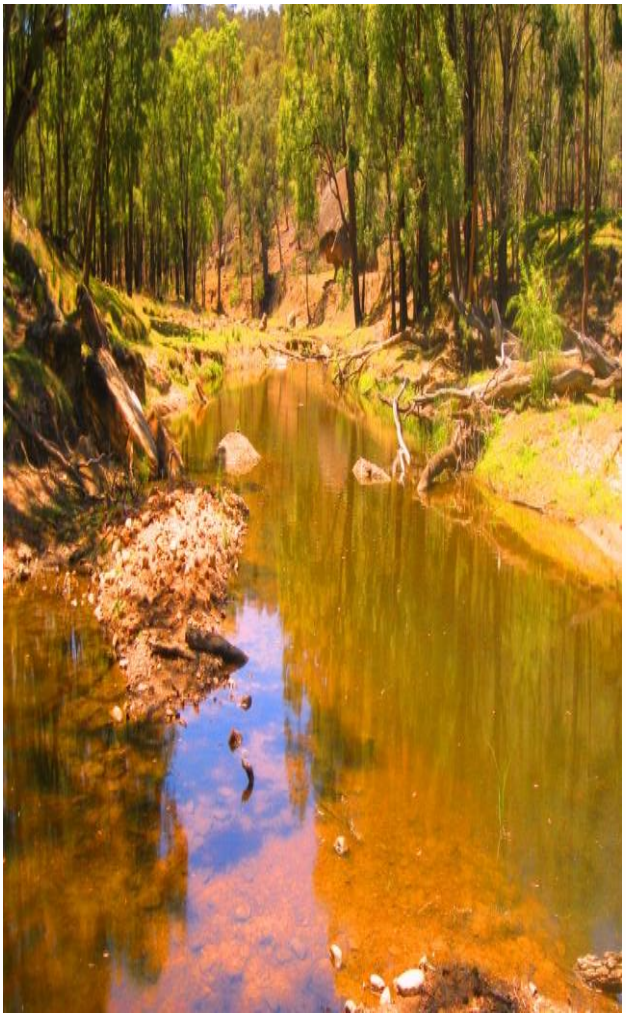
Wilpinjong & Cumbo Creek Stability Assessment, 2012-2013

Wilpinjong Coal Mine

For: Kieren Bennetts



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Mar-14
(Our Reference: 20366_E02)

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DOCUMENT TRACKING

ITEM	DETAILS
Project Name & Number	Wilpinjong and Cumbo Creek Stability Assessment 2012-2013, # 20366
Document Name	20366_E02
Project Manager	Kristy Bennetts Environmental Scientist
Report Preparation	Kristy Bennetts
Peer Reviewed	Ben Rourke
Status	FINAL
Version	2
Date	25 March 2014

ACKNOWLEDGEMENTS

Barnson Pty Ltd would like to thank Wilpinjong Coal Mine for their assistance in the preparation of this report.

DISTRIBUTION

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1.0 INTRODUCTION

Wilpinjong Coal Proprietary Limited (WCPL) commissioned Barnson Pty Ltd (Barnson) in December 2013 to undertake a stability assessment of Wilpinjong and Cumbo Creeks, as well as to review the 2012 assessment. The 2013 assessment was undertaken to assess any improvement in creek stability, erosion and riparian areas within the Wilpinjong Creek catchment.

This report provides details on the fieldwork undertaken in 2013 and 2012, and compares the state of Wilpinjong and Cumbo Creeks with a previous assessments undertaken in 2011.

1.1 Project Overview

Wilpinjong Coal Mine is situated in the Central Tablelands of NSW. It is located in the Mid-Western Regional Council Local Government Area, approximately 40 km north-east of Mudgee, near the Village of Wollar. The mine is located at the headwaters of the Goulburn River catchment, which is a major tributary of the Hunter River. The mine is wholly owned and operated by Peabody Energy Ltd.

The basis of this report is to satisfy Schedule 3, Condition 32 (e) of Project Approval (05-0021), together with the Channel Stability Monitoring Programme as outlined in Section 7 of the site Surface Water Management and Monitoring Plan. The plan states that *'the channel stability monitoring programme aims to provide qualitative measures of stream bed and bank erosion and channel instability along Wilpinjong and Cumbo Creeks.*' Monitoring details are provided in the plan and are largely based on obtaining cross sectional and longitudinal survey data and making comparisons in relation to change over time. This is with the exception of point four which states *'Photographs and written descriptions "of each site will be also undertaken, focusing on evidence of erosion and exposed soils'*.

This Environmental Stability Assessment builds on the previous surveys undertaken by Barnson, for comparative purposes.

1.2 Project Objectives

There are two main objective of this assessment. They are:

- Assess the stability of Wilpinjong and Cumbo Creeks using a rapid assessment methodology, which was refined in 2013.
- Compare visual channel stability at each of the pre-selected sites against a previous survey undertaken in 2011.

The visual assessment relies upon the established GPS photographic points previously determined.

1.3 Project Background

During 2007 permanent survey locations were selected by Peabody Energy. These survey locations are generally in use today. Updated site localities are identified in **Figure 1**. These points are along 13km of Wilpinjong Creek and 3km of Cumbo Creek. Barnson has undertaken monitoring of this creek on several occasions, including 2010, 2011 and 2012.

