fertiliser	Only initial slow-release fertiliser required. None required post-potting	3-6 months after potting
Length of time that potted seedlings require watering	10-18 months	3-6 months after potting
Length of time seedlings are in the nursery	10-18 months	6-12 months after potting

Conclusion

The use of the long-stem planting method provides an opportunity to improve the survival rate of native plants in the restoration of degraded ecosystems. Long-stem planting has shown to be successful in a wide range of environments and conditions.

The long-stem planting method has been shown to be a particularly successful method to use in environments where the surface soil conditions are not generally favourable for planting. This may be due to low moisture levels, high temperatures, high salinity, or surface ground movement due to flooding or human activities such as walking. In these cases the long-stem planting method offers the advantage of planting the seedling more deeply into the ground and away from these adverse effects. It is unclear whether the method provides the same advantages in environments where subsoil moisture conditions are unfavourable during drought.

We encourage others to trial the method at their work sites and would welcome feedback on the results.

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For further information

Australian Plants Society Central Coast Group: www.australianplants.org/longstem.htm
Hunter-Central Rivers Catchment Management Authority: www.hcr.cma.nsw.gov.au
Bill Hicks Longstem Tubestock DVD: www.norkhiltechnologies.com
NSW Environmental Trust: www.environment.nsw.gov.au