Monitoring of remediation works to arrest stream degradation in an agriculture-dominated catchment

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Abstract

Since European settlement many Australian waterways have experienced significant geomorphic and ecological change due to modification of flow regimes and catchment landuse. Current restoration guidelines for waterways place a low priority on rehabilitation in highly degraded stream reaches; it is considered pragmatic to abandon such sites in favour of focussing on threatened sites in better condition. However, a move away from remediation within highly degraded reaches does not address their high incidence in rural catchments, such as the Murrumbidgee. Our project monitored remediation works (channel realignment, levee-bank construction, revegetation) that were undertaken to stabilise severely eroded reaches of Umbango Creek in southern NSW. Annual assessments (2003-2006) showed a significant increase in percent vegetation cover within the channel despite persistent drought conditions across the catchment and the reintroduction of cattle into the remediated area. Our results demonstrate that remediation works undertaken on highly degraded streams have the potential to improve vegetation cover and assist in stabilising banks vulnerable to erosion.

Keywords

Channel morphology, drought, restoration assessment, vegetation survey

Introduction

Numerous rivers and streams in Australia have undergone significant geomorphic change during the period since European settlement. This has often been caused by substantial alterations to water regimes and by widespread modification of catchment land uses (Boulton & Brock, 1999; Rutherfurd, 2000). Declining water resources and increasing public awareness have prompted a move towards improved river management and more balanced decision making regarding water usage (Bennet *et al.*, 2002). It is now widely acknowledged that river restoration works are required to attempt to reverse the effects of human impacts (Koehn *et al*., 2001).

Current Australian restoration guidelines place a low priority on the rehabilitation of highly degraded stream reaches, in favour of focussing on threatened sites in good condition. The analogy used by Rutherfurd *et al.* (2000) is that of attempting to save victims from the sinking *Titanic*. Where can the ‘life boat’ of scarce restoration resources be most effectively used? It is considered preferable to focus on threatened sites in good condition, rather than squander resources on sites with poor remediation potential. However, this approach to river restoration does not address the high incidence of severely degraded sites in agriculture-dominated catchments, such as the Murrumbidgee. A move away from remediation within these highly degraded stream reaches may neglect an important area of need and slow research efforts to address degradation issues effectively (Watts & Wilson, 2004).

This research focussed on remediation works initiated by landholders to stabilise a severely eroded site on Umbango Creek, in south-eastern New South Wales. Since European settlement, this stream has suffered acute degradation resulting from tree clearing, domestic stock grazing, exotic pest invasion and channel alteration. Catchment land use changes have transformed Umbango Creek from a sinuous, meandering channel with deep pools and reed swamps into a deeply incised, low sinuosity system that is permanently isolated from its original floodplain (Page & Carden, 1998). The most severely affected reaches are now up to 7 metres deep and 70 metres wide. Despite the low priority given to recovery initiatives in highly degraded reaches (Brierley, 1999; Rutherfurd *et al.*, 2000), strong landholder commitment led to remediation works being undertaken as part of the Rivercare Program (NSW Department of Land and Water

Conservation). The stated aims of the Rivercare application were to stabilise creek banks, reduce erosion, reduce sedimentation in downstream reaches, provide a vegetated corridor for native fauna and, in time, provide shade and shelter for stock (G Sykes, 1999, *pers. comm*.). The initial works were undertaken in May 2001 and included channel realignment away from the undercut toe of the bank, levee bank construction and revegetation. Monitoring of channel morphology, vegetation cover, tree height and abundance has been conducted since 2003 to assess the outcomes of the remediation works.

Methods

Study area

Umbango Creek is a tributary of Tarcutta Creek which flows into the Murrumbidgee River in southern New South Wales (Figure 1). At the time of the arrival of Europeans in the 1800's, Umbango Creek's catchment area was characterised by eucalypt woodlands, stable valley side-slopes, a low capacity meandering channel and a swampy floodplain with deep alluvial soils. European landclearing resulted in gully erosion, channel aggradation and the burial of much of the former floodplain with up to one metre of sandy sediment (Page & Carden, 1998). Attempts by landholders to improve channel flow efficiency by removing in-stream vegetation and bend elimination resulted in incision, often to bedrock, and the transformation of the channel into a deep, low sinuosity bedload system in the reach upstream of Humula (Page & Carden, 1998). Subsequent widening of the incised channel since the 1950s (G. Sykes *pers. comm.*), which resulted in the loss of valuable river flats and associated infrastructure, has prompted some landholders along Umbango Creek to undertake remediation works. Our study focused on a project undertaken on the Sykes' property, upstream of the township of Humula.