Wilpinjong Creek is located within the Greater Wollar catchment area. The dominant non-mining land use within and around the project area is cattle and sheep grazing with some intermittent cropping (fodder crops). Cumbo Creek drains into Wilpinjong Creek approximately 4km upstream of the confluence of Wilpinjong Creek and Wollar Creek. Both creeks suffer moderate to severe erosion and poor riparian health as a result of past practises. The Environmental Impact Statement (EIS) undertaken for the Wilpinjong Coal project described Wilpinjong Creek in Table 3.4 of Section 3.2.2 of the EIS as being - *well incised channel (3-4m deep). Varies significantly including dry areas, semi-permanent soaks, poos and riffle sequences and swampy areas with extensive areas of reed growth along the creek bed. Severely impacted by grazing of livestock and kangaroos. Vegetation on the banks and overbank areas is predominantly grass with occasional trees and little riparian vegetation.* Cumbo Creek was described as - *Upper parts of the creek drain through low-lying marshes with stream bank and stream bed erosion. Heavily modified by land clearing and grazing. Little riparian vegetation.*

The Aquatic Ecosystem Assessment undertaken by Bio-Analysis for the EIS (Appendix AH) states in HD7 that *in general, the aquatic habitats were found to be in very poor condition and generally reflected the degraded nature of the immediate catchments.* This report indicates that *stock exclusion, weed control and establishment of vegetation in the riparian areas would lead to improved habitats for aquatic biota.*

A comprehensive surface water assessment was also undertaken by Resource Strategies in 2005 as part of the EIS. The assessment found that runoff (total catchment yield) is a small percentage of rainfall, and that baseflow (comprising both deeper groundwater and interflow/underflow) is estimated to account for some 40% of total flow. It was predicted that the Project has the potential to reduce flows in Wilpinjong Creek by up to 11%, as a result of a

reduction in overland flow from the Project catchment and indirectly through reductions in the rate of groundwater discharge to the creek. This should, in general terms, reduce baseflow induced erosion, such as sheeting.

Mitigation measures suggested in the EIS include the enhancement of riparian vegetation in sections of Wilpinjong and Cumbo Creeks. These enhancement works are expected to have a positive impact on the in-stream ecology of Wilpinjong and Cumbo Creeks. In terms of channel stability, enhancement works would also allow for improved creek stability and reduced erosion of the creek beds and banks.

Surface waters within the project area were re-assessed by Gilbert and Associates Pty Ltd in 2013 as part of the s75W modification to the current conditions of consent. No creek stability issues or recommendations were raised in this assessment.

Over the past several years the creek has been subject to drought and flooding. To date, no control sites along any other local creeks have been established or utilised for comparative purposes, nor has an historical assessment based on old aerial photographs been undertaken.

.

WILPINJONG CREEK STABILITY 2013

FIGURE 1 - WILPINJONG CREEK & CUMBO CREEK SURVEY POINTS

Coordinate System: GDA 95 MGA Zone 55

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DESIGN. PLAN. MANAGE

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Client: PEABODY ENERGY LIMITED

Project:
WILPINJONG CREEK
STABILITY 2013

Drawing Title:
FIGURE 1
WILPINJONG CREEK & CUMBO CREEK
SURVEY POINTS LOCATIONS

Design:	Drawn:
-	-
Check	QA:
-	KB

Drawing Sheet:
A3 - Scaled as noted

Rev.	Date	Ammendment
A	15/01/14	

Cartographer
Dennis Capparelli

Drawing Number
20366-G01

Revision
A

1.4 Report Limitations

It is not within the scope of this stability monitoring project to undertake extensive creek analysis in terms of the following forms of assessment. WCPL may consider undertaking some or all of these assessments in the future. Assessments not included in this project including, but not limited to:

- Geophysical Survey, including assessment of subsurface conditions
- Cross Sectional Analysis utilising accurate survey instrumentation and
- LiDAR (Light Detection and Ranging) Analysis.

No permanent marker/survey pegs have been installed along either of the creeks for ongoing monitoring purposes.

2.0 METHODOLOGY

2.1 Rainfall and Flood Analysis

The intensity and amount of rainfall can result in flooding and thus influence erosion by way of scouring, slumping and surface destabilisation within rural creeks. The amount of erosion is influenced by vegetation cover, topography, climatic factors and soil characteristics. The rate of soil erosion is influenced by the erosivity - the amount of rainfall and precipitation intensity.

IFD stands for Intensity-Frequency-Duration, of rainfall. The processes of determining IFD is known as frequency analysis, is an important part of hydrological design procedures. An IFD table for the Wilpinjong catchment was generated using the Bureau of Meteorology's (BoM) 'Rainfall IFD Data System', available at:

http://www.bom.gov.au/hydro/has/cdirswebx/cdirswebx.shtml.

Rainfall data from 1 January 2013 - 31 January 2013 was supplied by WCPL. Rainfall data was collected from the WCPL Meteorology Station in 15 minute increments. This data was examined in consultation with the IFD table to determine the ARI (average recurrence interval) or rarity of rainfall events over the 12 month period to determine if any rainfall events would impact creek stability or erosion.

2.2 Field Survey - Stability & Comparative Assessment

To satisfy the project objectives, a field survey was undertaken by Kristy Bennetts (Environmental Scientist) and Trevor Hoar (Survey Assistant) in December 2012 and December 2013. This involved walking each creek from the creek headwater to its confluence. Photographs of each site (upstream, downstream and across) were taken for comparative purposes, a field proforma was completed and any signs of bed lowering or erosion were identified and recorded. The pre-selected monitoring points are illustrated in **Figure 1,** and were found using survey GPS instrumentation. For the 2013 survey an updated proforma was established. This proforma has been adapted and refined using a number of sources, including:

- CSIRO Ephemeral Assessment Methodology;
- Australian Soil and Land Survey Field Handbook (2009);
- Heeren, D.M et al (2012) *Using Rapid Geomorphic Assessments to Assess Streambank Stability in Oklahoma Ozark Streams*, American Society of Agriculture and Biological Engineers.

The new proforma is contained at **Appendix A**, with a summary of results located in Section 3. The new proforma also aims to provide a Bank Erosion Hazard Index (BEHI), as proposed by Heeren et al and should be used as a guide in terms of stability ratings for each site.

3.0 RESULTS

3.1 Rainfall and Flood Analysis

The current (2012) total catchment area of Wilpinjong creek upstream of the Project Area (from the upstream gauging station) was calculated to be 81km^2, with the downstream catchment calculated to be 175km^2 (Gilberts & Associates, 2013). The Cumbo Creek catchment area (upstream of the confluence with Wilpinjong Creek) was reported to be 70km^2. Both Creeks are ephemeral in nature, meaning flow is limited to after prolonged rainfall or heavy storm events. Unfortunately, information relating to velocities of flow versus scouring potential of soils within each of these creeks has not been calculated. In general, a well vegetated creek bank and bed will not scour during a minor storm event (ie a 1 in 5 year ARI storm event).

