MARY RIVER
CATCHMENT
COORDINATING COMMITTEE

Mary River Catchment Recreational Fishing Habitat Improvement & Education Project

Author: Dale Watson

Barung
LANDCARE
WORKING FOR OUR FUTURE

Australian Government
Department of Agriculture, Fisheries and Forestry
Recreational Fishing Community Grants Programme

Mary River Catchment Recreational Fishing Habitat Improvement and Education Project

Dale Watson

Mary River Catchment Coordinating Committee Quality Control Statement		
Mary River Catchment Recreational Fishing Habitat Improvement and Education Project	**Draft Prepared:**	Dale Watson
	Draft Reviewed:	Brad Wedlock Deb Seal
	Final Reviewed:	Harry Jamieson
	Approved for Issue:	December 2006
Project Officer	Dale Watson	
Project Manager	Brad Wedlock	
Commencement Date	24th March 2006	
Completion Date		
File Path	C:\Shared Documents/Dales Documents/Recreational Fishing Community Grant/Final Report/Elaman Creek Wood Reintroduction - Final Report	
File Name	Elaman Creek Wood Reintroduction - Final Report	

The Mary River Catchment Coordinating Committee would like to thank the following people and organisations for their generous support of this project:

- Elaman Ck Landholders, Col Cork and Dave Garmany
- Australia Government Department of Agriculture, Fisheries and Forestry
- Barung Landcare (Jonathon Waites)
- Noosa District Community Fish Hatchery
- Department of Main Roads
- Department of Natural Resources & Water
- Andrew Brooks (Griffith University)
- Michael Hutchinson and Keith Chilcott (Dept Primary Industries & Fisheries)
- John and Beverly Pryor
- Peter Velenski – Kybong Landscape Supplies
- Bettina Hayward
- Mark Cridland – Barambah Environmental Education Centre
- Conservation Volunteers Australia
- Barung Landcare Green Corps Team
- Woodford Folk Festival Green Corps Team

TABLE OF CONTENTS

INTRODUCTION

The improvement of native freshwater fish habitat is an important issue in the Mary River Catchment. Due to de-snagging of local waterways and the lack of natural riparian timber inputs, wood has become scarce within many of the streams of the Mary River Catchment. Wood can be defined as any timber (trees or branches) that enter a stream, or lie along its banks. Wood is now recognised worldwide for the crucial role it plays in aquatic life habitat and stream stability. Wood provides a place for a wide range of animals to live and breed and as water flows over and around snags, they help shape the river (Koehn et al. 1999). Wood in streams of the Mary River Catchment is especially important for the endangered Mary River Cod, which relies on wood for protective cover and to spawn their adhesive eggs onto. Radio tagging of the Mary River Cod has found that of 344 encounters, 325 (95%) of them were within 2 metres of wood (Simpson & Mapleston, 2002). Wood is also an important element in the development and maintenance of riffle and pool sequences in streams, crucial for healthy functioning stream ecosystems and fish species habitat. Wood in our streams creates variations in flow, producing small local scour and deposition areas around the wood, providing a variation in water depths. This in turn creates crucial habitat for many aquatic species (Keller & Macdonald, 1995). Wood is also viewed as crucial habitat structures for algae, micro-organisms and macroinvertebrates (food sources for many fish species), and provides structures for a range of animals to enter and exit the water.

The reintroduction of wood can also be used to combat stream stability problems such as bank erosion. When wood is located near a stream bank it can create a roughness to the flow, reducing the power of the stream and its ability to erode the bank (Brooks, 1999). Alternatively, wood can settle into the bed of streams and form hard or control structures, important in reducing potential bed scour and erosion (Dudgeon, 2000). Reduction of sediment which can directly affect fish habitats and health is also a recognised benefit of the reintroduction of wood through the wood's bank and bed stabilising properties.

Two factors are responsible for the loss of wood in streams throughout Australia. The practise of 'de-snagging' (the physical removal of wood from streams) has been occurring since the late 1800's. There is strong evidence that de-snagging has caused increased flow velocity, bed degradation, massive channel enlargement, loss of fish habitat, and substantially higher rates of sediment flux, so that de-snagged streams bear little of their pre-disturbance morphological diversity (Buffington & Montgomery, 1999)(Erskine & Webb, 2003). There is very little evidence to support the idea that the removal of wood decreases flood levels and frequency (Gippel, 1999). Secondly, the removal and/or reduction of riparian vegetation along our stream banks has limited the natural input of wood into streams.

This report details the introduction of engineered log jams (ELJ), revetment logs and habitat logs at two degraded sites on Elaman Creek, near the township of Conondale in the Sunshine Coast Hinterland. It has been observed that log jams act as a natural type of bank protection over long periods of time. This has led to the idea that similar structures could be engineered to provide bank protection that is more representative of the natural character of our streams and rivers, as opposed to traditional rock revetment methods (Brooks, 2003).

Revegetation, fencing and off-stream watering provisions for the wood reintroduction sites are integral components of this project. This report will detail the steps taken to achieve these outcomes

This project also includes a strong educational component. Field days were held at Conondale State School, Maleny River School and Widgee State School. The field days linked with the QDPI&F Recreational Fishing Program that incorporates sustainable recreational fishing into the curriculum of Qld Environmental Education Centres. The field days allowed students to understand the many problems our native fish populations are encountering, such as sedimentation, lack of in-stream habitat and barriers to fish movement. The field days encouraged an interest in our native fish populations and demonstrated sustainable freshwater fishing practices to the students.