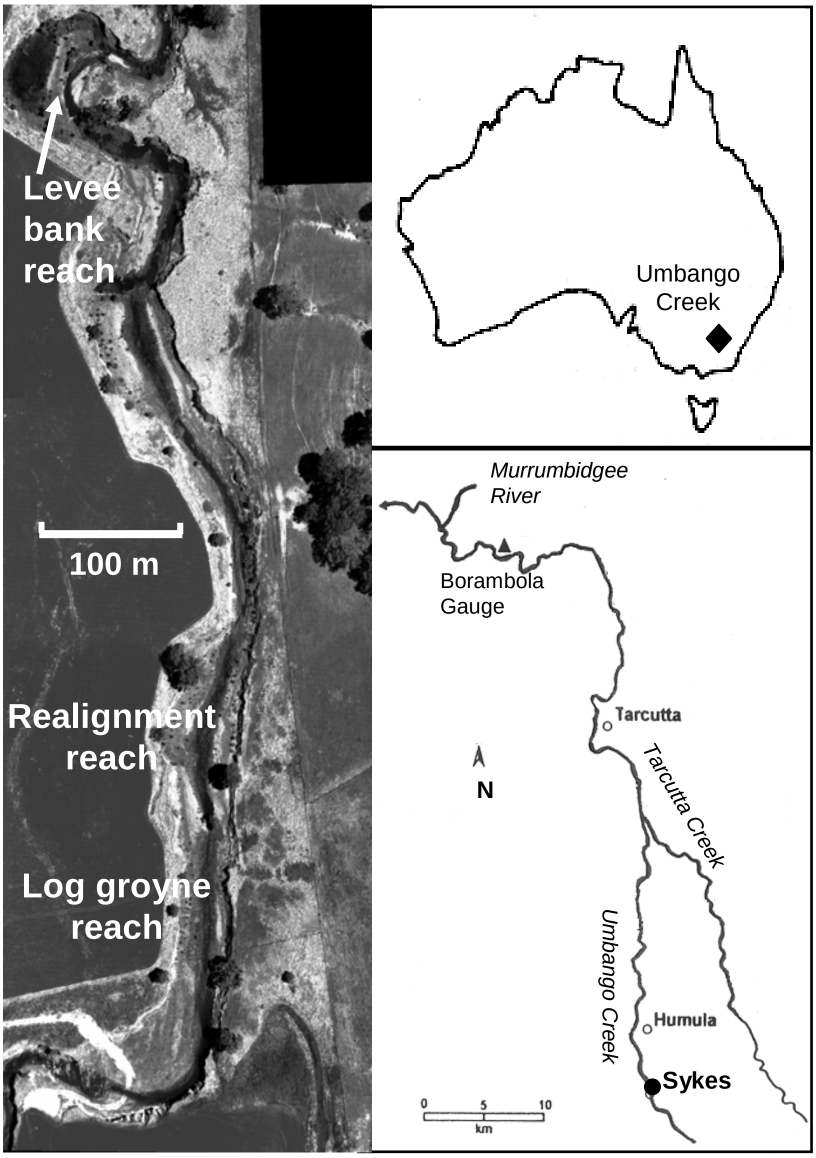

Figure 1. Location map of Umbango Creek study area.

Remediation works were undertaken in three reaches as follows (see Figure 1):

Log groyne reach – channel was realigned away from the eroding bank; timber groynes were used to reinforce the eroded bank; seedlings were planted between timber groynes and in-stream vegetation transplanted after earthworks.

Realignment reach – part of the bank was excavated and the channel realigned away from the eroding bank; eroded toe of the bank was armoured with river cobbles; seedlings were planted and in-stream vegetation transplanted after earthworks.

Levee bank reach – existing large bend was shortened by constructing a new channel adjacent to the slip-off slope; new levee bank was replanted with seedlings; bypassed bend also revegetated and in-stream vegetation transplanted after earthworks.

