Shire of Gunnedah
Land of Opportunity

Blackjack Creek Riparian Corridor/Channel Reconstruction

EPBC Referral 2013/6732 – Additional Information

June 2013

Constructive Solutions
Realising potential

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1. Introduction

A referral was made under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on behalf of Gunnedah Shire Council for the Blackjack Creek Riparian Corridor/Channel Reconstruction. This referral (reference number 2013/6732) was made due to the impact of the Reconstruction on the Koala, which is listed as a vulnerable species under the EPBC Act.

Following this referral, the Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) provided a letter dated 26 March 2013 stating that the Reconstruction will be assessed on preliminary documentation and requesting further information. The letter is provided in **APPENDIX A**.

Ongoing consultation with DSEWPAC since the provision of this letter has refined the understanding of the additional information that DSEWPAC required. This report forms the response to the request for further information.

2. Proposed avoidance and mitigation measures that directly reduce the scale and intensity of the impacts the proposal will have on Koalas (*Phascolarctos cinereus*)

Proposed mitigation measures which will directly reduce the scale and intensity of the impacts of the proposal on Koalas were provided to DSEWPAC in the *Review of Environmental Factors* (REF) (Section 6.7, pages 28-30) and *Species Impact Statement* (SIS) included as Appendix J of the REF (Section 7, pages 39-40) provided with the EPBC referral dated 21 January 2013. These mitigation measures are:

- A Koala Plan of Management will be prepared and rehabilitation will include proposals to expand Core Koala Habitat;
- As part of the Koala Plan of Management, a site induction of all personnel will occur to ensure that Koalas are protected within the Reconstruction site;
- A thorough inspection of all trees to be cleared or trimmed as a result of the proposal for the presence of Koalas or other fauna is to occur immediately prior to clearing. This inspection is to be completed by a suitably qualified and experienced person who is able to identify Koalas. Inspections will be completed prior to every tree removal and checked off by the Gunnedah Shire Council project manager. Where a Koala is present in a tree to be cleared or trimmed it will be allowed to move out of the tree of its own accord;
- To reduce the risk of vehicular strikes with any Koalas as a result of the increased traffic movements and heavy machinery associated with the Reconstruction all vehicles and machinery will be speed limited to a maximum of 20km/hr within the Reconstruction site; and

- All food scraps and rubbish are to be disposed of in sealed receptacles to prevent to provision of forage habitat for foxes and dogs, thus reducing the risk of predation of the Koala.

3. Proposed offsets for residual impacts on Koalas (*Phascolarctos cinereus*)

3.1 The impact area

The SIS (Section 5.7.1, page 27) identifies that 6.5ha of Core Koala Habitat and 37 habitat trees within Wandobah Reserve will be impacted by the Reconstruction, with the remaining 6.8ha of the Reconstruction impact area not considered to be Koala habitat due to current land-use and clearing. These figures are based on a 70m wide impact over a length of 1900m. The 70m width has been derived in the SIS from a 30m channel width plus 20m of Vegetated Riparian Zone (VRZ) on either side.

As stated in Section 2, page 2 of the *Vegetation Management Plan* (VMP) provided as Appendix I of the REF, the NOW *Guidelines for riparian corridors on waterfront land* (2012) recommends that the VRZ width for 2nd order streams should be 20m on each side of the watercourse from the highest point of the bank. As such, the Riparian Corridor (RC) for the Reconstruction will be approximately 100m wide - encompassing 30m of channel, additional area to the top of the channel banks at an average 1 in 4 slope, and 20m of VRZ on either side of the channel.

Construction impact will only occur for a width of 60m within this RC, encompassing the channel and its banks, with the additional 20m of VRZ on either side not being subject to construction activities. Further clarification from the detailed design identifies that the impact occurs within Wandobah Reserve for a length of 941m. As such, the impact will occur within a 60m width for a length of 941m, resulting in an impact area of 5.646ha within Wandobah Reserve.

This impact area is clearly delineated in the map provided in **APPENDIX B** of this report. The 37 habitat trees identified in the SIS occur within this 5.646ha impact area.

3.2 Area of habitat offset

The SIS (Section 6.1, page 33) identifies that Koala offsets will occur for the Reconstruction site as a result of rehabilitation, with a nominated area of 1900m x 70m = 13.3ha. Communication with DSEWPAC has identified that, despite the VMP identifying revegetation within the impact area, any revegetation of the impact area cannot be considered as an offset.

As such, further calculations were undertaken in order to provide appropriate an appropriate offset of the area of habitat which will be impacted by the Reconstruction. These calculations determined that an effective and appropriate offset can be achieved through the following:

- Revegetation within the 40m width of VRZ within Wandobah Reserve, as this area is not within the impact area. A 40m width for a length of 941m results in an offset area of 3.764ha;

- Revegetation within the 40m width of VRZ for the remainder of the Reconstruction length. A 40m length for a length of 1021m results in an offset area of 4.084ha; and

- Additional revegetation within the remaining unvegetated portion of Wandobah Reserve. Wandobah Reserve is 33.9ha in size. After subtracting the 9.41ha that comprise of the 5.646ha impact area and the 3.764ha VRZ revegetation area, and the 17.2ha that comprises the remaining vegetated portion, an unvegetated area of 7.29ha remains.

This results in a total offset area of 15.138ha. The offset areas are delineated on the map provided in **APPENDIX B** of this report.

This total offset area was placed into the EPBC Offsets Assessment Calculator. A copy of the output can be found in **APPENDIX C**. Current and future quality values for the total offset area were determined by calculating averages based on weighted values, as detailed in the table below.

Area (ha)	Percentage of Total Area	Start Quality	Future Quality	Notes
3.764	25	5	7	Start quality value derived from 70% of area being already vegetated, including previous plantings, and 30% being unvegetated
4.084	27	1	7	Future quality value potentially underestimated, allowing for high perimeter to area ratio
7.29	48	1	7	Future quality value potentially underestimated, as it is adjacent to high quality existing habitat and has a lower perimeter to area ratio
15.138	**100**	**2**	**7**	

A period of 20 years was used in the calculation for the time to ecological benefit. This may represent a conservative estimate as Koalas will frequently use 10 to 20 year old tree plantings (Crowther and Lunney 2006), as noted in Section 5.5 of the SIS.

A confidence in the result of 75% was used in the calculation. This was used as:

- Research has attributed the known unquantified increase in Koala populations in the Gunnedah region to revegetation aimed at addressing soil salinity problems (Lunney et al 2009); and

- A Study on Koala movements in the Gunnedah locality published by the Environmental Trust (Restoration) August 2011 supports the likelihood that Koala plantings will be successful. Key findings extracted from this study include:

    - The GPS tracking data show that koalas are not walking randomly across the landscape, but along the edges of paddocks, roadsides, railway tracks and Travelling Stock Routes;

    - Koalas are frequently walking across open paddocks to access isolated paddock trees. The level of use of roadside reserves and railway track corridors by koalas highlighted by this study is a major concern as road and rail related injury is one of the highest causes of koala death or entry into care;

    - Tracked koalas moved frequently between these plantings, through paddocks to isolated trees and to remnant woodland stands;

    - Koalas are moving considerable distances across the landscape, with movement of three to four kilometres over several weeks being a common occurrence. This includes movements to and from landholder-initiated tree plantings, between plantings, and between old paddock trees and trees along fence lines and remnant tree patches; and

    - Koalas therefore capitalised on the success of the plantings by using the full diversity of habitat resources available.

Thus, in light of these findings, it is considered highly likely that the biodiversity offsets will be successfully utilised by the local Koala population (Section 5.3 of the EPBC referral dated 23 February 2013).

Using the above mentioned values, an offset of 101.97% will be achieved for the impacted Koala habitat area.

3.3 Protected Matter Attribute (habitat trees) offset

The VMP (Table 1, page 4) provided with the REF identified that 1,000 trees will be planted as part of the rehabilitation component of the Reconstruction; with preference to be given to Koala habitat trees species such as River Red Gum and White Box. As such, the calculation allowed for 370 of the 1000 trees to be preferred Koala habitat tree species.

In addition, Gunnedah Shire Council has resolved to commit to the preliminary planting of an additional 200 trees in the 7.29ha portion of Wandobah Reserve (as illustrated in **APPENIDX B**) in September 2013. Preliminary planting September 2013 will provide for an improved outcome with regards to the offset of habitat trees as:

- Timing the planting for spring will reduce the potential mortality of the trees and facilitate establishment;
- Preliminary planting will provide the trees with time to establish, with a gap of at least 17 months from planting to construction anticipated; and
- The planting of an additional 200 trees to that proposed in the VMP, with at least 75 of these to be preferred Koala habitat tree species will facilitate an improved offset outcome.

As such, the VMP has been revised to include the planting of an additional 200 trees in the 7.29ha offset area in Wandobah Reserve. The revised VMP is provided in **APPENDIX D**.

Using the same time to ecological benefit and confidence values as detailed above, an offset of 794.63% will be achieved for the impacted Koala habitat trees through the planting of 445 koala habitat trees.