An IFD table was generated using the BoM website and is provided at Table 1, together with the corresponding ARI's for the area.

Table 1 : Rainfall intensity in mm/h for varies durations and average reoccurrence intervals - WCPL

DURATION	1 Year		2 Years		5 Years		10 Years		20 Years		50 Years		100 Years	
	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm	mm/hr	mm
5 Mins	64.1	5.34	83.7	6.98	110	9.17	127	10.58	149	12.42	181	15.08	206	17.17
6 Mins	59.7	5.97	78	7.8	102	10.2	118	11.8	139	13.9	168	16.8	192	19.2
10 Mins	48.7	8.12	63.5	10.58	82.6	13.77	94.9	15.82	111	18.5	135	22.5	153	25.5
20 Mins	35.6	11.87	46.2	15.4	59.4	19.8	67.8	22.6	79.3	26.43	95.1	31.7	108	36
30 Mins	28.9	14.45	37.3	18.65	47.7	23.85	54.3	27.15	63.2	31.5	75.6	37.8	85.4	42.7
1 Hr	19.3	19.3	24.9	24.9	31.5	31.5	35.6	35.6	41.3	41.3	49.1	49.1	55.4	55.4
2 Hrs	12.3	24.6	15.9	31.8	20	40	22.6	45.2	26.2	52.4	31	62	34.9	69.8
3 Hrs	9.39	28.17	12.1	36.3	15.2	45.6	17.2	51.6	19.9	59.7	23.5	11.75	26.5	79.5
6 Hrs	5.85	35.1	7.52	45.12	9.47	56.82	10.7	64.2	12.3	73.8	14.6	87.6	16.4	98.4
12 Hrs	3.64	43.68	4.68	56.16	5.87	70.44	6.61	79.32	7.64	91.68	9.04	108	10.2	122.4
24 Hrs	2.25	54	2.89	69.36	3.6	86.4	4.04	96.96	4.66	111.84	5.49	131.76	6.15	147.6
48 Hrs	1.34	64.32	1.72	82.56	2.13	102.24	2.38	114.24	2.73	131.04	3.2	153.6	3.58	171.84
72 Hrs	0.959	69.05	1.23	88.56	1.52	109.44	1.69	121.68	1.93	138.96	2.27	163.44	2.53	182.16

The total rainfall for the period 1 Jan 2013-31 Dec 2013 was calculated to be 496.2 mm, with the wettest day being 29 January 2013 when 56.4mm was recorded by the WCPL meteorological station in the 24 hour period from 9am-9am. The WCPL Annual Environment Management Report (AEMR) for 2012 identified the cumulative annual rainfall for the same period in 2012 as 629.2mm. This is in comparison to the BOM long term average of 653mm, meaning that 2013 was a dry year for the catchment. On assessment of the available 15-min rainfall data it was determined that no rainfall events during 2013 triggered a rating more than a 1 in 1 year storm event, indicating that erosibility of the creeks within the local catchment area would not have been subject to major flooding or erosive events.

3.2 Field Survey - Stability Results

The following tables provides a summary of results from this year's stability assessment.

Creek stability during low flow is, in areas, improving along much of the Wilpinjong Creek. 2012 and 2013 endured low rainfall within the catchment, which did not assist plant growth on the creek banks. However, destocking and fencing along the creek have allowed for natural regeneration to occur. Of the 40 sites assessed along Wilpinjong Creek, 15 sites were rated within the unstable range. The creek bed remains largely obscured by in stream vegetation, therefore there was little evidence of bed erosion, bed lowering, knickpoints and sediment deposition. Instream species diversity is low, with minimal snags and habitat features. There remains visible areas of bank erosional features along the length of the creek – including large areas of undercutting, sheet wash and gullying, however groundcover in general is improving and areas are regenerating. The upper banks are subject to high erosional potential during high flows or flooding. Riparian health along much of the creek remains poor. This is the result of a floristic profile being dominated by grasses and a tree and shrub layer being largely absent along the creek. Noxious weed species such as blackberry and prickly pear still exist along the length of the creek.

Creek Stability along Cumbo Creek remains stable. Only one site was assessed as being within the unstable range. This creek continues to lack species diversity in terms of structure. It possesses low banks with moderate to low slopes. Banks are largely stable as a result of a high degree of groundcover. Erosional features continue to remain minimal. The creek bed is largely obscured by in stream vegetation, which is again dominated by one species. Riparian health along the creek remains largely poor. This is the result of a floristic profile being dominated by grasses and a tree and shrub layer being largely absent along the creek. As a result of the low slopes and high ground cover, Cumbo creek remains largely stable.

Table 2: Stability - Bank erosion hazard index (BEHI) for Wilpinjong Creek

Site Number									
Questions	1	2	3	4	5	6	7	8	9
1	5	7.5	7.5	7.5	7.5	7.5	7.5	5	5
2	2	4	4	6	2	4	2	2	4
3	7.5	2.5	5	7.5	5	7.5	2.5	5	2.5
4	5	5	7.5	7.5	5	7.5	0	2.5	5
5	2.5	2.5	7.5	7.5	5	2.5	0	5	5
6	7.5	10	12.5	12.5	7.5	2.5	0	7.5	10
7	7.5	12.5	15	12.5	12.5	12.5	10	12.5	12.5
8	2.5	0	2.5	0	0	0	0	0	2.5
Total Rating	39.5 Stable	44 Stable	61.5 Mod Unstable	61 Mod Unstable	44.5 Stable	44 Stable	22 Highly Stable	39.5 Stable	46.5 Unstable
Site Number									
Questions	10	11	12	13	14	15	16	17	18
1	2.5	5	2.5	2.5	2.5	10	0	0	5
2	2	2	2	2	4	4	0	0	2
3	0	2.5	0	2.5	5	2.5	0	0	2.5
4	0	2.5	2.5	2.5	2.5	2.5	0	0	5
5	2.5	2.5	2.5	5	2.5	5	0	0	5
6	2.5	2.5	7.5	10	10	7.5	2.5	0	10
7	12.5	12.5	12.5	10	12.5	10	15	0	7.5
8	0	0	5	5	0	0	0	0	0
Total Rating	22 Highly Stable	29.5 Mod Stable	34.5 Mod Stable	39.5 Stable	39 Stable	41.5 Stable	17.5 Highly Stable	0 Highly Stable	37 Stable