Also as part of this project's funding was provided to the Gerry Cook Fish Hatchery at Lake Macdonald to assist in the rearing of Mary River Cod Fingerlings. Fingerlings were released on and around the Elaman Creek wood reintroduction sites enhancing the existing freshwater fish stocks of the Mary River catchment. In time, this will increase recreational freshwater fishing opportunities for locals and visitors to the region.

SITE SELECTION & DESCRIPTION

Elaman Creek flows from near the township of Maleny and enters the Mary River just downstream of the township of Conondale. The wood reintroduction sites are located near the township of Conondale on two private properties. The first site is located on a small grazing property owned by Col Cork on the Maleny Conondale Road, and will be referred to as the "Cork wood reintroduction site". The second site is located on Cooks Road on property owned by Dave Garmany and will be referred to as the "Garmany wood reintroduction site".

Local powerlines cross Elaman Creek at both of the wood reintroduction sites. Underneath these powerline crossings are the two severe stream bank erosion scours. Both of the powerline crossings (and scoured banks) are located on bends in the creek where streambank erosion is most likely to occur. It is possible that due to some clearing under the powerlines in the past, a weak spot in the bank may have been created due to a lack of riparian vegetation.

The Elaman Creek wood reintroduction sites are located in the "Elaman Creek" reach as identified in the Mary River and Tributaries Rehabilitation Plan (Stockwell, 2000). The reach is defined as a Priority 2 Reach – Protecting and Rehabilitating Reach of Local Conservation Value.

The MRCCC's Priority Action Project, 2005, identified this reach of Elaman Creek as a Priority 3 Reach. Priority 3 Reaches are defined as reaches of local conservational value, with a high recovery potential, natural assets in good condition and considered to be surviving remnants of the original waterway. The focus of management action is to protect and rehabilitate these relatively common Priority 3 Reaches.

Reports from local landholders state that the Mary River Cod was once abundant in Elaman Creek: "Sunday's in Conondale involved playing cricket on the Conondale oval all morning, then heading down to Elaman Creek to sit on the shady bank and catch some Mary River Cod". With the reintroduction of the wood, riparian revegetation and education of sustainable fishing it is hoped that the community may again paint a scene such as this.

The landscape surrounding the area in which the wood is to be reintroduced is known to contain the following threatened and endangered species:

- Mary River Cod (Maccullochella peelii mariensis)
- Conondale Crayfish
- Giant Barred Frog
- Cascade Tree Frog
- Glossy Black Cockatoo
- Regent Honey Eater