4. Consistency of the offsets with the Commonwealth EPBC Act Environmental Offsets Policy (October 2012)

The offsets meet the requirements of the Commonwealth EPBC Act Environmental Offsets Policy (October 2012) as follows:

4.1 Must deliver an overall conservation outcome that improves or maintains the viability of the protected matter

The current calculator shows that the offsets will provide over 100% offset for both the area of habitat and number of habitat trees impacted by the Reconstruction. Plantings will improve the overall quality of the habitat for Koala and the improvement in habitat quality will also facilitate the greater usage of the Reconstruction as a wildlife corridor for fauna travelling towards the Namoi River, as per the ecological report and SIS. Revegetation is to be specifically targeted at Koala feed tree species, with the REF, SIS and revised VMP all including this.

4.2 Suitable offsets must be built around direct offsets but may include other compensatory measures

The calculator demonstrates that direct offsets greater than 100% will be achieved. Gunnedah Shire Council is committed to developing the Reconstruction to act as habitat and wildlife corridor, rather than purely as a flood mitigation measure. This commitment is evidenced by the development a VRZ despite the Reconstruction not requiring a Controlled Activity Approval under the *Water Management (General) Regulation 2011*.

Wandobah Reserve is already under Gunnedah Shire Council's protection and management, with the REF and associated documentation providing guidance as to how this will be managed into the future to provide for conservation of the

Koala. The private land which will be acquired as part of the proposal will be subject to the same protection. No existing EPBC offsets are impacted in any way by this proposal.

4.3 Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter

The offsets allow for the protection of the Koala in accordance with its statutory protection. Section 5.5 of the SIS provides greater detail of how relevant matters such as State-listed Key Threatening Processes have been addressed.

4.4 Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter

The offsets are proportionate in size and scale to the impacts on the Koala, with offsets achieved directly adjacent to the impact area and providing improved outcomes with regards to habitat connectivity.

4.5 Suitable offsets must effectively account for and manage the risks of the offset not succeeding

The calculator contains the assessed risk values, with the SIS including information on the considered likelihood of success. The revised VMP provides for the ongoing monitoring and maintenance of the plantings to ensure that it succeeds.

The additional 17.2 ha of already vegetated area within Wandobah Reserve which is not included in the offset area will provide suitable habitat of a greater extent than the impact area available both during the Reconstruction and following. This provides a safety net despite the success of the plantings being considered to be high, as per Section 3.2 of this report.

4.6 Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other scheme or programs

Section 4 of the REF contains details of State legislation and regulations applicable to the Reconstruction. The referral of the Reconstruction under the EPBC Act for the Koala is the overarching legislative requirement, with the removal of the habitat permissible under relevant legislation and planning regulations.

The inclusion of a VRZ within the design of the Reconstruction is not legally required under the *Water Management (General) Regulation 2011*. However, as Gunnedah Shire Council aim for the Reconstruction to act as suitable habitat and not just a flood mitigation measure, a VRZ has been included in the design which will facilitate the improvement of Koala habitat within the Reconstruction site and provide for an improved wildlife corridor from Wandobah Reserve to the extensive tracts of vegetation present in the hills and ridgelines to the south of Gunnedah (as per the SIS).

4.7 Suitable offsets must be efficient, effective, timely, transparent, scientifically robust and reasonable

The proposed offsets are considered to be efficient as the offset will be provided directly adjacent to the impact site and will occur as part of the overall works program for the Reconstruction.

The offsets are considered to be effective, with the SIS providing comment on the likely success of revegetation (as detailed in Section 3.2 of this report) and the VMP providing for the ongoing monitoring and management of revegetation to ensure success.

The offsets are considered to be timely as they are included as part of the overall works program for the Reconstruction, with staged revegetation clearly identified as a priority throughout. The overall works program for the Reconstruction allows for staged revegetation to occur as a part of the Reconstruction works, with 1000 trees to be planted in the VRZ. In addition, Gunnedah Shire Council will undertake preliminary planting of 200 trees in the 7.29ha unvegetated section of Wandobah Reserve (as illustrated in **APPENDIX B**) which is outside of the Reconstruction impact footprint in September 2013. This preliminary planting will facilitate the establishment of plantings prior to construction.

The offsets are considered to be transparent as they will occur directly adjacent to the Reconstruction site where they will be visible to the public and Gunnedah Shire Council has considered including volunteers in the plantings (Section 6 of the VMP).

The offsets are considered to be scientifically robust in that the documentation, including the ecological report, SIS and offset calculations have been prepared by suitably qualified individuals, with statements made in the ecological report and SIS reinforced with references from peer-reviewed scientific sources.

The offsets are considered to be reasonable in that they will occur directly adjacent to the impact Reconstruction and will improve outcomes for the Koala in the vicinity of the Reconstruction site, while facilitating the improvement of socio-economic outcomes through the mitigation of flooding in the vicinity.

5. Additional relevant information

Following is additional relevant information, as requested in the DSEWPAC letter.

5.1 Details in relation to the proposed offsets package

The location and size of the offset site, including landscape context and boundaries is provided in the mapping in **APPENDIX B**.

The entire Reconstruction site is zoned RE1 – Public Recreation under the *Gunnedah Local Environmental Plan 2012*. Environmental protection works are permitted without consent under the provisions of this zone.

Wandobah Reserve is owned by Gunnedah Shire Council. Lot 78, DP 755503 ('Fermanagh') and Lot 77, DP 755503 and Lot 2, DP 542293 ('Balmoral') are privately owned properties. Gunnedah Shire Council will progress with the necessary acquisition of the land required to complete the Reconstruction should final planning approval be granted. Following acquisition, covenants and zoning provisions will be placed on the land which will secure it in perpetuity.

Gunnedah Shire Council's commitment to the acquisition necessary to undertake the Reconstruction has been demonstrated through the following:

- The provision of $150,000 in its 2013-2014 budget for the land acquisition process;
- The initiation of preliminary valuations which indicate that this is approximately the value of the land involved;
- Zoning of the subject private land as "Future Open Space" in the Gunnedah LEP 1986, effectively restricting development of the land (including subdivision) in order that it would at some point in time be available for acquisition to address the Blackjack Creek flood issues;
- Maintenance of this zoning in the Gunnedah LEP 1998; and
- Zoning of the subject private land as Recreation (RE1), effectively ensuring that the land is available and maintained as open space, under the *Gunnedah Local Environmental Plan 2012*, following the NSW Government standard template requiring that zoning must be definitive, meaning that there are no "Future" zones as in previous LEPs.

The land upon acquisition must be classified under the Local Government Act 1993 as 'community' or 'operational'. Community land must be used only for purposes that benefit the community and cannot be on-sold without a public reclassification process. Any land that is zoned Recreation (RE1) automatically becomes Community and. As the subject private land is zoned Recreation (RE1) under the *Gunnedah Local Environmental Plan 2012*, the acquired land will become Community land for the benefit of the community.

As such, upon acquisition the land will have a number of legal controls that will ensure it is maintained as open space into the future. It should be noted that the land will not be a 'reserve' – it will be open space managed by Council in accordance with the provisions of the *Environmental Planning & Assessment Act 1979* and the *Local Government Act 1993*.

The presence of Koala within the Reconstruction site is discussed in detail in the ecological assessment and SIS included as appendices of the REF, with the sighting of a single male Koala in the adjacent Cemetery during surveys.

Detailed information regarding the presence and the quality of the habitat for the Koala is provided in the ecological assessment and SIS included as appendices of the REF.

5.2 Provide information and justification regarding how the offsets package will deliver a conservation outcome that will maintain or improve the viability of the protected matter consistent with the EPBC Act Environmental Offsets Policy (October 2012)

Refer to Section 4 for details of consistency with the EPBC Act Environmental Offsets Policy (October 2012).

The implementation of the revised VMP will ensure that the offsets are achieved through the monitoring and maintenance of plantings. The placement of covenants and zoning provisions on the acquired land will ensure that it is secured in perpetuity.

As per Section 3.2 and the calculator provided in **APPENDIX C**, the proposed offset will be provided in 20 years time. This may represent a conservative estimate as Koalas will frequently use 10 to 20 year old tree plantings (Crowther and Lunney 2006), as noted in Section 5.5 of the SIS, and the preliminary plantings undertaken in September 2013 will be in advance of the construction works and the remainder of the plantings.

While Wandobah Reserve is already considered to be under the protection of Gunnedah Shire Council, the adjacent private land is not. As such, this section could be subject to further degradation, damage or destruction as a result of the agricultural activities which occur on this land, with the private land not considered to be Koala habitat due to the level of degradation and lack of suitable habitat (as per SIS). The acquisition of this land by Gunnedah Shire Council will ensure that the offset established in the VRZ is protected.

5.3 Provide information regarding how the proposed offsets packages is additional to what is already required, as determined by law or planning regulations, agreed to under other schemes or programs or required under an existing duty-of-care

Refer to Section 4.6. The inclusion of a VRZ within the design of the Reconstruction is not legally required; however, as Gunnedah Shire Council aim for the Reconstruction to act as suitable habitat and not just a flood mitigation measure, a VRZ has been included in the design which will facilitate the improvement of Koala habitat within the Reconstruction site and provide for an improved wildlife corridor from Wandobah Reserve to the extensive tracts of vegetation present in the hills and ridgelines to the south of Gunnedah.

5.4 The overall cost of the proposed offsets package

The overall cost of the proposed offsets package comprises of land acquisition, revegetation, and ongoing monitoring and maintenance.