Site Number									
Questions	19	20	21	22	23	24	25	26	27
1	2.5	7.5	2.5	5	5	5	5	7.5	5
2	6	6	6	4	4	2	6	4	8
3	10	10	7.5	0	2.5	2.5	5	5	7.5
4	10	7.5	7.5	7.5	7.5	5	7.5	5	7.5
5	7.5	7.5	7.5	7.5	7.5	2.5	7.5	5	7.5
6	12.5	10	12.5	12.5	12.5	7.5	12.5	12.5	15
7	15	15	15	15	15	15	15	15	15
8	0	0	0	2.5	5	2.5	0	2.5	2.5
Total Rating	63.5 Mod Unstable	63.5 Mod Unstable	58.5 Mod Unstable	54 Unstable	59 Mod Unstable	42 Stable	58.5 Mod Unstable	56.5 Mod Unstable	68 Highly Unstable
Site Number									
Questions	28	29	30	31	32	33	34	35	36
1	7.5	7.5	7.5	5	7.5	7.5	7.5	5	7.5
2	6	6	4	4	6	6	4	4	4
3	7.5	7.5	2.5	5	7.5	7.5	5	7.5	2.5
4	7.5	7.5	5	5	5	7.5	5	5	5
5	7.5	7.5	2.5	5	7.5	7.5	5	7.5	2.5
6	15	15	7.5	7.5	7.5	10	10	7.5	7.5
7	15	15	10	15	15	10	15	15	15
8	2.5	0	2.5	0	0	2.5	2.5	2.5	0
Total Rating	68.5 Highly Unstable	66 Highly Unstable	41.5 Stable	46.5 Unstable	56 Mod Unstable	58.5 Mod Unstable	54 Unstable	54 Unstable	44 Stable

Site Number									
Questions	37	38	39	40	41	42	43	44	45
1	7.5	10	Removed	Removed	Removed	10	5	2.5	5
2	6	2				6	6	6	4
3	7.5	2.5				10	7.5	10	5
4	2.5	2.5				7.5	5	7.5	2.5
5	5	2.5				7.5	7.5	7.5	2.5
6	2.5	10				10	10	12.5	7.5
7	15	10				12.5	15	15	10
8	0	2.5				0	0	0	2.5
Total Rating	46 Unstable	42 Stable	0	0	0	63.5 Mod Unstable	56 Mod Unstable	61 Mod Unstable	39 Stable

Site Number				
Questions	46	47	48	49
1	5	5	5	7.5
2	6	6	4	6
3	7.5	7.5	5	5
4	0	7.5	5	7.5
5	2.5	5	5	5
6	7.5	2.5	7.5	7.5
7	7.5	15	15	12.5
8	2.5	0	0	2.5
Total Rating	38.5 Stable	48.5 Stable	46.5 Stable	53.5 Unstable

Table 3: Stability - Bank erosion hazard index (BEHI) for Cumbo Creek

Site Number										
Questions	1	2	3	4	5	6	7	8	9	10
1	2.5	0	2.5	2.5	5	2.5	Removed	2.5	2.5	0
2	2	2	2	2	2	6		2	2	2
3	0	2.5	2.5	2.5	2.5	7.5		0	2.5	0
4	0	5	5	0	2.5	2.5		0	0	0
5	0	5	2.5	0	0	2.5		0	0	0
6	0	12.5	10	2.5	0	10		0	2.5	0
7	15	15	15	15	15	15		15	15	15
8	0	2.5	5	2.5	2.5	0		2.5	5	0
Total	19.5	44.5	44.5	27	29.5	46	0	22	29.5	17
Rating	Highly Stable	Stable	Stable	Mod Stable	Mod stable	Unstable		Highly Stable	Mod Stable	Highly Stable

Questions	10	11	12	13	14	15	16	17	18
1	2.5	5	2.5	2.5	2.5	10	0	0	5
2	2	2	2	2	4	4	0	0	2
3	0	2.5	0	2.5	5	2.5	0	0	2.5
4	0	2.5	2.5	2.5	2.5	2.5	0	0	5
5	2.5	2.5	2.5	5	2.5	5	0	0	5
6	2.5	2.5	7.5	10	10	7.5	2.5	0	10
7	12.5	12.5	12.5	10	12.5	10	15	0	7.5
8	0	0	5	5	0	0	0	0	0
Total	22	29.5	34.5	39.5	39	41.5	17.5	0	37
Rating	Highly Stable	Mod Stable	Mod Stable	Stable	Stable	Stable	Highly Stable	Highly Stable	Stable

3.3 Comparative Results

Appendix B (upstream) and **C (downstream)** provides a comparison of site photographs from the December 2011 survey to the December 2012 and December 2013 surveys for Wilpinjong and Cumbo Creeks. Most notably, differences relate to changes in groundcover and groundcover health as a result of a lack of rainfall over the past 2 years.