Since the implementation of the remediation works in 2001, the catchment has been subject to prolonged drought conditions (Figure 2). Although continuous monitoring of creek discharge was not undertaken at the remediated reach, a nearby permanent gauging station was used to examine the peaks of flow experienced in the catchment. Flow data obtained from the Borambola gauge (Figure 1 & 2) indicated that two elevated flow events were experienced at the study site in 2003 and 2004, but these were probably relatively small. Potentially erosive high flows were not received at the study site until late in 2005.

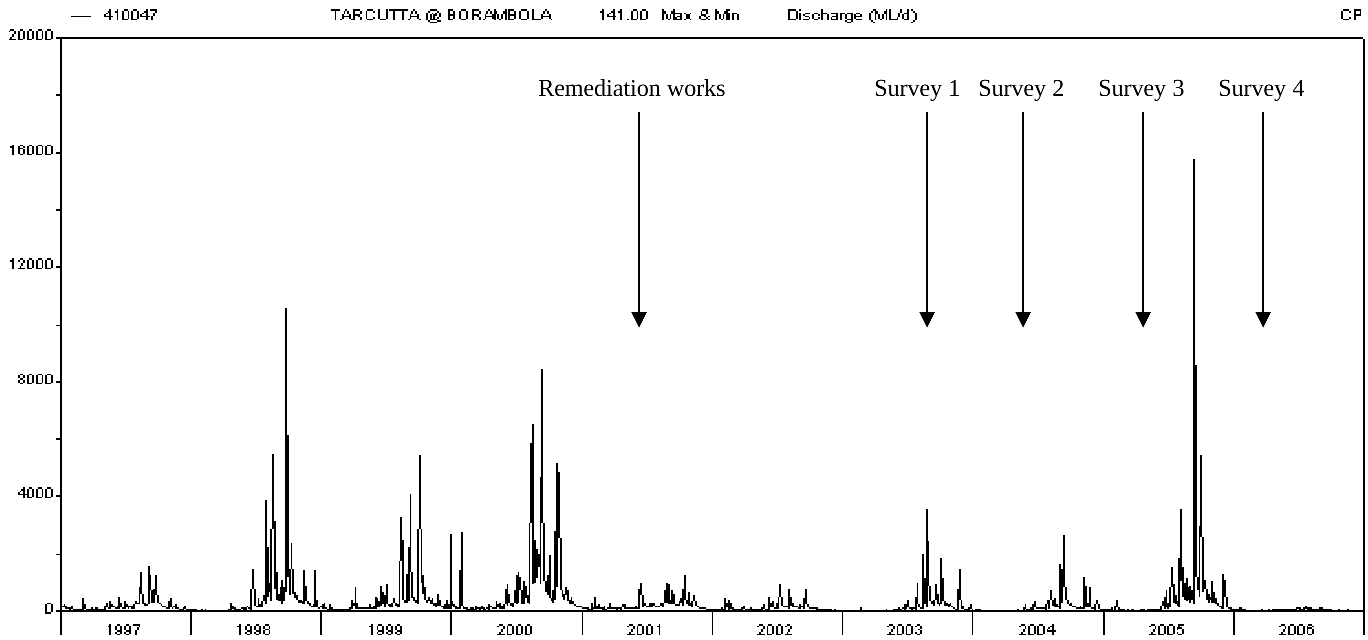

Figure 2. Hydrograph of stream discharge between 1997 and 2006 downstream of study site on Tarcutta Creek (http://waterinfo.nsw.gov.au/cgi-bin/browse.epl?site=410047).

Vegetation surveys

Vegetation surveys were undertaken within the stream channel at the three study reaches annually between 2003 and 2006. Trees and shrubs occurring within 5m wide transects across the channel were surveyed with tree type and height recorded. The extent of grazing damage to each tree was categorised as: none, minor (70-80% of leaves remaining), major (50-40% of leaves remaining), severe (less than 20% of leaves remaining) and very severe (no leaves remaining). Analysis of variance (ANOVA) was used to compare standardised tree abundance at each sampling period.

Percent vegetation cover was estimated along 5m wide transects across the channel at each study reach. Vegetation (other than trees) observed along each transect was allocated to one of the following broad categories – grass, herbs and forbs, sedges, reeds, other aquatic plants, moss/lichen. Total vegetation cover for each year was calculated by adding together all cover values for each vegetation category. ANOVA was used to investigate any differences between the percent cover of vegetation across all years assessed.