Land acquisition is anticipated to cost $75,000 for the necessary portion of Lot 78, DP 755503 ('Fermanagh') and $92,000 for the necessary portions of Lot 77, DP 755503 and Lot 2, DP 542293 ('Balmoral'), as per preliminary valuations received by Gunnedah Shire Council in December 2012. There is, however, some

potential for the cost of acquisition to be higher depending on negotiations with the landholders.

The revised VMP (**APPENDIX D**) identifies total revegetation (Table 4, page 10) and ongoing maintenance costs (Table 5, page 11). For the purposes of calculating the cost of the offsets, only the costs associated with planting and maintaining trees and shrubs in the VRZ and additional 7.29ha preliminary planting area have been included. As such the cost of revegetation within the offset is estimated to be $25,200, with an annual monitoring and maintenance cost of $34,360. The annual monitoring and maintenance cost will decrease over time as infill/replanting costs decrease, as per Table 5 of the VMP.

As such, the overall cost of the proposed offsets package is estimated to be $192,200, with an annual maintenance cost of up to $34,360.

6. Conclusion

This report provides additional information to DSEWPAC regarding the proposed offsets for the Blackjack Creek Riparian Corridor/Channel Reconstruction (2013/6732).

The offsets are consistent with the EPBC Act Environmental Offsets Policy (October 2012) and direct offsets of over 100% will be achieved for both the habitat area and number of habitat trees impacted by the Reconstruction. The proposed offsets will also facilitate the improvement in habitat connectivity by connecting remnant habitat in Wandobah Reserve with habitat in the hills and ridgelines south of Gunnedah.

7. References

- Constructive Solutions Pty Ltd 2013, *Blackjack Creek Riparian Corridor/Channel Reconstruction – EPBC Referral dated 21 January 2013;*
- Constructive Solutions Pty Ltd 2013, *Blackjack Creek Riparian Corridor/Channel Reconstruction Review of Environmental Factors – DRAFT*;
- Constructive Solutions Pty Ltd 2013, *Blackjack Creek Riparian Corridor/Channel Reconstruction Vegetation Management Plan*. Provided as Appendix I in the REF;
- Crowther, M.S., Lunney, D., Lemon, J., Wheeler, R. & Madani, G. 2010, 'Restoration of koala habitat in Gunnedah 11: movement of koalas across a patchy rural landscape', *Australian Mammal Society 56th Meeting*, Canberra, ACT;
- Crowther, M.S., McAlpine, C.A., Lunney, D., Shannon, I. & Bryant, J.V. 2009, 'Using broad-scale, community survey data to compare species

conservation strategies across regions: A case study of the Koala in a set of adjacent 'catchments', *Ecological Management & Restoration*, 10:S88-S96;

- Department of Sustainability, Environment, Water, Population and Communities 2012, *Environment Protection and Biodiversity Conservation Act 1999 Environmental Offsets Policy*;
- Environmental Trust 2011, 'Restoring koala habitat in Gunnedah: building on a 1990 success, *Environmental Trust (Restoration) August 2011*;
- *Gunnedah Local Environmental Plan 2012*;
- NSW Office of Water 2012, *Guidelines for riparian corridors on waterfront land*;
- OzArk Environmental and Heritage Management Pty Ltd 2013, *Koala Species Impact Statement: Blackjack Creek Restoration in Gunnedah, NSW*. Provided as Appendix J of the REF;
- OzArk Environmental and Heritage Management Pty Ltd 2012, *Ecological Assessment: Blackjack Creek Restoration in Gunnedah, NSW*, Provided as Appendix H of the REF;
- *Water Management (General) Regulation 2011*.

APPENDIX A
DSEWPAC Letter

Australian Government

Department of Sustainability, Environment, Water, Population and Communities

Mr Robert E Campbell
General Manger, Gunnedah Shire Council
PO Box 63
GUNNEDAH NSW 2380

EPBC Ref: 2013/6732

Dear Mr Campbell

Blackjack Creek riparian corridor/ channel reconstruction, Gunnedah, NSW (2012/6732).

On 07 March 2013, I decided that the above proposed action required assessment and approval under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). While it has been determined that your project will be assessed by preliminary documentation, the department requires some further information to be able to assess the relevant impacts of the action. Specifically, the following is required:

1) Proposed avoidance and mitigation measures that directly reduce the scale and intensity of the impacts the proposal will have on Koalas (*Phascolarctos cinereus*).

2) Proposed offsets for residual impacts on Koalas (*Phascolarctos cinereus*)

Please demonstrate how the proposed offset is consistent with the Commonwealth EPBC Act Environmental Offsets Policy (October 2012), available at www.environment.gov.au/epbc/publications/environmental-offsets-policy.html

The attached information sheet detials what the department requries to assess whether proposed offset packages meet the department's offset policy and can be used as a guide in the preperation of your material.

In any correspondence with the department please quote the title of the action and EPBC reference number. You can send information to us:

By letter;
NSW Section, South-Eastern Australia Environment Assessments
Department of Sustainability, Environment, Water, Population & Communities
GPO Box 787
CANBERRA ACT 2601

By email; Pat.Guinane@environment.gov.au

Once the department receives satisfactory information, a direction to publish will be issued so that the preliminary documentation is made available for public comment.

If you have any questions about the referral process or this request for additional information, please contact the project manager, Pat Guinane, by email to Pat.Guinane@environment.gov.au, or telephone 02 6275 9010 and quote the EPBC reference number shown at the beginning of this letter.

Yours sincerely

James Tregurtha
Assistant Secretary
South-Eastern Australia Environment Assessments
26/3/2013

Information that should be provided to the department regarding offsets:

- Details in relation to the proposed offsets package, including:
  - the location and size, in hectares, of any offset site(s);
  - maps clearly showing for each offset site:
    - the relevant ecological features;
    - the landscape context; and
    - the cadastre boundary.
  - the current tenure arrangements (including zoning and ownership) of any proposed offset sites;
  - confirmed records of presence (or otherwise) of relevant protected matter(s) on the offset site(s); and
  - detailed information regarding the presence and quality of habitat for relevant protected matter(s) on the offset site. The quality of habitat should be assessed in a manner consistent with the approach outlined in the document titled How to use the offset assessment guide available at: http://www.environment.gov.au/epbc/publications/environmental-offsets-policy.html;
- Provide information and justification regarding how the offsets package will deliver a conservation outcome that will maintain or improve the viability of the protected matter(s) consistent with the *EPBC Act environmental offsets policy* (October 2012); including:
  - management actions that will be undertaken that improve or maintain the quality of the proposed offset site(s) for the relevant protected matter(s). Management actions must be clearly described, planned and resourced as to justify any proposed improvements in quality for the protected matter(s) over time.
  - the time over which management actions will deliver any proposed improvement or maintenance of habitat quality for the relevant protected matter(s)
  - the risk of damage, degradation or destruction to any proposed offset site(s) in the absence of any formal protection and/or management over a foreseeable time period (20 years). Such risk assessments may be based on:
    - presence of pending development applications, mining leases or other activities on or near the proposed offset site(s) that indicate development intent;
    - average risk of loss for similar sites; and
    - presence and strength of formal protection mechanisms currently in place.
  - the legal mechanism(s) that are proposed to protect offset site(s) into the future and avert any risk of damage, degradation or destruction.
- Provide information regarding how the proposed offsets package is additional to what is already required, as determined by law or planning regulations, agreed to under other schemes or programs or required under an existing duty-of-care.
- The overall cost of the proposed offsets package; including costs associated with, but not limited to:
  - acquisition and transfer of lands/property;
  - implementation of all related management actions; and
  - monitoring, reporting and auditing of offset performance.

APPENDIX B
Mapping

REVISIONS					
A	03.12.2012	DB	ISSUED FOR REVIEW		--
REV.	DATE	BY	DESCRIPTION		CHK.

VEGETATED RIPARIAN ZONE EXTENTS PLAN - BLACKJACK CREEK

Client: GUNNEDAH SHIRE COUNCIL

BLACKJACK CREEK RIPARIAN CORRIDOR & CHANNEL RECONSTRUCTION

CONSTRUCTIVE SOLUTIONS PTY. LTD.
PO Box 1498 Tamworth NSW 2340 Australia
Tel: (02) 6762 1969 Fax: (02) 6762 1969
Email: admin@constructivesolutions.com.au
www.constructivesolutions.com.au

Design Completed:	Designed:	Status:	Plan Size:	Drawing No:
03.12.2012	DB	PRELIMINARY	A1	201201-035

APPENDIX C
Offset Calculator

Offsets Assessment Guide

For use in determining offsets under the *Environment Protection and Biodiversity Conservation Act 1999*
2 October 2012

This guide relies on Macros being enabled in your browser.