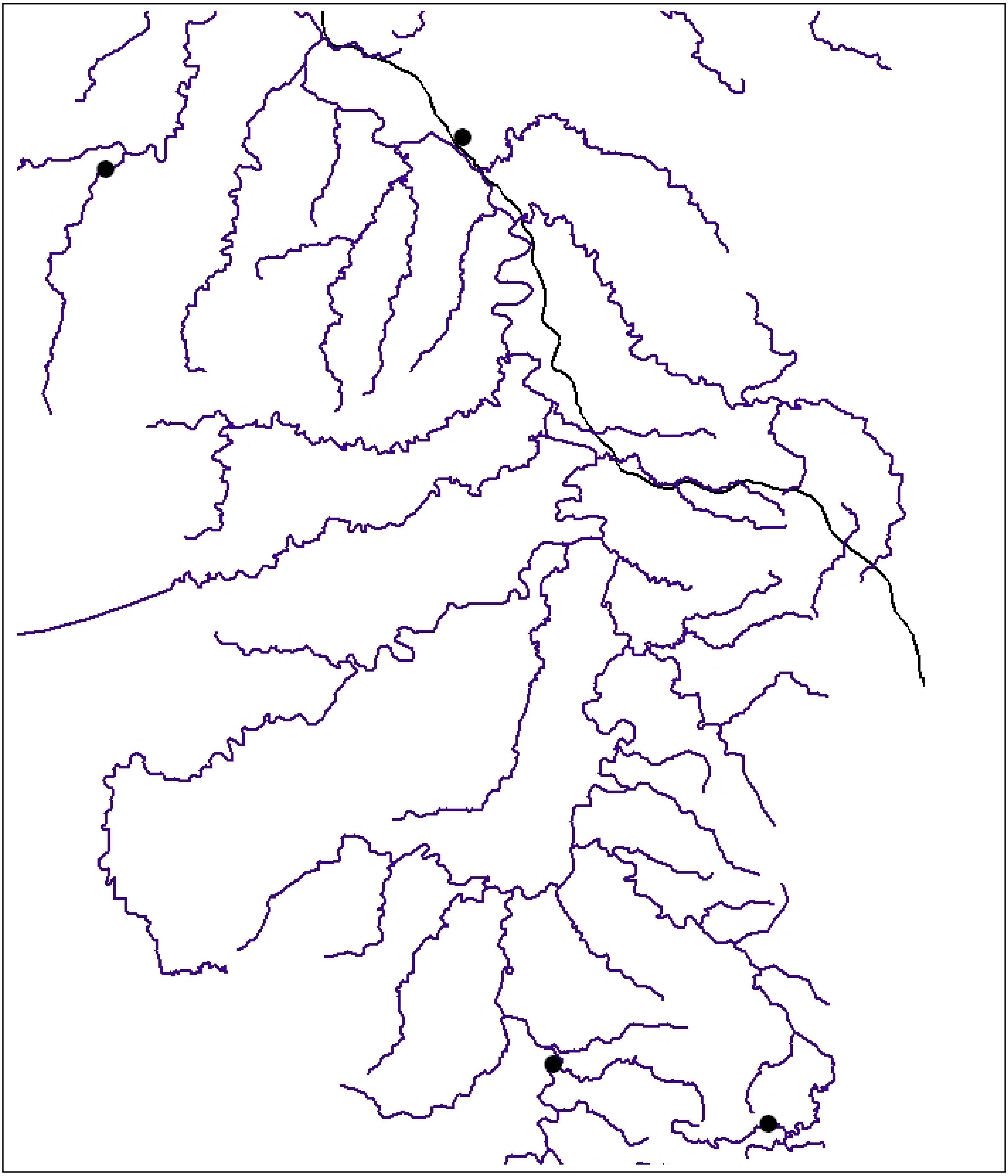

Figure 1. Location or project component locations

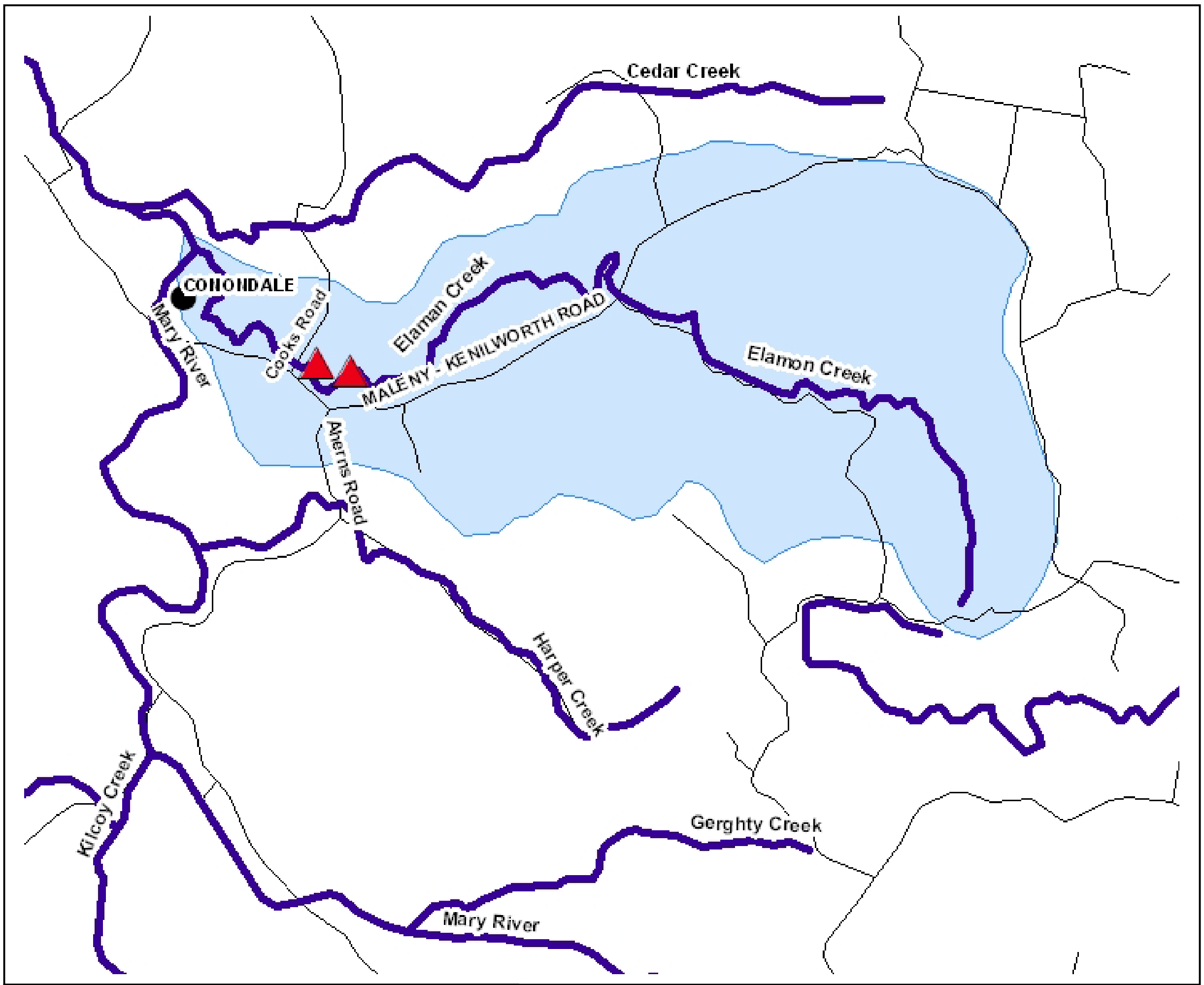

Figure 2. Location of Elaman Creek

Figure 3. Location of wood reintroduction projects on Elaman Creek

PRE-CONSTRUCTION SITE PHOTOS AND SITE DESCRIPTIONS

Garmany Site – Looking upstream at eroded bank

Garmany Site – Looking upstream at eroded bank

Garmany Site – Pool upstream of eroded bank

Garmany Site – Run and riffle section downstream of eroded bank

Garmany Site – Facing eroded bank form inside gravel bend

Garmany Site – Logs to be reintroduced

Garmany Site – Logs to be reintroduced

Cork Site – Looking downstream at eroded bank

Cork Site – Pool downstream of eroded bank

Cork Site – Looking upstream at eroded bank

Cork Site – Looking downstream at eroded bank

Cork Site – Looking at eroded bank from inside gravel bench

PRE-CONSTRUCTION MONITORING:

The pre-construction monitoring of the wood reintroduction sites focused on a two 400m reaches of Elaman Creek (one at each of the wood reintroduction sites). The monitoring consisted of an Index of Stream Condition (ISC) assessment (including macroinvertebrate sampling), a Corridors of Green (COG) vegetation assessment, geomorphic surveying and analysis using the Geomorphic Assessor, site history (landholder interviews), existing wood loadings (full census) and fish abundance and diversity (DPI electro-fishing). All of these assessment tools were used to develop the sites plan, and each assessment tool will be discussed in the following sections.

Index of Stream Condition (ISC) & Corridors of Green (COG) Assessment.

The ISC has been developed as a rapid assessment tool to take a 'snap shot' of the condition of a stream and its associated riparian zone. ISC will assist in management of waterways and can be used to aid objective setting by catchment managers, benchmark the condition of streams, and assess the long-term effectiveness of management intervention in rehabilitating streams (Ladson & White, 1999). The ISC consists of four sub-indexes: Water Quality, Physical Form, Streamside Zone and Macroinvertebrates. The ISC monitors a 400m stream reach, with three transects (Transect 1 being the central point of monitoring) (see Figure 4).

The COG vegetation assessment was developed by Greening Australia, Tiaro as a method of recording plant species diversity and condition from three quadrats located along a set transect. The COG Transect is located along the ICS's Transect 1. The COG data sheet information has been converted into a score for both vegetation condition and diversity. These scores and the associated data give a valuable measure of plant species diversity at the site, which the ISC lacks.

For more information on the ISC and COG methodologies please refer to the ISC manuals by Ladson and White and the 2003 Mary River and Tributaries Rehabilitation Plan Monitoring and Evaluation Report by the MRCCC.

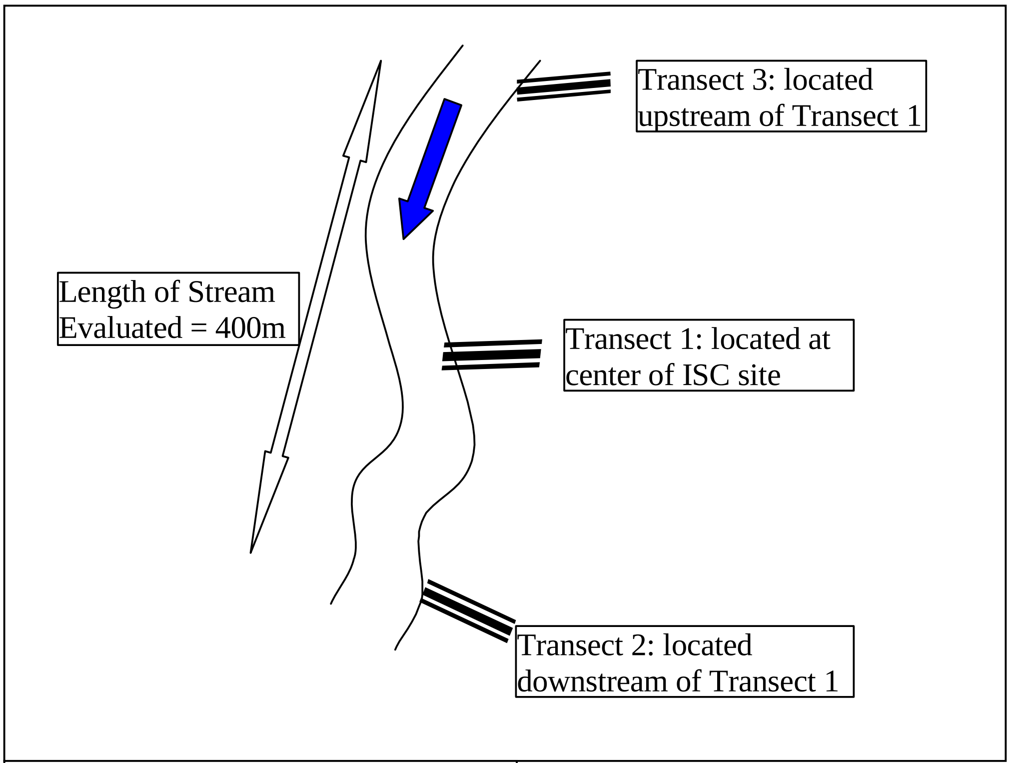

Figure 4. Position of ISC transects

A combination of the ISC and COG scores for Elaman Creek wood reintroduction sites are compared against 60 other riparian sites monitored throughout the Mary River catchment using the ISC and COG methodology (excluding the Macroinvertebrate subindex) as illustrated in Figure ****. As the graph shows, the combination of ISC and COG scores for the Elaman Creek wood reintroduction sites rate relatively low against other sites in the Mary Catchment. The COG scores for the Elaman Creek wood reintroduction sites rated extremely low, as Transect 1 for both sites was located on the scoured banks. The COG score will no doubt significantly increase after the revegetation of the site.