Airborne video imagery

Vegetation assessment was also made using CSU's multispectral airborne video system in 2001 and 2004. A mask was created to include vegetation only within the extent of the remediated creek channel. The Normalized Difference Vegetation Index (NDVI) was used to estimate the amount of green vegetation cover within the study area. The NDVI is obtained using the following spectral reflectance calculation from the remotely sensed data: (Near IR band - Red band) divided by (Near IR band + Red band).

Channel morphology

Channel morphology was recorded at the three reaches within Umbango Creek where remediation work had been undertaken. Permanent survey marks were established at each reach to allow surveys to be taken at the same location every year. Channel cross sections were surveyed at 90° to the direction of creek flow across the channel.

Results and discussion

Vegetation surveys
Comparison of percent vegetation cover data showed a significant increase between 2003 and 2005 (ANOVA; P<0.05; Figure 3). This increase occurred despite the drought conditions existing across the catchment and the reintroduction of cattle into the remediated area for intermittent grazing on a number of occasions. The use of infrequent livestock grazing was necessary as feed for cattle became increasingly scarce during the drought. There also appeared to be a decrease in vegetation cover after the high erosive flows that occurred in late 2005, although this was not statistically significant. Inspection of the study sites after these increased flows showed evidence of in-stream vegetation being scoured and tree damage.

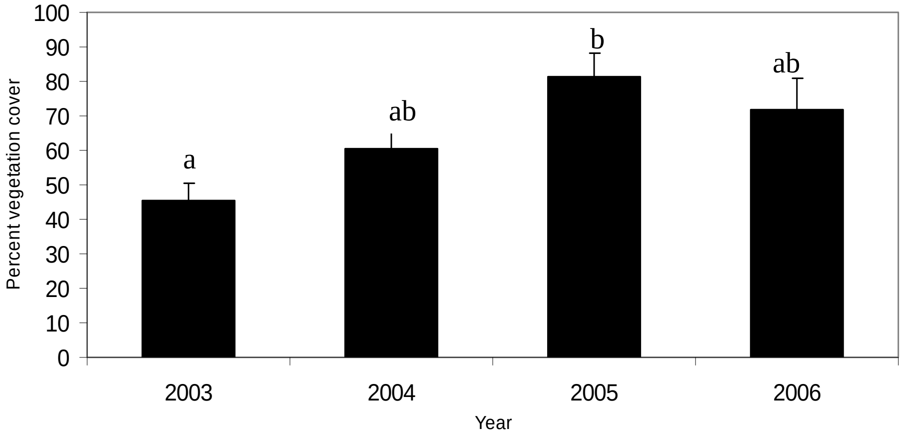

Figure 3. Average percent cover of vegetation along transects (*n*=3) surveyed within Umbango Creek in 2003, 2004, 2005 and 2006. Different letters indicate statistically significant differences (ANOVA; P<0.05).

The average number of trees and shrubs counted along the study transects within the remediated reaches significantly increased between 2003 and 2004 (ANOVA; P<0.05; Figure 4). This increase was largely the result of natural regeneration. However, tree abundance was subsequently reduced by grazing and flood damage. The assessments of grazing damage inflicted on trees demonstrated substantial impacts in 2003 and 2004, where 77% and 64% of trees respectively were recorded as having severe damage. Only 7% of trees were recorded as having severe grazing damage in 2005. These data indicate that some recovery from grazing was evident at the study site. Importantly, the abundance of trees in 2005 and 2006 was not significantly lower than 2003 levels (ANOVA; P>0.05).