4.0 RECOMMENDATIONS & CONCLUSIONS

The following dot points provide recommendations for continued assessment and ongoing improvement of Wilpinjong and Cumbo Creeks:

- Stability monitoring during low flow should continue for both creeks. It is suggested that panoramic photographs are taken at each site in the future;
- Cross sectional analysis is recommended to be undertaken every 3-5 years. This should be undertaken by survey instrumentation such as GNSS equipment with a base and rover unit. This equipment holds accuracies of approximately 30mm in x, y and z coordinates, making it reliable for future cross-sectional comparisons;
- Consideration should be given to installation of permanent coloured wooden survey pegs on the high bank to enable ease of site location;
- Consideration of the installation of erosion pins at some or all survey points should be given. These pins are surveyed in and bench marked with cross sectional analysis of the creek undertaken. Ongoing surveys will identify qualitatively bank erosion and widening, as well as areas of deposition;
- Continued works to improve the riparian zone of Wilpinjong creek should be considered in future site remediation works;
- Incorporation of bank soil testing at random locations, including aggregate stability testing – which involves dispensability and solidity calculations;
- Best Practise Management of weeds in areas along both creeks – sightings of blackberry, prickly pear, Bathurst Burr and several other noxious weeds were noted during the survey; and
- Continued Best Practise Management of stock around watercourses should continue.

This report provides WCPL with a stability assessment and photographic survey for future comparative purposes relating to ongoing monitoring of erosion, remediation and stability of both creeks. There is currently no visible indication that mining within the vicinity of the creek has resulted in any creek bed lowering or increased erosion, beyond natural occurrence.

5.0 REFERENCES

Abernethy B, and Rutherfurd I.D. (1999) *Guidelines for Stabling Stream banks with Riparian Vegetation,* Cooperative Research Centre for Catchment Hydrology, Technical Report 99/10.

CSIRO (2009) *Australian Soil and Land Survey Field Handbood – 3rd Edition*, CSIRO Publishing, Collingwood Victoria.

CSIRO (n.d) The *Ephemeral Stream Assessment,* CSIRO, viewed October 2012 http://www.cse.csiro.au/research/efa/resources/EphemeralDrainageLineAssessment.pdf

Heeren D.M, Mittelstet A.R, Fox G.A, Storm D.E, Al-Madhhachi T, Midgley T.L, Stringer A.F, Stunkel K.B and Tejral R.D (2012), *Using Rapid Geomorphic Assessments to Assess Streambank Stability in Oklahoma Ozark Streams,* American Society of Agricultural and Biological Engineers Vol. 55 (3) 957-968.

Land and Water Australia (2002), *River Landscapes – Streambank Stability,* Land and Water Australia, viewed October 2012,

http://lwa.gov.au/files/products/river-landscapes/pf020254/pf020254.pdf

Appendix A

Field Sheet Proforma

Wilpinjong Creek Stability Survey 2013

Site No :	Date:	Assessor:
Easting:	Northing:	Photos collected:

Snags and or Habitat Features present (non living) : _____ Estimated Percentage (cross sectional cover)_____

Sediment Deposition (circle): Yes No Unable to Tell

Bed Erosional Features (Circle) : Yes No Unable to tell

Vegetation Rating		Tick
1	Little or no vegetation growing on drainage line floor (<20% cross sectional cover).	
2	Minor vegetation cover growing on drainage line floor (20-40% cross section cover)	
3	Fair vegetation cover growing on drainage line floor (40-60% cross section cover)	
3	Moderate vegetation cover growing on drainage line floor (60-80 cross section cover)	
4	Dense vegetation cover growing on drainage line floor (80%+ cross section cover)	

Ground Cover and Exposed Soil on Bank (Rating)

Vegetation Rating		Tick LEFT	Tick RIGHT
1	Little or no vegetation growing on bank wall (<10%)		
2	Minor vegetation growing on bank wall (10- 20%)		
3	Moderate vegetation growing on bank wall (20-50%)		
4	Dense vegetation growing on bank wall (50-90%		

Material Rating (tick)		Left Bank	Right Bank	Stability Rating		Left Bank	Right Bank
1	Dispersive material is exposed for greater than 1m of the wall height – evidence of erosion			1	Unstable, many eroded areas, 'raw' area frequenta aling straight sections and beds, obvious bank sloughing 60-100% of bank has erosional scars		
2	Materials that slake rapidly, or disperse are exposed on greater than 0.3m and less than 1m of vertical wall height (the sum of multiple layers if present) – evidence of erosion			2	Moderately unstable, 30-60% of bank has areas of erosion, high erosion potential during floods		
3	Materials that slake and/or disperse are exposed on less than 0.3m of wall height – minor evidence of erosion			3	Moderately stable, infrequent, small area of erosion mostly healed over, 5-30% of bank has areas of erosion		
4	Materials that do not slake or disperse are exposed on wall surface – no evidence of erosion			4	Excellent – Bank stable, evidence of erosion or bank failure absent or minimal, little potential for future problems, <5% of bank affected by erosion.		

Vegetation Rating (tick)		Left Bank*	Right Bank**	Riparian General Health (tick)		Left Bank	Right Bank
0	Little to no grasses growing on drainage line walls. No trees or shrubs.			0	Very Poor - No canopy cover, minor ground cover and minor leaf litter. Dominated by exotic species		
1	Minor grasses and shrubs growing on drainage line walls.			1	Poor - Little canopy and understorey cover between 1-30%, groundcover 1-30%, minor leaf litter, mixture of native and exotic species		
2	Moderate vegetation cover of grasses and shrubs. Several trees			2	Fair - Canopy and understorey cover between 6-30%, groundcover between 30-60%, some leaf litter, mixture of native and exotic species		
3	Dense perennial plant cover similar to vegetation on flood plain or riparian zone.			3	Good - Canopy and understorey cover between 6-30%, groundcover between 30-60%, large amount of leaf litter, dominated by native species, exotics sparse		
				4	Excellent - Canopy and understorey cover greater than 30%, groundcover greater than 60%, large amount of leaf litter, some habitat features (fallen logs), dominated by native species, exotics sparse		