Matter of National Environmental Significance	
Name	Koala
EPBC Act status	Vulnerable
Annual probability of extinction Based on IUCN category definitions	**0.2%**

Key to Cell Colours
User input required
Drop-down list
Calculated output
Not applicable to attribute

Impact calculator

Protected matter attributes	Attribute relevant to case?	Description	Quantum of impact		Units	Information source
Ecological communities						
Area of community	No		**Area**			
			Quality			
			Total quantum of impact	0.00		
Threatened species habitat						
Area of habitat	Yes	Wandobah reserve only (941 m) x width 60 m	**Area**	5.646	Hectares	Quality refers only to the koala
			Quality	**9**	Scale 0-10	
			Total quantum of impact	5.08	Adjusted hectares	
Protected matter attributes	**Attribute relevant to case?**	**Description**	**Quantum of impact**		**Units**	**Information source**
Number of features e.g. Nest hollows, habitat trees	Yes	Habitat Trees	37		Count	Field Survey (Maximum impact to habitat trees)
Condition of habitat Change in habitat condition, but no change in extent	No					
Threatened species						
Birth rate e.g. Change in nest success	No					
Mortality rate e.g Change in number of road kills per year	No					
Number of individuals e.g. Individual plants/animals	No					3000

Offset calculator

Protected matter attributes	Attribute relevant to case?	Total quantum of impact	Units	Proposed offset	Time horizon (years)		Start area and quality		Future area and quality without offset		Future area and quality with offset		Raw gain	Confidence in result (%)	Adjusted gain	Net present value (adjusted hectares)	% of impact offset	Minimum (90%) direct offset requirement met?	Cost ($ total)	Information source
Ecological Communities																				
Area of community	No				**Risk-related time horizon (max. 20 years)**		**Start area (hectares)**		**Risk of loss (%) without offset**		**Risk of loss (%) with offset**									
									Future area without offset (adjusted hectares)	0.0	**Future area with offset (adjusted hectares)**	0.0								
					Time until ecological benefit		**Start quality (scale of 0-10)**		**Future quality without offset (scale of 0-10)**		**Future quality with offset (scale of 0-10)**									
Threatened species habitat																				
Area of habitat	Yes	5.08	Adjusted hectares	15.138	**Time over which loss is averted (max. 20 years)**	20	**Start area (hectares)**	15.138	**Risk of loss (%) without offset**	5%	**Risk of loss (%) with offset**	5%	0.00	90%	0.00	0.00	5.18	101.97%	Yes	$167,000.00	
									Future area without offset (adjusted hectares)	14.4	**Future area with offset (adjusted hectares)**	14.4								
					Time until ecological benefit	20	**Start quality (scale of 0-10)**	**2**	**Future quality without offset (scale of 0-10)**	**2**	**Future quality with offset (scale of 0-10)**	**7**	5.00	75%	3.75	3.60				
Protected matter attributes	**Attribute relevant to case?**	**Total quantum of impact**	**Units**	**Proposed offset**	**Time horizon (years)**		**Start value**		**Future value without offset**		**Future value with offset**		**Raw gain**	**Confidence in result (%)**	**Adjusted gain**	**Net present value**	**% of impact offset**	**Minimum (90%) direct offset requirement met?**	**Cost ($ total)**	**Information source**
Number of features e.g. Nest hollows, habitat trees	Yes	37	Count	445	20		37		37		445		408	75%	306.00	294.01	794.63%	Yes	$25,200.00	
Condition of habitat Change in habitat condition, but no change in extent	No																			
Threatened species																				
Birth rate e.g. Change in nest success	No																			
Mortality rate e.g Change in number of road kills per year	No																			
Number of individuals e.g. Individual plants/animals	No																			

Summary

Protected matter attributes	Quantum of impact	Net present value of offset	% of impact offset	Direct offset adequate?	Cost ($)		
					Direct offset ($)	Other compensatory measures ($)	Total ($)
Birth rate	0				$0.00		$0.00
Mortality rate	0				$0.00		$0.00
Number of individuals	0				$0.00		$0.00
Number of features	37	294.01	794.63%	**Yes**	$25,200.00	N/A	$25,200.00
Condition of habitat	0				$0.00		$0.00
Area of habitat	5.0814	5.18	101.97%	**Yes**	$167,000.00	N/A	$167,000.00
Area of community	0				$0.00		$0.00
					$192,200.00	**$0.00**	**$192,200.00**

APPENDIX D
Vegetation Management Plan

Shire of Gunnedah
Land of Opportunity

Blackjack Creek Riparian Corridor/Channel Reconstruction

Vegetation Management Plan

June 2013

Constructive Solutions
Realising potential

Report prepared by:

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Director: Steve O'Rourke

DOCUMENT HISTORY AND STATUS

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1	A	S. O'Rourke	1	20/12/12	S. O'Rourke	S. O'Rourke
1	B	Gunnedah Shire Council	1	08/01/13	L. Johnson	M. Silver
1	1	Gunnedah Shire Council	1	11/01/13	L. Johnson	M. Silver
2	1	DSEWPAC	1	17/06/13		

Printed: 17 June 2013
Author: Sarah Horne
Project Manager: Michael Bloem
Name of Project: Blackjack Creek Riparian Corridor/Channel Reconstruction
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TABLE OF CONTENTS

1. Introduction

Gunnedah Shire Council (GSC) is proposing to reconstruct the Blackjack Creek riparian corridor/channel in order to provide for flood mitigation. GSC has completed extensive investigations to date, culminating in the preparation of the Blackjack Creek Riparian Corridor/Channel Reconstruction Concept Design and Feasibility Study (Constructive Solutions 2012).

As part of Stage 3 – Technical Review and Detailed Design – of the Blackjack Creek Riparian Corridor/Channel Reconstruction Concept Design and Feasibility Study, a Review of Environmental Factors (REF) has been prepared. This REF recommends that a Vegetation Management Plan (VMP) be prepared for the Blackjack Creek Riparian Corridor/Channel Reconstruction in accordance with the NSW Office of Water (NOW) *Guidelines for vegetation management plans on waterfront land* (2012).

Although GSC is exempt from requiring a Controlled Activity Approval (CAA) under the *Water Management Act 2000* (WM Act) through the provisions of the *Water Management (General) Regulation 2011*, this VMP has been prepared to meet the NOW requirements for the preparation of a VMP where a Controlled Activity Approval for disturbance to waterfront land is required.

The VMP addresses the NOW criteria for the preparation of a VMP in the following sections:

- Locality – details of the location of the bed and banks, riparian corridor width, maps, site photographs, and access arrangements;
- Species selection and application – details of vegetation species composition, planting layout, planting densities, and sources of seed;
- Revegetation methods – rehabilitation methods, staging and schedule;
- Maintenance and monitoring – provisions for monitoring and maintenance during and post-construction; and
- Costs – details of the costs associated with revegetation and maintenance.

2. Locality

The Blackjack Creek Riparian Corridor/Channel Reconstruction (the Reconstruction) traverses Wandobah Reserve and the agricultural properties 'Fermanagh' and 'Balmoral' in Gunnedah.

Using the Land and Property Information Spatial Information Exchange SIX Viewer it was identified that Blackjack Creek is a 2nd order stream, as per the Strahler classification system. The NOW *Guidelines for riparian corridors on waterfront land* (2012) recommends that the Vegetated Riparian Zone (VRZ) width for 2nd order streams should be 20m on each side of the watercourse from the highest point of the bank.

The Reconstruction will result in a 30m channel width for the majority of the Reconstruction length, with a 20m width spanning 'Balmoral'. As such, the Riparian Corridor (RC) for the Reconstruction will be approximately 100m encompassing 30m of channel, additional area to the top of the channel banks at an average 1 in 4 slope, and 20m of VRZ on either side of the channel. Figure 1 illustrates a typical VRZ.

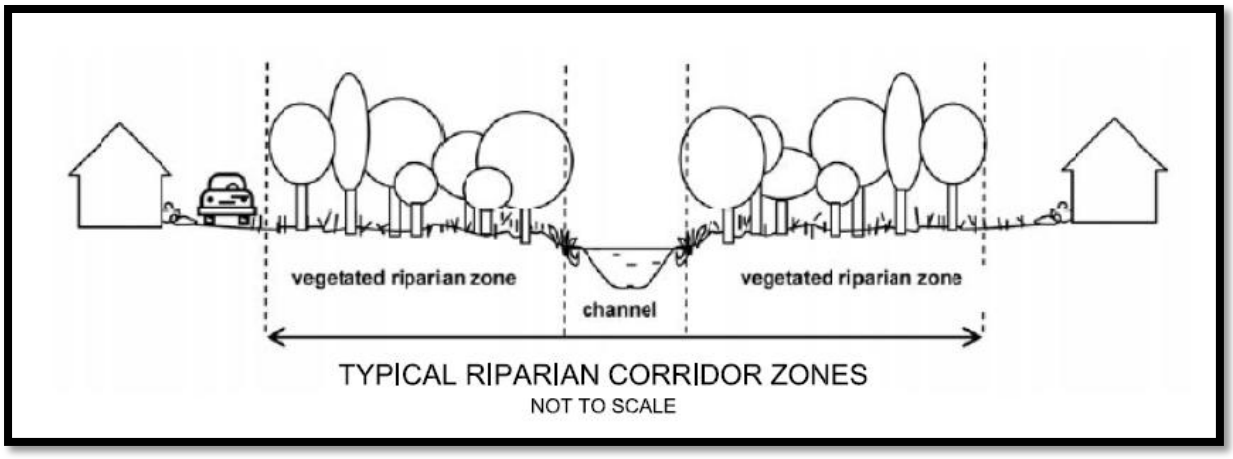

Figure 1 – Typical VRZ (NSW Office of Water 2012)

The Reconstruction location, current conditions, channel width, bank width, and VRZ width of the Reconstruction are illustrated in the *Blackjack Creek Riparian Corridor/Channel Reconstruction Detailed Design* (Constructive Solutions 2012).