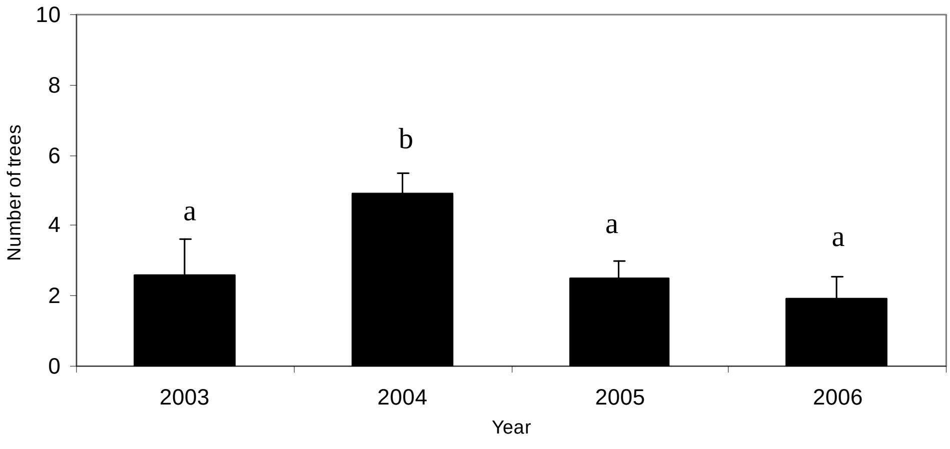

Figure 4. Number of trees (standardised/10m) (*n*=3) at Umbango Creek in 2003, 2004, 2005 and 2006. Different letters indicate statistically significant differences (ANOVA; P<0.05).

Airborne video imagery
NDVI assessment using multispectral airborne video imagery indicated a pattern of increased vegetation cover in the remediated reaches. Between 2001 and 2004 green vegetation cover increased from approximately 0.4 hectares to 0.8 hectares.

Channel morphology
Channel cross sections surveyed at the three reaches of Umbango Creek showed that relatively little change to channel morphology occurred at the log groyne reach during the study period (e.g. Figure 5). This channel stability reflects the generally low flow conditions throughout 2003 and 2004 when the Creek experienced low discharge conditions with flow velocities below those required to entrain cobbles. Minor river freshes, which occurred in August 2003 and September 2004 following widespread rainfall in the catchment had very little impact. Changes to channel morphology as a result of a higher flood pulse in 2005 were evident only at the levee bank reach where substantial bank erosion and thalweg deepening occurred (Figure 6).

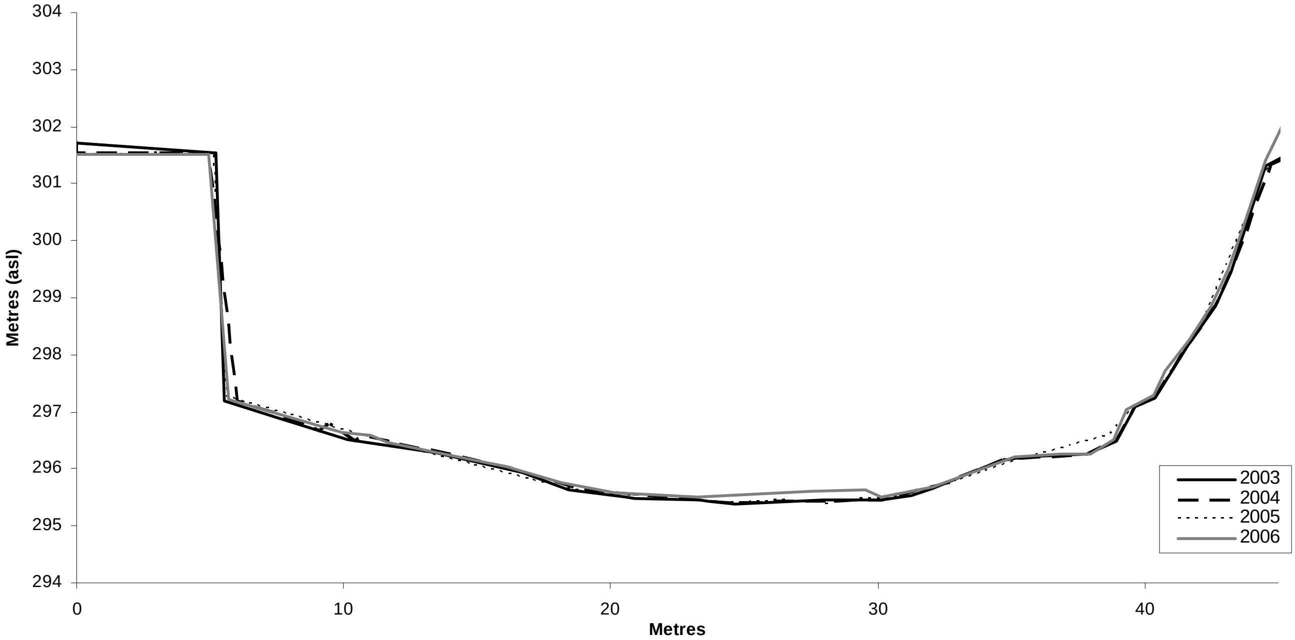

Figure 5. Channel cross sections at log groyne reach in Umbango Creek surveyed in 2003, 2004, 2005 and 2006.