Figures 8, 9 and 10 separate three of the subindexes of the ISC (Water Quality, Physical Form and Stream Side Zone). The graphs show that the Water Quality Sub-Index scored quite well, indicating a relatively healthy site and subcatchment in terms of factors that may affect water quality (such as salinity and nutrient problems). The Physical Form Sub-Index scored moderately, indicating no major bank or bed along the reach (when compared to the larger scale bank and bed erosion along some of the reaches of the Mary River and Obi Obi Creek). The Stream Side Zone Sub-Index scored quite poorly due to the lack of vegetation along the transects, the presence of some weed species and the absence of regeneration of native plant species (likely due to the presence of cattle in the riparian zone). The full results from the water quality and COG assessment results can be viewed in Appendices 1 and 2.

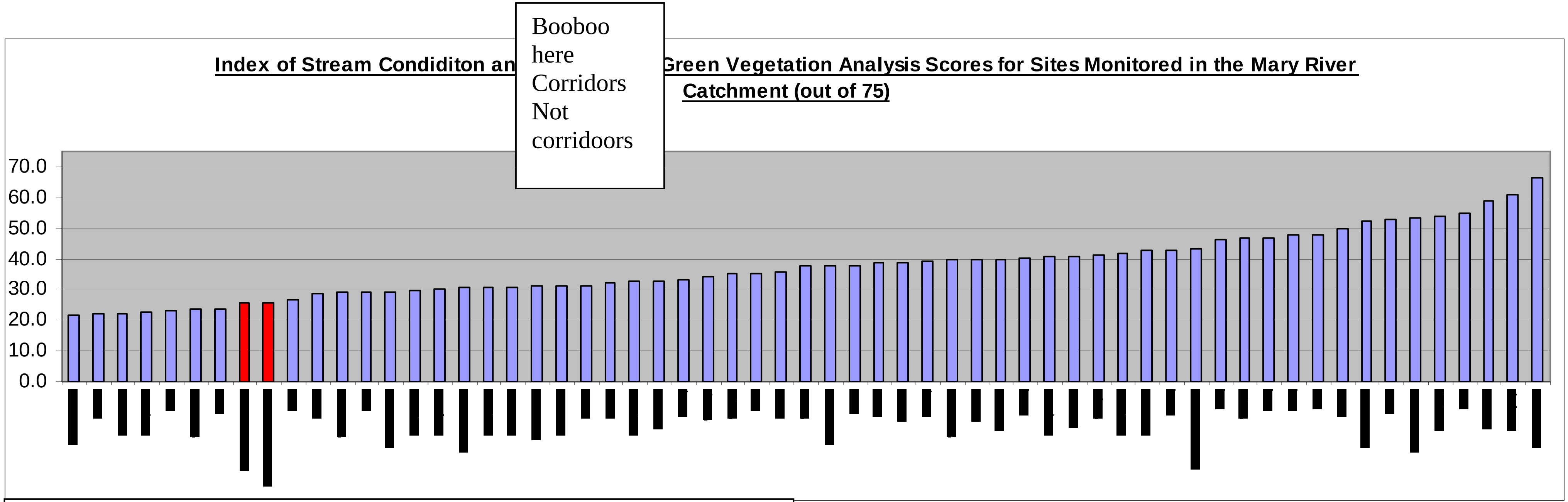

Figure 5. ISC & COG Scores (not including Macroinvertebrate Sub-index

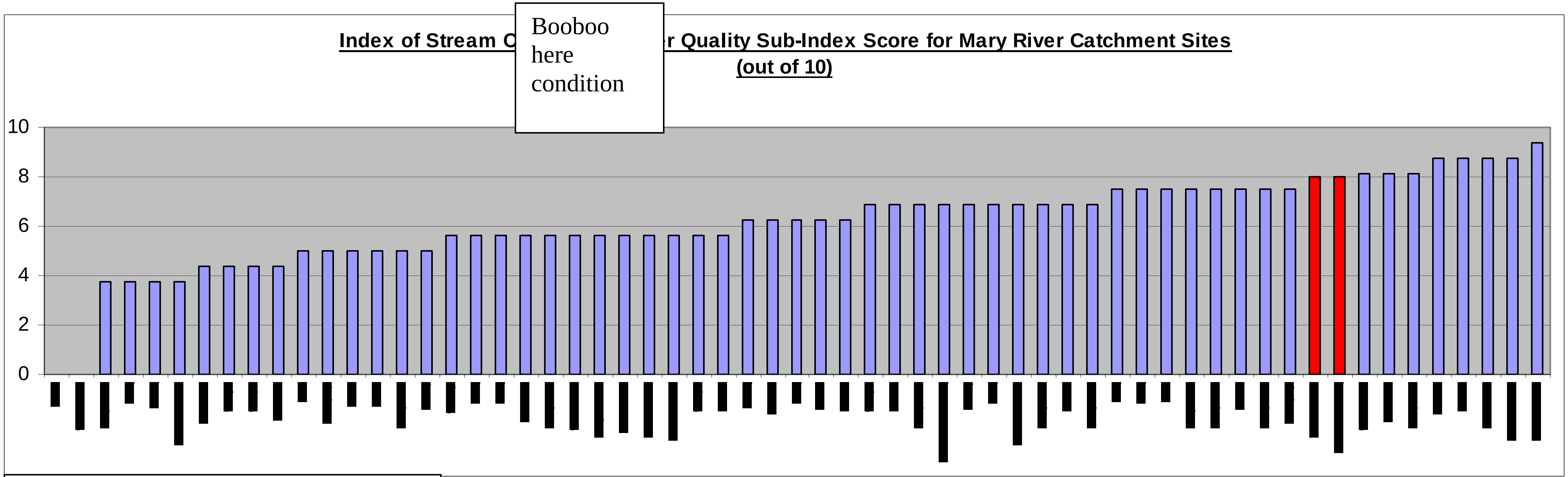

Figure 6. ISC Water Quality Sub-index

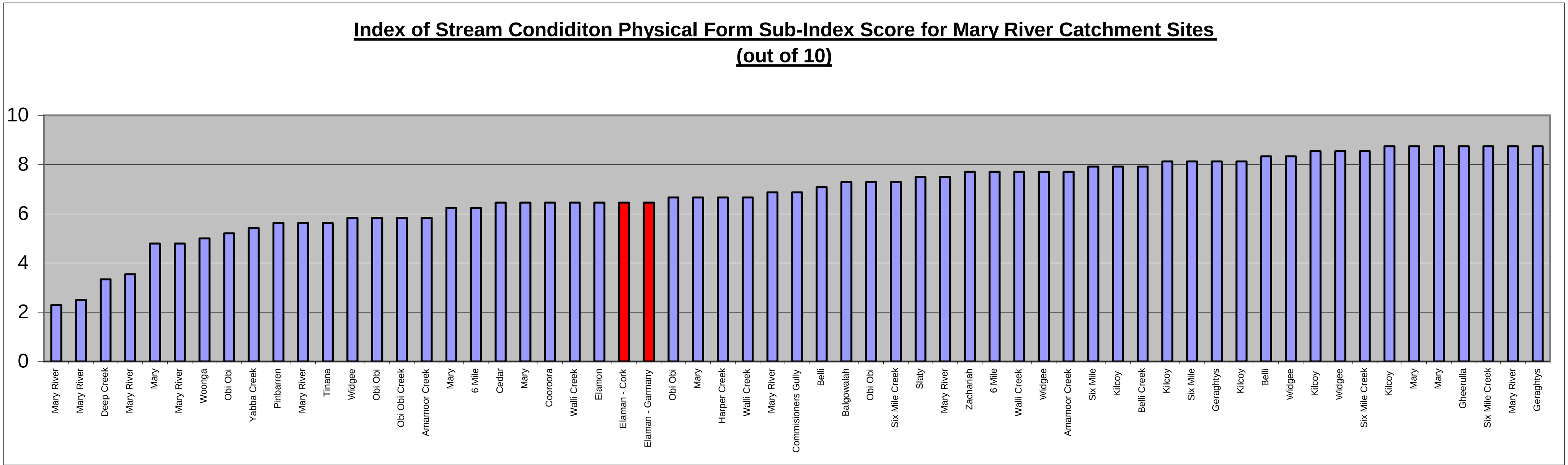

Figure 7. ISC Physical Form Sub-index

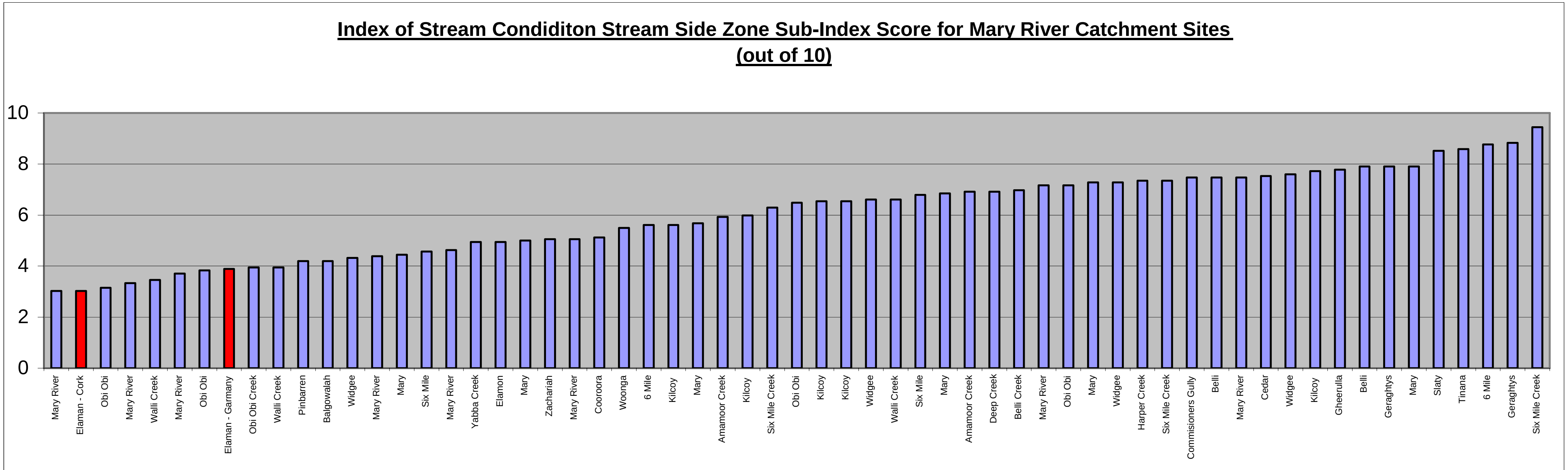

Figure 8. ISC Stream Side Zone Sub-index

A Macroinvertebrate study of the site was also included at the Elaman Creek wood reintroduction site. The SIGNAL 2, 2003, sampling methodology was followed. The methodology involves the sampling of a variety of habitats (i.e. pool bed, riffle, run, edge and macrophyte), ‘picking’ the collected macroinvertebrates for 30 minutes, and identifying to family classification. The SIGNAL 2 pollution sensitivity rating (family level) was used to derive the scores presented in Table 2.