Note: * Left Bank = left bank when looking downstream

** Right Bank = right bank when looking downstream

Stability Rating - Using Critical Bank - At Cross Sectional Point

Circle - Left Bank Right Bank

Bank Height - _____m Bank Face, length - _____m

1.	Bank Height (m)						
(m)	0 - 1.5	1.5-3	3-4.5	4.5-6	6+	Value	
Value	0	2.5	5	7.5	10	Score	
2.	Bank Angle						
(^{o})	0-20	21-60	61-80	81-90	91-120	> 120	Value
Value	0	2	4	6	8	10	Score
3.	Percentage of Bank Height with a Bank Angle Greater than 80^o						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0	2.5	5	7.5	10	Score	
4.	Evidence of Mass Wasting (% of Bank)						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0	2.5	5	7.5	10	Score	
5.	Unconsolidated Material (% of Bank)						
%	0-10	11-25	26-50	51-75	76-100	Value	
Value	0	2.5	5	7.5	10	Score	
6.	Streambank Protection (% of Streambank covered by plant roots, vegetation, logs, branches, rocks etc						
%	0-10	11-25	26-50	51-70	70-90	90-100	Value Score
Value	15	12.5	10	7.5	2.5	0	
7.	Established Beneficial Riparian Woody - Vegetation Cover						
%	0-10	11-25	26-50	51-70	70-90	90-100	Value Score
Value	15	12.5	10	7.5	2.5	0	
8.	Stream Curvature						
Descriptor	Meander	Shallow Curve	Straight	Value Score			
	5	2.5	0				
Total	0 - 25	26-35	36-45	46-55	56-65	66-85	Rating
	Highly Stable	Mod Stable	Stable	Unstable	Mod Unstable	Highly Unstable	

Appendix B

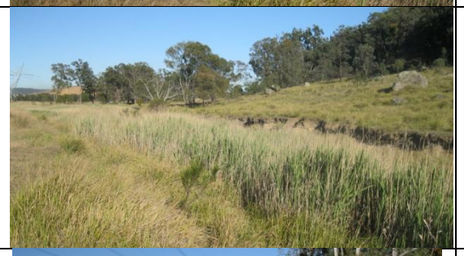
Photo Comparison Upstream

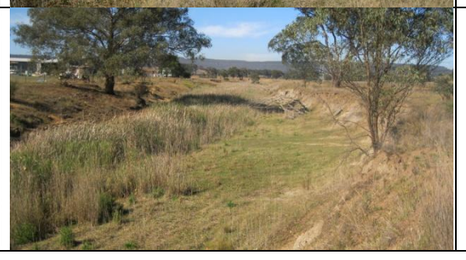
Wilpinjong Creek Photo Comparison Upstream December 2011, 2012 & 2013

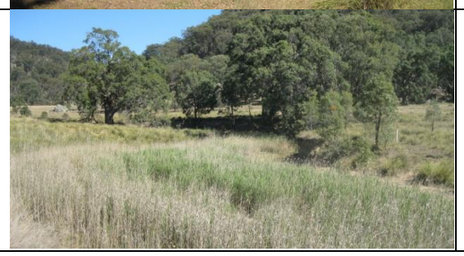
Site	Upstream December 2011	Upstream December 2012	Upstream December 2013	Main Comparison
1				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the bank face between 2011-2012. • A reduction in creek width over the 2 year period.
2				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in tree snagging in 2012. Snags were clear in 2013. • An increase in soil exposure on the bank face between 2011-2012. • A reduction in creek width over the 2 year period.
3				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure and debris on the bank face between 2011-2012. • A reduction in creek width over the 2 year period. A reduction in groundcover and in stream vegetation between 2011-2012. • In increase in bank erodeability during 2013.
4				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure, bank undercutting and erosion of the bank face between 2011-2012. • Continued erosion of the left bank and bank slumping during 2013 as a result of minimal groundcover. • In increase in bank erodeability during 2013.
5				• A reduction in groundcover within the creek bed and on the creek bed during 2011-2012. • An increase in soil exposure during 2011-2012. • Sites remained similar in terms of stability and groundcover during 2012-2013.

6				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure of the creek bed and bank face between 2012-2013. • A reduction in the active channel width during 2012-2013. • An increase in bed debris and woody material during 2012-2013.
7				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure of the creek bed and bank face between 2012-2013. • A reduction in the active channel width during 2012-2013. • An increase in bed debris and woody material during 2012-2013.
8				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • In increase in plant growth within the creek bed and on the creek bank during 2013. • An increase in groundcover on the creek banks during 2013.
9				• No considerable differences in the creek bed or bank observed at this site during 2011-2013.
10				• No considerable differences in the creek bed or bank observed at this site during 2011-2013.
11				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A reduction in the active channel between 2011-2013.

12				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure of the creek bed and bank face between 2011-2013. • A reduction in the active channel width during 2012-2013. • An increase in bed debris during 2011-2013.
13				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure of the creek bank face between 2012-2013. • A reduction in the active channel width during 2012-2013. • An increase in bank debris and woody material during 2012-2013.
14				• No considerable differences in the creek bed or bank observed at this site during 2011-2013
15				• Slightly different locations in 2012 to 2011 and 2013. • A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure of the creek bank face between 2012-2013. • A reduction in the active channel width during 2012-2013.
16				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2012-13. • No considerable differences in the creek bed or bank observed at this site during 2012-2013
17				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Creek bed and banks remain stable.

18				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure during 2012. However this remained stable in 2013. • A reduction in the active channel width during 2012-2013.
19				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A reduction in the active channel width during 2011-2013.
20				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure and erosion of the right bank during 2012. This continued in 2013. • A reduction in the active channel width during 2012-2013.
21				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • A reduction in the active channel width during 2011-2012. • No considerable differences in the creek bed or bank observed at this site during 2012-2013.
22				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure on the creek bank faces during 2012. However this remained stable in 2013, with an increase in groundcover observed in 2013. • A reduction in the active channel width during 2011-2012.
23				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure on the left creek bank face during 2012, which is evident by an area of surface sheet erosion. A reduction of sheet erosion in 2013, with an increase in groundcover noted. • An increase in soil exposure on the right bank resulting in sheet erosion and gullying between 2011-2012. This remained stable in 2013.