Access to Wandobah Reserve can be obtained from Wandobah Road to the east or from unformed tracks off Alford Road to the west. Access to the Reconstruction for 'Fermanagh' and 'Balmoral' can be obtained from the private access tracks within those properties. No long-term measures for preventing access or encroachment to the Reconstruction site for Wandobah Reserve are proposed, however the RC may be fenced within the private properties.

Photographs of the Reconstruction site in its current condition, including coordinates to facilitate ongoing monitoring, are provided in **APPENDIX A**.

3. Species Selection and Application

Revegetation of the Reconstruction is to be carried out in accordance with the NOW *Guidelines for vegetation management plans on waterfront land* (2012) which delineates the RC into 4 zones – the stream, toe, middle and upper. These are illustrated in Figure 2. As per the guidelines, the main objective is to provide a stable watercourse and riparian zone which will emulate local native vegetation communities.

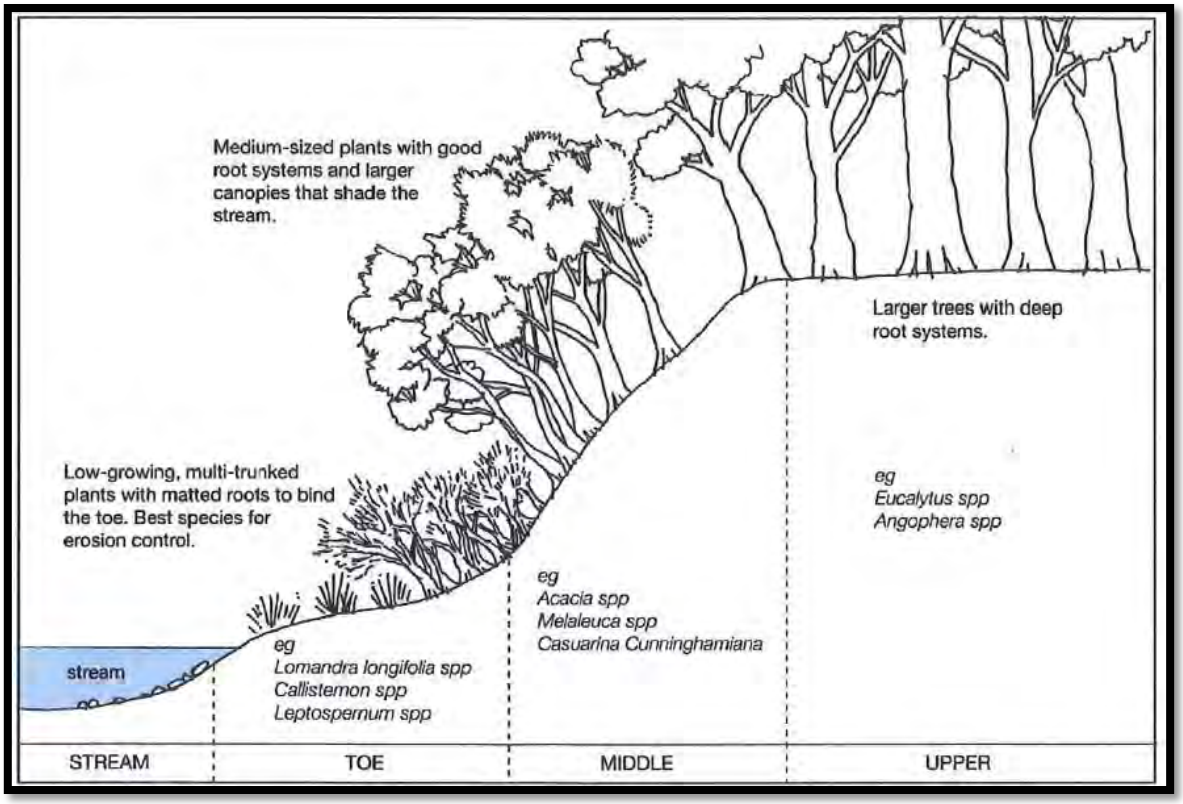

Figure 1 – Typical riparian cross section (NOW 2012)

For the Reconstruction, the widths of the 4 RC zones will generally be:

- Stream – 30m;
- Toe – 10m (5m on either side of the stream on the inner bank);
- Middle – 20m (10m on either side of the stream on the inner bank); and
- Upper or VRZ – 40m (20m on either side of the stream from the top of the bank).

As the Reconstruction site has been identified as Core Koala Habitat, offsets for area of habitat and number of habitat trees have been determined using the *Environment Protection and Biodiversity Conservation Act 1999* Offsets Assessment Guide. This determined that an effective and appropriate area offset can be achieved through the following:

- Revegetation within the 40m width of VRZ within Wandobah Reserve, as this area is not within the impact area. A 40m width for a length of 941m results in an offset area of 3.764ha;
- Revegetation within the 40m width of VRZ for the remainder of the Reconstruction length. A 40m length for a length of 1021m results in an offset area of 4.084ha; and
- Additional revegetation within the remaining unvegetated portion of Wandobah Reserve. Wandobah Reserve is 33.9ha in size. After subtracting the 9.41ha that comprise of the 5.646ha impact area and the 3.764ha VRZ revegetation area, and the 17.2ha that comprises the remaining vegetated portion, an unvegetated area of 7.29ha remains.

This results in a total offset area of 15.138ha. The offset areas are delineated on the map provided in **APPENDIX B** of this report.

In order to achieve an effective and appropriate offset for the 37 Koala habitat trees which will be removed by the Reconstruction, at least 370 of the 1000 trees planted in the VRZ will be preferred Koala habitat tree species. 200 additional trees will be planted in the 7.29ha unvegetated portion of Wandobah Reserve, with at least 75 of these to be preferred Koala habitat tree species.

In order to emulate local native vegetation communities the species to be used in revegetation of the Reconstruction have been derived from the Namoi Catchment Management Authority guide *Native Plants for Creek and Rivers in the Namoi* (2012). Blackjack Creek is located in the Alluvial Plains of Area C in the Namoi Catchment and is classified as a riparian area. **APPENDIX C** provides the recommended planting list for the Reconstruction, including the name, description, propagation method and riparian zone for each species.

The recommended planting list will be adhered to a closely as possible, with the potential for some species exclusions to occur based on seed and/or seedling availability. Anticipated planting densities are provided in Table 1.

Planting layout and density will be dictated by the riparian zone location, with all planting to occur in an irregular fashion in order to mimic the natural growth of plants rather than in lines.

Table 1 – Anticipated planting densities for the RC

Zone	Area	Vegetation Type	Density	Total to be Planted
Upper/VRZ	80,000m^2	Trees	1 per 80m^2	1,000
		Shrubs	1 per 50m^2	1,600
Middle	40,000m^2	Shrubs	1 per 25m^2	1,600
		Herbs	1 per 10m^2	4,000
Toe	20,000m^2	Sedges and Rushes	5 per 1m^2	100,000
Entire RC	200,000m^2	Grasses	15kg per ha	300kg

200 additional trees will be planted in the 7.29ha unvegetated portion of Wandobah Reserve, with at least 75 of these to be preferred Koala habitat tree species.

It should be noted that the above anticipated planting densities are based on open space with no existing vegetation. As there is extensive existing vegetation within Wandobah Reserve, the overall densities will be significantly higher than those indicated in the table. These higher densities will contribute to the overall function of the Reconstruction as a riparian corridor.

GSC currently sources seed and seedlings from Gunnedah Forestry Nursery and Fields Native Nursery in Uralla. The volumes required for the Reconstruction may result in the need to source additional volumes elsewhere. GSC will endeavour to ensure that seed and tubestock sources are located as close to Gunnedah as possible in order to provide for seed provenance.

4. Revegetation Methods

Revegetation will be undertaken utilising various methods, including hydromulching, conventional planting, and long-stem planting, depending on the species, location and establishment requirements. Examples of these are provided in Table 2.

Table 2 – Revegetation methods

Vegetation Type	Revegetation Method	Common Zones
Sedges and Rushes	Conventional planting	Toe; in rip rap surrounding stormwater outlets
Grasses	Hydromulching	Stream, toe, middle and upper
Herbs	Conventional planting	Middle and upper
Wattles	Long-stem planting	Middle and upper
Shrubs	Long-stem planting	Middle and upper
Trees	Long-stem planting	Upper

Appropriate site preparation, including eradication of noxious weeds, is to be undertaken prior to commencement of revegetation.

4.1 Conventional Planting

Conventional planting of seedlings is used in many revegetation projects. The benefits of seedlings include:

- Higher, more guaranteed survival rates;
- The ability to select species; and
- The ability to plan final spacing and densities of planting.

The use of seedlings as opposed to direct seeding is appropriate where rapid growth is required, with seedlings achieving faster growth rates in the first year after establishment than germinants from direct seeding (Schirmer and Field 2000).