Site	SIGNAL 2 Score (without abundance weighting)	SIGNAL 2 Score
Elaman Creek – Cork	4.6	4.17
Elaman Creek – Garmany	4.8	3.53

Table 1. Macroinvertebrate SIGNAL Score

The SIGNAL 2 Scores represent moderately healthy macroinvertebrate populations at the Elaman Creek wood reintroduction sites. The full macroinvertebrate survey results can be viewed in Appendix 3.

Fish Species Abundance and Diversity

The following paragraphs are excerpts from the Department of Primary Industries and Fisheries report ‘Electrofishing Survey of Elaman Creek Spring 2006 Report to Mary River Catchment Coordinating Committee’ by Stephanie Backhouse, Michael Hutchison and Keith Chilcott.

During Spring 2006, the Department of Primary Industries and Fisheries, Animal Science - Sustainable Fisheries Unit conducted a fisheries survey of Elaman Creek on behalf of the Mary River Catchment Coordinating Committee. The brief for this study was to provide an indication of the fish species present as well as their abundance and size before stream rehabilitation occurred. Once all rehabilitation works are completed (addition of large woody debris, replanting of vegetation, fencing to restrict cattle access, etc.), we will repeat our sampling efforts to determine what, if any changes in the fish assemblages have occurred.

Fish were sampled by both boat and backpack electrofishing. Boat electrofishing works by creating an electric field in the water between a pair of anodes hung from booms off the bow of the vessel, and a cathode (the hull of the boat). The electric field temporarily stuns fish, which are then netted by a netter standing on the bow of the boat, and transferred to a live well. Effective stunning range is approximately 2-3 metres but can vary according to water temperatures, conductivities and bottom substrate. Fish sitting in deep water are not captured by electrofishing.

Boat electrofishing at Cork Site

Backpack electrofishing works on similar principles, but at a smaller scale, and is useful for shallower waters inaccessible by boat. The electrofishing operator wears the unit on their back, with the anode on the end of a long pole, and the cathode trailing behind them. A netter follows the electrofishing operator and nets the stunned fish, transferring them to a bucket. Effective stunning range is approximately 1 meter, but again can vary according to water temperatures, conductivities and conditions.

Backpack electrofishing at Garmany Site

Fifteen species of fish were captured during the survey (Table 3). Numerous small fish were recorded. The majority of these were carp gudgeons *Hypseleotris spp.*, glassy perchlets *Ambassis agassizii* and hardyheads, both flyspecked *Craterocephalus stercusmuscarum* and Marjories *Craterocephalus marjoriae*. Flathead gudgeons *Philypnodon grandiceps* were also found in large numbers, especially in the riffles sampled by backpack electrofishing. Two invasive non-native species were found, the mosquitofish *Gambusia holbrooki* and the swordtail *Xiphophorus helleri.* All individuals of these species were lethally anaesthetized.

Larger species caught included long finned eels *Anguilla reinhardtii* and eel tailed catfish *Tandanus tandanus*. Some of the Eels were beginning to show signs of silvering, indicating reproductive maturity and a readiness to migrate to salt water. Tandans build gravel nests upon which they lay and guard their eggs. Large numbers of these nests were observed, and a large tandan was electrofished directly on top of one. This fish was measured immediately, and returned to the nest.

A Mary River cod, *Maccullochella peelii mariensis* (Figure 6), was caught in a deeper hole near some large woody debris. While the cod was not pit tagged, stocking of untagged fish has occurred in the Conondale area five or more years ago, so it is possible that this fish was a stocked one. The cod was netted and placed in the aerated tub along with the rest of the fish, however when we returned to process the fish, numerous large (approximately 3 mm diameter) pale orange eggs were found on the bottom of the tub. The cod's belly was flaccid, indicating it was a ripe and running female. As this was the only cod we caught in this stretch, it is unlikely successful reproduction could have occurred, but it is indicative that with increased re-stocking and habitat enhancement (such as addition of large woody debris), a reproducing population could be established.

Mary River Cod from Elaman Creek

This is a summary of the species present prior to rehabilitation of Elaman Creek. Once restoration works (addition of large woody debris, re-planting and fencing) are complete, we will re-sample these areas. By statistically comparing our before and after data, we will determine what changes in the species assemblage, if any, have resulted from the rehabilitation of the stream.

Table 2. Species catch rate per electrofishing shot.