24				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure on the left top of bank during 2012, which is evident by an area of surface sheet erosion. This is reduced in 2013.
25				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure on the left creek bank face during 2012, which is evident by an area of surface sheet erosion along the bank face. This has reduced in 2013, with an increase in groundcover noted.
26				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • An increase in active channel width in 2013, as noted by an increase in instream flora from 2012. • Increase soil exposure on the left creek bank face during 2012, which is evident by an area of surface sheet erosion along the bank face. This has reduced in 2013, with an increase in groundcover noted.
27				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • No considerable differences in the creek bed or bank observed at this site during 2012-2013.
28				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure and erosion on both creek bank faces during 2012. This has reduced in 2013, with an increase in groundcover noted. • A reduction in the active channel width during 2011-2013.

29				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • No considerable differences in the creek bed or bank observed at this site during 2012-2013.
30				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Site relatively stable between 2011-2013 with good ground cover and minimal exposed surfaces.
31				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the right creek bank face during 2013, however site remains stable.
32				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the right creek bank face during 2013, however site remains stable. • A reduction in the active channel width during 2011-2013.
33				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the right creek bank face during 2013, however site remains stable. • A reduction in the active channel width during 2011-2013.
34				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the left creek bank face during 2012, however regeneration occurred during 2013 with the bank being more stable. • A reduction in the active channel width during 2011-2013.

35				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the right creek bank face during 2012, and this exposure continued during 2013. • A reduction in the active channel width during 2011-2013.
36				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the right creek bank face during 2012, however regeneration occurred during 2013 with the bank being more stable. • A reduction in the active channel width during 2011-2013.
37				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure on the right creek bank face during 2012, and this exposure continued during 2013. • A reduction in the active channel width during 2011-2013.
38				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of both creek bank faces during 2012, and this exposure continued during 2013. • A reduction in the active channel width during 2011-2013.
39	No Access - Private property			
40	No Access - Private property			
41	No Access - Private property			
42				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of both creek bank faces during 2012, and this exposure remains stable during 2013. • Continued increase in debris within the creek channel with woody material during 2012 and 2013.

43				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of the left creek bank faces during 2012, however regeneration occurred during 2013 with the bank being more stable as a result of an increase in groundcover. • and this exposure • A reduction in the active channel width during 2011-2013.
44				• Photo is slightly downstream of previous location. • A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of both creek bank faces during 2012, however regeneration occurred during 2013 with the bank being more stable as a result of an increase in groundcover. • Increase in inner bank undercutting noted during 2013 of the left bank.
45				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of both creek bank faces during 2012, and this exposure remains stable during 2013. • Bedrock material exposure remains stable.
46				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • A reduction in the active channel width during 2012-2013. • An increase in woody debris deposition during 2013.
47				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of both creek bank faces during 2012, and this exposure remains stable during 2013. • A reduction in the active channel width during 2012-2013.
48				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure of both creek bank faces during 2012, and this exposure remains stable during 2013, with a slight increase in groundcover as a result of an increase in debris on the banks.

49				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure of both creek bank faces during 2012, however regeneration occurred during 2013 with the bank being more stable as a result of an increase in groundcover.

Cumbo Creek Photo Comparison Upstream December 2011, 2012 & 2013

Site	Upstream December 2011	Upstream December 2012	Upstream December 2013	Main Comparison
1				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Site remains well vegetated and stable.
2				• Slightly different location in 2012. • A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure of both bank faces is noted during 2013.
3				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A reduction in the active channel width during 2012-2013. • Site remains well vegetated and stable.
4				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure and instability is noted on the right bank in 2012. This is reduced in 2013. • A reduction in the active channel width during 2012-2013.
5				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • An increase in soil exposure and instability is noted on the bank faces in 2012. This is reduced in 2013. • A reduction in the active channel width during 2012-2013, with an increase in revegetation.

6				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • An increase in soil exposure and instability is noted on the bank faces in 2012. This is reduced in 2013. • A reduction in the active channel width during 2012-2013, with an increase in revegetation.
7			Removed from survey due to works in area.	• A reduction in 'green' groundcover within the creek bed, and on the bank faces and within riparian areas between 2011-12. • An increase in soil exposure and instability is noted on the bank faces in 2012. This is reduced in 2013. • A reduction in the active channel width during 2012-2013, with an increase in revegetation
8				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • Site remain well vegetated and stable.
9				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • Site remain well vegetated and stable.
10				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • Site remain well vegetated and stable.

Appendix C

Photo Comparison Downstream

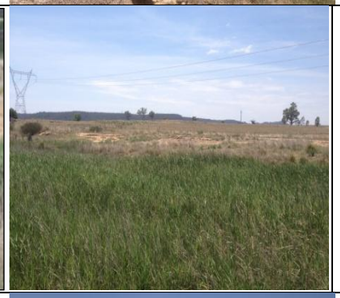
Wilpinjong Creek Photo Comparison Downstream December 2011, 2012 & 2013

Site	Downstream December 2011	Downstream December 2012	Downstream December 2013	Main Comparisons
1				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the bank face between 2011-2012. • A reduction in creek width over the 2 year period. • An increase in woody snags over the two year period.
2				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the left bank top between 2011-2012. This has reduced in 2013, with an increase in groundcover noted in 2013. • A reduction in the active creek width over the 2 year period.
3				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the left bank top between 2011-2012, which has continued during 2013. • An increase in deposition of sediment on the left bank bend in 2013. • A reduction in the active creek width over the 2 year period.
4				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the left bank top between 2011-2012, which has continued during 2013, as noted by an increase in rootlet exposure. • A reduction in the active creek width over the 2 year period. • An increase in woody debris on the creek banks between 2012-2013.
5				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the left bank top between 2011-2012. This has reduced in 2013, with an increase in groundcover noted in 2013. • A reduction in the active creek width over the 2 year period. • An increase in woody debris and leaf litter on the creek banks between 2012-2013.