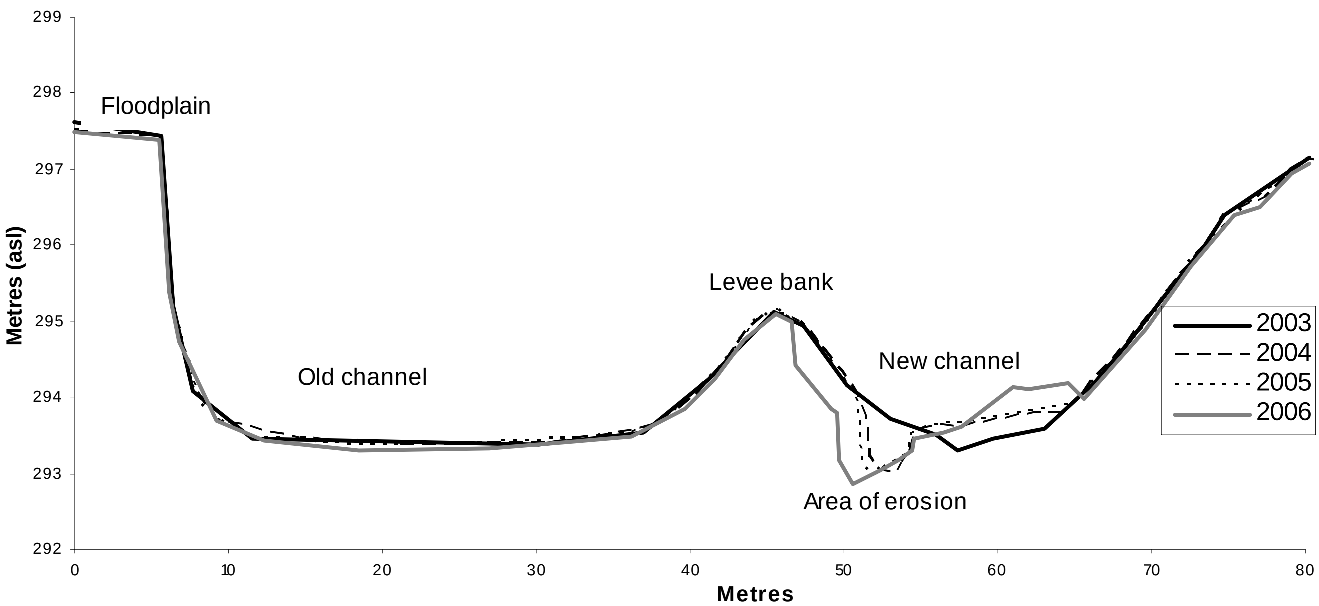

Figure 6. Channel cross sections at levee bank reach in Umbango Creek surveyed in 2003, 2004 2005 and 2006.

It is apparent from Figure 5 that erosion of the levee bank occurred at the bend axis after the high flows in late 2005. Bend shortening at this reach has increased local channel slope and potential bed shear. The vulnerability of the constructed levee bank to future bend erosion presents a challenge to the on-going success of remediation work in this reach and therefore requires periodic monitoring. However, the lack of a significant breach of the levee bank earthworks during a substantial discharge event suggests an increase in bank strength resulting from enhanced vegetation cover (Hickin, 1984). Additionally, the presence of trees, shrubs, ground cover and in-stream vegetation is likely to have enhanced channel roughness and therefore reduced flow velocity in the study reaches.

Conclusion

Results from this study demonstrate that remediation works undertaken on highly degraded creek reaches have the potential to improve vegetation cover and may assist in stabilising banks vulnerable to erosion. Despite minor channel erosion and vegetation scouring after the arrival of higher flows in late 2005, the remediation works appear to have been successful in arresting severe stream degradation. One of the strengths of this project was the enthusiasm of the landholders to improve existing creek conditions, including a commitment to exclude livestock when possible and to undertake revegetation works. The weather conditions immediately after implementation reduced exposure to high flows and allowed the establishment of replantings. However, if these erosive flows had been received earlier in the life of the project, it is likely that this high risk remediation may have resulted in a negative outcome. Our data demonstrate the potential advantages of implementing high risk remediation works during dry periods. The long-term recovery trajectory of this creek will continue to be monitored, particularly at vulnerable locations where bend shortening has raised potential bed shear.

Acknowledgements

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