The use of seedlings for conventional planting in the Reconstruction instead of seeds will facilitate quicker establishment of soil stablising sedges, rushes and herbs, with quick establishment of these essential in order to mitigate potential

erosion. This is particularly important in areas surrounding stormwater outlets and where high erosive potential occurs. Conventional planting of seedlings, in conjunction with the stablilisation measures proposed in the Reconstruction design, such as reno mattresses and jute mesh, will ensure that the Reconstruction is stablised quickly following construction.

The use of 'Hiko' or multi-cell seedlings has increased in revegetation projects, as they are easy to propagate and plant and have a smaller cost when compared to standard and advanced seedlings (Schirmer and Field 2000). As such, it is proposed to source multi-cell seedlings for the herb, sedge and rush species to be used in the revegetation of the Reconstruction.

4.2 Long-stem Planting

Long-stem planting requires the planting of seedlings which have been matured for longer than conventional seedlings to three-quarters of their length below the soil surface, with the buried stem and leaf nodes developing roots. The benefits of long-stem planting include:

- The creation of an older, stronger seedling for planting due to the consistent nutrients and water provided in the longer nursery period;
- Insulation of the deeply planted root ball from changes in soil temperature and moisture;
- Increased chance of survival in hotter and drier environments, with the root ball located further away from these influences;
- Greater stability of newly planted seedlings in comparison to conventional planting;
- Greater ability to withstand the effects of moving water such as flood conditions in riparian zones;
- Limited watering during planting, with no further watering required post-planting; and
- Reduced loss from vandalism as it is harder to pull up a deeply planted root ball.

Long-stem planting for the Reconstruction will generally follow the auspices of *The Long-stem Planting Guide* (The Australian Plants Society NSW 2010). This is provided in **APPENDIX D**.

4.3 Hydromulching

Hydromulching is a one-step process where seed, fertilizer, mulch and a binder are combined in water, with the resulting slurry sprayed onto the soil surface providing a wood fibre, interlocked mat which provides moisture and protection for seed gernmination. Hydromulching is more expensive than other forms of direct seeding, however it provides for greater soil stability and protection of seed. Hydromulching with native seed has been used successfully in the rehabilitation of mine overburden (Spraygrass 2009).

Figure 2 – Hydromulch application (Spraygrass 2009)

A hydromulch mix will be applied to the whole RC as part of the revegetation of the Reconstruction. In preparation for the hydromulch mix the RC should be ripped, up to 200mm deep, and topsoiled. Where possible, weed growth, large stones and other debris should be removed. The application of the hydromulching native seed should commence immediately after surface preaparations have been completed. Table 3 provides the recommended hydromulch mix for the Reconstruction.

Table 3 – Hydromulching application rates for native grass seed

Zone	Area	Item	Application Rate	Total to be Applied
Entire RC	20 ha	Native Seed Mix	15kg per ha	300kg
		Cover Crop Seed (Couch)	35kg per ha	700kg
		Fertiliser*	150kg per ha	3,000kg
		Wood Fibre Mulch	2.5t per ha	50t
		Binder	250L per ha	5,000L

*** Fertilizer rates and type are to be determined by soil testing during the preparation stage.**

The above items shall be thoroughly mixed together to form a slurry then applied under pressure onto the RC by means of hydromulching equipment specifically designed for the purpose by operators trained in the use of this equipment.

Watering of the RC should be carried out in order to keep the wood-fibre moist until satisfactory germination occurs. Post-germination, limited watering should be carried out as necessary to ensure to native grasses reach a stage where they are self-sufficient.

If, during the construction tendering process, it is determined that an alternative method of establishing grasses (e.g. direct seeding) is preferred, this VMP will be updated to reflect the application and monitoring requirements of the alternative method.

4.4 Staging and Scheduling

The planting of 200 trees in the 7.29ha offset area discussed in Section 3 and delineated in the mapping provided in **APPENDIX B** is to occur in September 2013. Construction is not anticipated to commence until at least 17 months following these plantings, thus allowing time for establishment.

Revegetation of the RC will occur immediately following construction of the Blackjack Creek Reconstruction, with staging of construction allowing for staging of revegetation. This staging shall be undertaken in a manner so as to ensure that an area no greater than half the length and width of the Reconstruction is to be disturbed at any one time.

All earthworks activities within the Reconstruction will be scheduled so as to facilitate the preparation of the Reconstruction site for revegetation immediately following the placement of topsoil.

5. Maintenance and Monitoring

The following maintenance and monitoring measures will be utilised by GSC to ensure the establishment and ongoing efficacy of revegetation at the Reconstruction site:

- Site inspections during construction to ensure that site preparation and topsoiling occurs in accordance with revegetation requirements;
- Employment/engagement of suitably qualified employees/contractors to undertake the revegetation, particularly with regards to hydromulching;
- Site inspections during planting/hydromulching to ensure that revegetation is occurring in accordance with the reference documents provided in this VMP;
- Regular watering of plantings/hydromulch post-planting to ensure establishment/germination;
- Regular monitoring of climatic conditions and soil surface moisture at the Reconstruction site post-establishment of revegetation, with watering to be provided should it be needed;
- Regular site inspections post-construction to ensure that any dead/damaged plants are replaced, including following a flood event in Blackjack Creek; and
- Regular mowing and pruning of vegetation as necessary.

APPENDIX E provides the monitoring and maintenance checklists for the revegetation of the Reconstruction.

Mowing will not be undertaken if grasses are lower than 10cm, and mowing debris will not be allowed to enter the waterway.

No burning of the riparian zone will be undertaken by GSC.

6. Costs

Table 4 provides the anticipated revegetation costs for the Reconstruction. The unit costs have been derived from *The cost of revegetation* (Schirmer and Field 2000), with unit costs checked against current supplier prices to ensure accuracy.

Table 4 – Anticipated revegetation costs

Item	Volume	Unit Cost	Total Cost
Tree seedlings (tubestock)	1,200	$2.50	$3,000.00
Shrub seedlings (tubestock)	3,200	$2.50	$8,000.00
Herb seedlings (multi-cell)	4,000	$1.00	$4,000.00
Sedge and rush seedlings (multi-cell)	100,000	$1.00	$100,000.00
Plastic sleeve guards, stakes and weed matting for trees and shrubs	4,400	$1.50	$6,600.00
Contractor cost to plant tree and shrub seedlings, including placement of plastic sleeves, stakes, and weed matting	4,400	$5.00	$22,000.00
Contractor cost to plant herb, sedge and rush seedlings	104,000	$1.00	$104,000.00
Hydromulch native grass	20ha	$11,500/ha	$230,000.00
Total revegetation cost			**$477,600.00**

While it is likely that contractors will be used to undertake the revegetation, as per the table above, there is some potential for GSC to reduce rehabilitation costs through the involvement of volunteers in the planting of the seedlings; however this will result in a cost resulting from the need to provide supervision, equipment and refreshments to any such volunteers. *The cost of revegetation* (Schirmer and Field 2000) estimates that an inexperienced volunteer would need 43 hours to plant 1000 seedlings with tree guards and that refreshment for volunteers would cost $20 per hectare. If 20 volunteers were utilised, with GSC supervision at a cost of $50 per hour and provision of refreshments, the planting component of the revegetation of Blackjack Creek would take approximately 233 hours, at a cost of $11,650 for supervision and $304 for refreshments.

This represents a significant saving over the use of contractors for planting; however it is unlikely that volunteers will be utilised to plant such large volumes as:

- At the above calculated rate, and working for 8 hours each day, revegetation of the Reconstruction would take approximately 29 days;
- Recruiting sufficient volunteers with adequate amount of available time may not be possible due to volunteers having other commitments; and
- Difficulties relating to maintaining volunteer interest over such a long period may be experienced.

Ongoing maintenance costs have been derived from *The cost of revegetation* (Schirmer and Field 2000), with GSC labor and plant hire rates incorporated into this. Table 5 provides the anticipated maintenance costs for revegetation of the Reconstruction.