6				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure on the left bank top between 2011-2012, which has stabilised in 2013. • An increase in inner bank undercutting of the left bank in 2013. • A reduction in the active creek width over the 2 year period.
7				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A clear reduction in groundcover coverage between 2011-2012, which continued in 2013. • A reduction in the active creek width over the 2 year period.
8				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • A clear reduction in groundcover between 2011-2012. However, in 2013 groundcover growth increased in this area. • An increase in woody debris and snags in 2012 and 2013.
9				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Good ground coverage and stability was maintained between 2011-13. • No substantial changes in ground coverage or soil exposure between 2012 and 2013.
10				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • No substantial changes in ground coverage or soil exposure between 2012 and 2013.
11				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A clear reduction in groundcover between 2011-2013. • An increase in woody debris and snags in 2012 and 2013. • Site remains relatively stable.

12				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A reduction in the active creek width over the 2 year period. • Site is relatively stable with good ground coverage.
13				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • A reduction in the active creek width over the 2 year period. • An increase in soil exposure on both bank faces between 2011-2013.
14				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area remains relatively well vegetated and stable.
15				• Slightly different locations in 2012 to 2011 and 2013. • A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in soil exposure and sheet erosion of the right bank between 2011 and 2013. • A reduction of the active channel width in 2013.
16				• Slightly different locations due to access, however general area remains well vegetated and stable.
17				• Slightly different locations due to access, however general area remains well vegetated and stable.

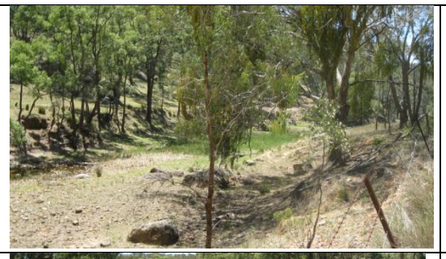
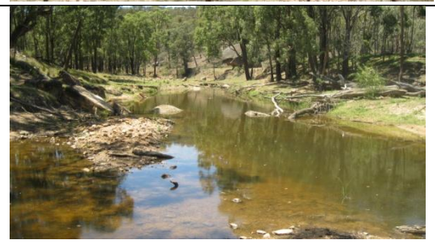
18				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.
19				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.
20				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.
21				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.
22				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.
23				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.

24				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover between 2011 and 2013.
25				• Slightly different locations in 2011 to 2012-2013 - opposite banks. • A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in bedrock exposure and undercutting of the left bank between 2012 and 2013. • A reduction in the active channel in 2013.
26				• Area has remained stable with good groundcover between 2011 and 2013.
27				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase in soil exposure and sheet erosion of the left bank over the 2 year period. • Reduction in the active channel width in 2013.
28				• Site is slightly downstream of 2011 site. • A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase in soil exposure and sheet erosion of the left bank over the 2 year period, with an increase in gullying and slumping noted in 2013. • Reduction in the active channel width in 2013.

29				• Site is on opposite bank in 2013 to 2011. • A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Erosion of the left bank continues over the 2 year period, with a lack of groundcover and steep slope maintianed. • Reduction in the active channel width in 2013.
30				• Site is on opposite bank in 2013 to 2011. • A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Area has remained stable with good groundcover and general stability between 2011 and 2013.
31				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has regenerated with an increase in groundcover in 2013. • Reduction in the active channel width in 2013.
32				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has stabilised in 2013. • Reduction in the active channel width in 2013.
33				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has stabilised in 2013.
34				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has stabilised in 2013. • Reduction of the active channel width in 2013.

35				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has regenerated with an increase in groundcover in 2013.
36				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has regenerated with an increase in groundcover in 2013.
37				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has stabilisaed in 2013. • Reduction of the active channel width in 2013.
38				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase in soil exposure and sheet erosion of the right bank in 2012, which has regenerated with an increase in groundcover in 2013. • An increase in erosion of the left bank, with evidence of sheet erosion noted on the lower banks in 2013.
39	No Access - Private property			
40	No Access - Private property			
41	No Access - Private property			
42				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. Site remains similar in 2013. • Increase in soil exposure, erosion and regretation of the right bank, as noted by an increase in bank steepness and rootlet exposure in 2013. • An increase in undercutting of the left bank in 2013. • Channel width has remained similar.

43				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Increase soil exposure of the left creek bank faces during 2012, however this has stabilised in 2013. • A reduction in the active channel width during 2011-2013.
44				• Photo is slightly downstream of previous location. • A reduction in 'green' groundcover on the creek bank faces and within riparian areas between 2011-12. • An increase in bank undercutting in 2012 in comparison to 2011, however this has stabilised in 2013. • An increase in instream vegetation growth in 2013.
45				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Increase soil exposure of both creek bank faces during 2012 and 2013, with an increase in soil and rocky exposure/deposition.
46				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Site has stabilised in 2013.
47				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • Site has stabilised in 2013.

48				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • An increase in soil exposure and erosion in 2012, however this has stabilised in 2013 with an increase in groundcover.
49				• A reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-12. • An increase in soil exposure and erosion in 2012, however this has stabilised in 2013 with an increase in groundcover.

Cumbo Creek Photo Comparison Downstream December 2011, 2012 & 2013

Site	Downstream January 2011	Downstream December 2012	Downstream December 2013	Main Comparisons
1				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • Site remains well vegetated and stable.
2				• A slight reduction in 'green' groundcover within the creek bed, on the bank faces and within riparian areas between 2011-13. • An increase in right bank soil exposure and sheet erosion of the right bank in 2013.
3				• Site is slightly in a different location to previous surveys. • Site remains well vegetated and stable.
4				• Site is slightly in a different location to previous surveys. • Site remains well vegetated and stable.
5				• Site is slightly in a different location to previous surveys. • Pond feature reduced in site between 2011 and 2012. • An increase in instream vegetation growth and coverage in 2013. • Site is currently well vegetated and stable.

6				• A slight reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-13. • There has been an increase in instream vegetated growth in 2013. • Site remains well vegetated and stable.
7			Removed from survey due to works in area.	• A slight reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12.
8				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • Site remain well vegetated and stable.
9				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • Site remain well vegetated and stable.
10				• A reduction in 'green' groundcover on the bank faces and within riparian areas between 2011-12. • Site remain well vegetated and stable.