Table 5 – Anticipated annual maintenance costs

Item	Volume	Unit Cost	Total Cost
Monitoring (2 hours, 12 times per annum)	24hrs	$60 per hour	$1,440.00
Refill/infill planting*	n/a	10% of original cost	$24,760.00
Watering (16 hours, 2 times per month, 3 months per annum)	96hrs	$85 per hour	$8,160.00
Mowing (16 hours, 6 times per annum)	96hrs	$135 per hour	$12,960.00
Total annual maintenance cost			**$47,320.00**

*** Refill/infill planting costs will decrease over time and only apply to trees, shrubs, herbs, sedges and rushes. Figures are exclusive of corporate recharge costs.**

7. References

- Constructive Solutions 2012, *Blackjack Creek Riparian Corridor/Channel Reconstruction Concept Design and Feasibility Study*
- Constructive Solutions 2012, *Blackjack Creek Riparian Corridor/Channel Reconstruction Detailed Design*
- Land and Property Information 2012, *SIX Maps*. Retrieved from http://maps.six.nsw.gov.au/
- Namoi Catchment Management Authority 2012, *Native Plants for Creeks and Rivers in the Namoi*
- NSW Office of Water 2012, *Guidelines for riparian corridors on waterfront land*
- NSW Office of Water 2012, *Guidelines for vegetation management plans on waterfront land*
- Schirmer, J. and Field, J. 2000, *The cost of revegetation*. Prepared by ANU Forestry, FORTECH and the Natural Heritage Trust
- Spraygrass 2009, *Hydromulching*. Retrieved from http://www.spraygrass.com.au/hydromulching.html
- The Australian Plants Society NSW 2010, *The Long-stem planting guide*. Prepared in conjunction with Gosford City Council and the NSW Environmental Trust
- Water Management Act 2000
- Water Management (General) Regulation 2011

APPENDIX A
Site Photographs

Blackjack Creek Riparian Corridor/Channel Reconstruction – Photos and Coordinates

Photo 1 – 'Balmoral' looking north. Coordinates -30.991591 150.230782

Photo 2 – 'Balmoral' looking south. Coordinates -30.990991 150.230179

Photo 3 – Wandobah Reserve looking north. Coordinates -30.979584 150.241286

Figure 4 – Wandobah Reserve looking south. Coordinates -30.980736 150.240330

Figure 5 – Wandobah Reserve looking south. Coordinates -30.983114 150.238288

APPENDIX B
Offset Areas Map

REVISIONS

REV.	DATE	BY	DESCRIPTION	CHK.
A	03.12.2012	DB	ISSUED FOR REVIEW	--

VEGETATED RIPARIAN ZONE EXTENTS PLAN - BLACKJACK CREEK

Client: GUNNEDAH SHIRE COUNCIL

BLACKJACK CREEK RIPARIAN CORRIDOR & CHANNEL RECONSTRUCTION

CONSTRUCTIVE SOLUTIONS PTY. LTD.
PO Box 1498 Tamworth NSW 2340 Australia
Tel: (02) 6762 1969 Fax: (02) 6762 1969
Email: admin@constructivesolutions.com.au
www.constructivesolutions.com.au

Design Completed:	Designed:	Status:	Plan Size:	Drawing No:
03.12.2012	DB	PRELIMINARY	A1	201201-035

APPENDIX C
Recommended Planting List

Namoi Catchment Riparian Zone Planting List

	Botanical Name	Common Name	Description	How to Propagate	Where do you live in the Catchment? (see map overleaf)						Riparian Zones (Zones shown on front)				
					Area A		Area B		Area C						
					Slopes	Alluvial Plains	Slopes	Alluvial Plains	Slopes	Alluvial Plains	Waters edge	Sand Bar	Lower Bank	Upper Bank	Buffer
Sedges & Rushes	*Bolboschoenus fluviatilis*	Marsh Club-rush	1m tall sedge. Good soil stabiliser	S,D					✓	✓	✓				
	Carex appressa	Tall Sedge	1.2m tall sedge. Good for rocky sites	S,D	✓	✓	✓	✓	✓	✓	✓	✓			
	Cyperus exaltatus	Giant Sedge	1.5m sedge. Very flood resistant	S,D		✓		✓		✓	✓				
	Cyperus gunnii	Flecked Flat-sedge	60cm sedge. Good for all sites	S,D	✓	✓	✓	✓	✓	✓	✓				
	Cyperus gymnocaulos	Spiny Sedge	80cm sedge. Good for drier sites	S,D		✓		✓		✓	✓	✓			
	Cyperus vaginatus	Tall Umbrella Sedge	60cm sedge. Good for all sites	S,D	✓	✓	✓	✓	✓	✓	✓	✓			
	Schoenoplectus validus	River Club-rush	1.5m sedge. Good for wet sites	S,D	✓	✓	✓	✓	✓	✓	✓				
	Lomandra longifolia	Spiny-headed Mat Rush	Tufted rush to 1m. Flood resistant	S,D	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Typha orientalis	Broadleaf Cumbungi	Vigorous 2.5m herb.	D		✓		✓		✓	✓	✓			
Grasses	*Astrebla lappacea*	Curly Mitchell Grass	Tufted perennial for black soils	S						✓					✓
	Bothriochloa bladhii	Forest Bluegrass	Perennial 1m grass for black soils	S,D						✓			✓	✓	✓
	Bothriochloa decipiens	Pitted Bluegrass	Common 60cm grass	S,D	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Bothriochloa macra	Red Grass	Common widespread 60cm grass	S,D	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Chloris truncata	Windmill Grass	Short 20cm grass. Good ground cover	S,D	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Chloris ventricosa	Tall Chloris	Tufted 40cm grass	S,D	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Cynodon dactylon	Couch	Vigorous grass. Good soil stabiliser	S,D	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
	Austrodanthonia caespitosa	Ringed Wallaby	Uncommon grass of black soil	S						✓				✓	✓
	Austrodanthonia bipartita	Wallaby Grass	Common grass of lighter soils	S	✓	✓	✓	✓	✓	✓				✓	✓
	Austrodanthonia racemosa	Wallaby Grass	Common grass of lighter soils	S	✓	✓	✓	✓	✓					✓	✓
	Austrodanthonia richardsonii	Wallaby Grass	Frequent grass of sheltered areas	S					✓					✓	✓
	Dichanthium sericeum	Queensland Bluegrass	Very common grass. Good coloniser	S	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Eriochloa pseudoacrotricha	Early Spring Grass	Fast growing grass for bank stabilisation	S		✓		✓		✓			✓	✓	✓
	Leptochloa digitata	Umbrella Canegrass	Excellent grass for bank stabilisation	S,D						✓	✓	✓	✓	✓	✓
	Microlaena stipoides	Weeping Grass	Good 30cm grass. Soil stabiliser	S	✓	✓	✓	✓	✓			✓	✓	✓	✓
	Panicum decompositum	Native Millet	Tufted 60cm grass	S					✓	✓		✓	✓	✓	✓
	Paspalidium aversum	Bent Summer Grass	Excellent grass for black soils	S,D						✓			✓	✓	✓
	Paspalidium gausum	Tall Slender Panic	Excellent grass for black soils	S						✓			✓	✓	✓
	Paspalidium gracile	Slender Panic	Slender grass for rocky areas	S,D					✓				✓	✓	✓
	Paspalidium jubiflorum	Warrego Grass	Excellent grass for black soils	S,D						✓			✓	✓	✓
	Paspalum distichum	Water Couch	Creeping grass. Good for wet areas	S,D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Pennisetum alopecuroides	Swamp Foxtail	Tufted 60cm grass for wet areas	S,D	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	Phragmites australis	Common Reed	Vigourous 2m grass for steep banks	S,D		✓		✓		✓	✓	✓	✓		
	Austrostipa verticillata	Slender Bamboo Grass	Slender tufted 1m grass	S,D	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Themeda australis	Kangaroo Grass	Common grass of slopes	S	✓	✓	✓		✓				✓	✓	✓
Herbs	*Calotis scapigera*	Tufted Burr-daisy	Prostrate creeping daisy	S,D						✓		✓	✓	✓	✓
	Commelina cyanea	Scurvy	Blue flowered groundcover	D	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓
Wattles	*Acacia dealbata*	Silver Wattle	Fast growing small tree to 8m	SH	✓		✓							✓	✓
	Acacia filicifolia	Fern-leaved Wattle	Small tree to 6m. Fast growing	SH	✓		✓		✓					✓	✓
	Acacia implexa	Hickory Wattle	Good suckering shrub to 5m	SH	✓		✓		✓					✓	✓
	Acacia melanoxylon	Blackwood	Small tree to 6m.	SH	✓		✓		✓					✓	✓
	Acacia pendula	Weeping Myall	Attractive weeping small tree to 6m	SH						✓					✓
	Acacia salicina	Cooba	Exellent small tree for black soils	SH						✓				✓	✓
	Acacia stenophylla	River Cooba	Small 5m tree. Good soil stabiliser	SH						✓			✓	✓	✓
Shrubs	*Capparis mitchellii*	Wild Orange	Shrub to 4m. Bird attracting	S,C					✓	✓					✓
	Callistemon sieberi	River Bottlebrush	Weeping shrub to 4m. Bird attracter	S,C					✓	✓			✓	✓	✓
	Leptospermum brevipes	Grey Tea-tree	Bushy shrub to 4m. Bird attracter	S,C	✓	✓	✓	✓					✓	✓	✓
	Leptospermum polygalifolium	Tantoon	Bushy 3m shrub. Bird attracter	S,C	✓		✓					✓	✓	✓	✓
	Melaleuca bracteata	Black Tea-tree	Large Shrub to 6m. Soil stabiliser	S,C	✓	✓					✓	✓	✓		
	Notelaea microcarpa	Native Olive	Tall shrub to 5m	SF	✓	✓	✓	✓	✓	✓				✓	✓
	Bursaria spinosa	Black Thorn	Prickly shrub to 2m. Bird attracter	SF	✓	✓	✓	✓	✓					✓	✓
	Muehlenbeckia florulenta	Lignum	Tangled 2m shrub. Bird attracter	S,C						✓			✓	✓	✓
	Geijera parviflora	Wilga	Pendulous 3m tress	SF	✓	✓	✓	✓	✓	✓				✓	✓
	Melicytus dentatus	Tree Violet	Prickly 2m shrub. Good for birds	S,C	✓		✓		✓					✓	✓
Trees	*Casuarina cunninghamiana*	River Oak	Tree 12m. Excellent soil binder	S	✓	✓	✓	✓	✓	✓			✓	✓	✓
	Angophora floribunda	Rough-barked Apple	Common tree up to 15m tall	S	✓	✓	✓	✓	✓	✓					✓
	Eucalyptus albens	White Box	Widespread tree to 20m	S	✓		✓		✓						✓
	Eucalyptus camaldulensis	River Gum	Tree to 25m. Good for fauna habitat	S		✓		✓		✓				✓	✓
	Eucalyptus coolabah	Coolibah	Tree to 15m. Common on floodplains	S						✓				✓	✓
	Eucalyptus melliodora	Yellow Box	Tree to 20m. Bird attracter	S	✓	✓	✓	✓	✓	✓					✓
	Eucalyptus viminalis	Ribbon Gum	Tall 25m trees of sheltered areas	S	✓		✓								✓
	Alectryon oleifolius	Western Rosewood	Twisted small tree to 5m	SF					✓	✓				✓	✓
	Brachychiton populneus	Kurrajong	Widespread small tree. Good fodder	S	✓	✓	✓	✓	✓	✓				✓	✓

PROPAGATION: S = Seed; **C** = Cuttings; **D** = Division; **SF** = Fresh Seed; **SH** = hot water treatment (cover seeds with boiling water, allow to cool & then soak overnight)

APPENDIX D
Long-stem Planting Guide

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Return to viewing and printing instructions.

The **Long-stem Planting** Guide

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Acknowledgements: Thanks to Hunter-Central Rivers Catchment Management Authority and Bill Hicks for their contributions.

Design by Marjo Peteri, 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, Yarrama; rainforest area, Kariandra 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).

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 7.6 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

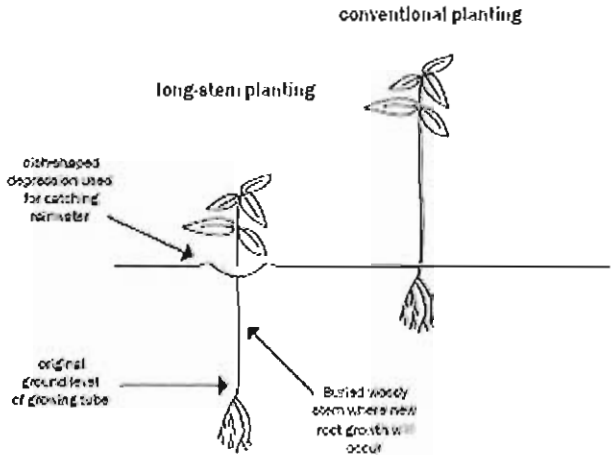
1. Dig holes that are deep enough to allow three-quarters of the plant to be buried. The use of power tools such as a soil auger in heavy clay may result in smooth walls in the hole, these may need to be roughened slightly to allow the roots to penetrate the smooth walls more easily.
2. Pour approximately 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.



long-stem step-by-step guide - how to plant seedlings 15

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.

long-stem planting benefits - riparian environment 19

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.

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

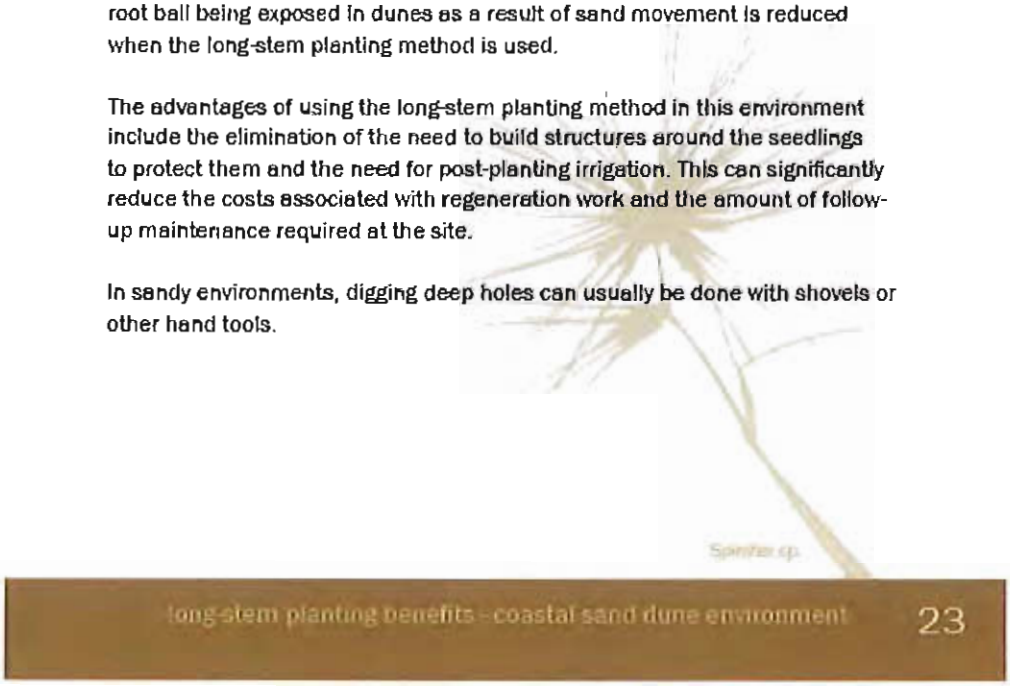
It has been shown that in coastal areas long-stem planting of native sand dune plant species has been successful without the need for protective planting sleeves or follow-up watering. Seedlings planted in dune areas using the long-stem method experienced greater survival and growth rates than tube stock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



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.

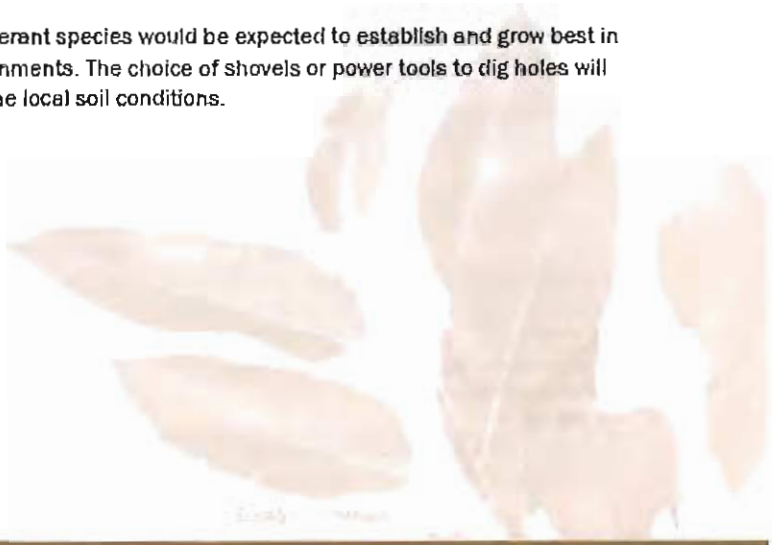
Saline environment

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.



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

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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.

References

Bakewell G., Raman A., Hodgkins D. and Nicol H. (2009). Suitability of *Acacia longifolia* var. *sophorae* (Mimosaceae) in Sand-Dune restoration in the Central Coast of New South Wales, Australia. New Zealand Journal of Forestry Science Vol. 39, 5-13.

Chalmers A., Bakewell G. and Taggart, A. (2007). Improved growth and survival of deep-planted long stem tube-stock with a rainforest edge on the Central Coast of New South Wales: Preliminary results. Ecological Management & Restoration Vol. 8 No. 2, 152-154.

Hicks, B. (n.d.) Long-stem planting. http://www.australianplants.org/longstem.htm

Hicks B., Raine A., Crabbe G. and Elsley M. (1999). The use of native Long-stem tubestock as an alternative to willows for controlling stream bank erosion. In: Second Australian Stream Management Conference Proceedings, pp. 331-334, Adelaide, SA.

Hicks B. (2003). Revolutionary approach to tubestock planting drops natives securely into hostile territory. Ground Cover, Issue 43, Feb 2003. Grains Research Development Corporation, Canberra.

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

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APPENDIX E
Monitoring and Maintenance Checklists

Blackjack Creek Riparian Corridor/Channel Reconstruction

Weekly Revegetation Monitoring and Maintenance Checklist

Issue	Yes	No	Notes/Remedial Action
Has site preparation been undertaken in accordance with the VMP?			
Are all staff and contractors adequately qualified?			
Has revegetation occurred in accordance with the VMP and appendices?			
Has watering been undertaken fortnightly, or more frequently depending on meteorological conditions?			

Name…….. Position……

Signed…….. Date……

Blackjack Creek Riparian Corridor/Channel Reconstruction

Monthly Post-Construction Revegetation Monitoring and Maintenance Checklist

Issue	Yes	No	Notes/Remedial Action
Soil moisture			
Is there adequate soil moisture?			
If not, has watering occurred?			
Plants			
Have plants died or has a flood event occurred?			
If so, have infill plants been planted?			
Mowing and Pruning			
Has any illegal burning occurred in the riparian zone?			
If so, is additional infill planting required?			
Has all mowing been undertaken only for grasses above 10cm?			
Have all large branches resulting from pruning and any rubbish encountered during mowing been prevented from entering the waterway where possible?			

Name…….. Position……

Signed…….. Date……