	Shot Number								
Species	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	**TOTAL**
Ambassis agassizii	1	2	0	0	15	16	21	11	66
Anguilla reinhardtii	5	0	2	2	2	1	1	0	13
Craterocephalus marjoriae	0	0	0	0	0	0	33	1	34
Craterocephalus stercusmuscarum	0	0	1	0	17	0	0	0	18
Gambusia holbrooki	1	0	5	16	3	0	10	0	35
Hypseleotris galii	2	1	1	0	0	1	0	0	5
*Hypseleotris spp**	27	0	10	8	17	13	1	4	80
Maccullochella peelii mariensis	0	0	0	0	0	1	0	0	1
Melanotaenia duboulayi	1	0	1	0	9	1	4	6	22
Philypnodon grandiceps	1	6	3	18	2	1	0	0	31
Philypnodon spp	2	0	0	0	1	0	1	2	6
Pseudomugil signifer	0	0	3	5	1	1	5	3	18
Retropinna semoni	0	0	6	15	1	0	4	0	26
Tandanus tandanus	1	0	0	2	1	2	0	3	9
Xiphophorus helleri	0	0	2	2	0	0	4	9	17
TOTAL	41	9	34	68	69	37	84	39	**381**

* *Hypseleotris* sp. Refers to those individuals in the genus *Hypseleotris* that could not reliably be identified to species level. This includes juveniles of *Hypseleotris* species and morphs that resemble Lake's carp gudgeon and Midgely's carp gudgeon. Recent genetic work has shown that these two species cannot be reliably separated on morphometrics alone, and indeed some Lake's and Midgley's morphs are hybrids.

Geomorphic Assessment

Three cross section surveys were taken at each of the sites, as well as a cobble size survey (using the Big-toe methodology). The cross sectional data, cobble size data, estimated Manning's n value and dominant discharge data were entered into 'Geomorphic Assessor' to produce the stream velocity measurements presented in Table 3 below.

The Manning's n value conservatively estimated to be 0.022 based on the predictions listed in the tables 3 and 4 below.

Elamon Creek:- Manning's n Predictions:	
0.044	River Landscapes: Roughness Values for Australian Streams, using values obtained for Mitta Mitta and Tambo Rivers
0.022 - 0.026	Geomorphic Assessors inbuilt prediction tool.
0.048	HECRAS: Mountain Streams, no vegetation in channel, banks usually steep, with trees and brush on banks submerged, bottom gravels, cobbles, and few boulders.
0.028 - 0.035	Gravel with median bed cobble size of 2 - 64mm, Modified from Aldridge & Garret, 1973.
0.025 -0.030	Unlined channel, gravel, grass, some weeds, McCuen 2004
0.034	Cowan's, 1956, Method for predicting Manning's n.
0.076 - 0.080	Australian Handbook of Stream Roughness Coefficients Merimans Creek, Stradbroke West.

Table 3. Manning n Predictions for Elaman Creek

Geomorphic Assessor Results							
Site	Bank full Discharge (m3/sec)	Critical Design Velocity (m/sec)	Design Scour Depth (scour below bed) (m)	Design Scour Depth (scour below water level) (m)	Tractive Stress (min size of rocks) (mm)	Tractive Stress Velocity (m/sec)	Unit Stream Power (Watts/m2)
Cork	463	2.5	0.9	2.7	697	6.38	909
	231	2.7	0.5	1.9	585	6	630
	718	2.2	1.2	4	855	8.65	1934
Garmany	279	2.6	0.7	2	126	4.18	230
	244	2.8	0.6	1.7	131	4.77	240
	566	2.8	1.1	3.6	577	6.05	638
Average	417	3	1	3	495	6.01	764

Table 4. Geomorphic Assessor results for Elaman Creek Wood Reintroduction Sites

A safety factor of 1.5 was used in the model and slope was determined by surveying approximately 1200m of Elaman Creek upstream and downstream of the wood reintroduction sites, using a sighted dumpy level to produce a slope value of 0.0044 and 0.0081. Using the 'Big toe' cobble survey method produced particle size of 24.6mm. Elaman Creeks catchment area was calculated to be $42km^2$

By averaging the various velocity values (see Table 4) a figure of 6.01 m/s was derived to represent the largest stream velocity the reintroduced wood may encounter. This value was then used in the wood stability analysis calculations outlined in the Wood Stability Analysis section below.

WOOD SOURCE AND TRANSPORTATION

A total of 45 pieces of wood were sourced from a development clearing near the township of Nambour. The logs were loaded by an excavator responsible for the removal of the trees at the development site. Claytons Towing were hired to transport the logs to the wood reintroduction sites, using a tilt tray semi-trailer. The truck was able to use its tilt tray to unload the logs at the reintroduction site, eliminating the need for an excavator on site for unloading, thus reducing costs dramatically.

Only native tree species logs were chosen. They had to meet the necessary characteristics of size and have an attached root wad. The length and weight of the wood is limited by the transporting trucks capacity, in this case no longer than 11 metres for the semi-trailer. The driver was able to carry a maximum of 5 logs per trip. Appendix 4 shows the characteristics of the wood to be reintroduced.

WOOD PLACEMENT/CONFIGURATION

The log jam structures designed are loosely based on Brooks (2003) engineered log jam (ELJ) designs. The Cork wood reintroduction site has three ELJ's along the scoured bank in question, with two revetment logs between the ELJ's. The Garmany site has two ELJ's with three revetment logs attached to the bank between the ELJ's. Figures 9, 10, 11 and 12 show the Garmany and Cork sites pre wood reintroduction and post wood reintroduction with the placement of the ELJ's and revetment logs. Each ELJ is placed strategically along the scoured bank to maximise stream flow deflection and prevention of scour during high flows. Each of the ELJ's consists of 8 lateral logs constructed in a layered design (see Figure 13).

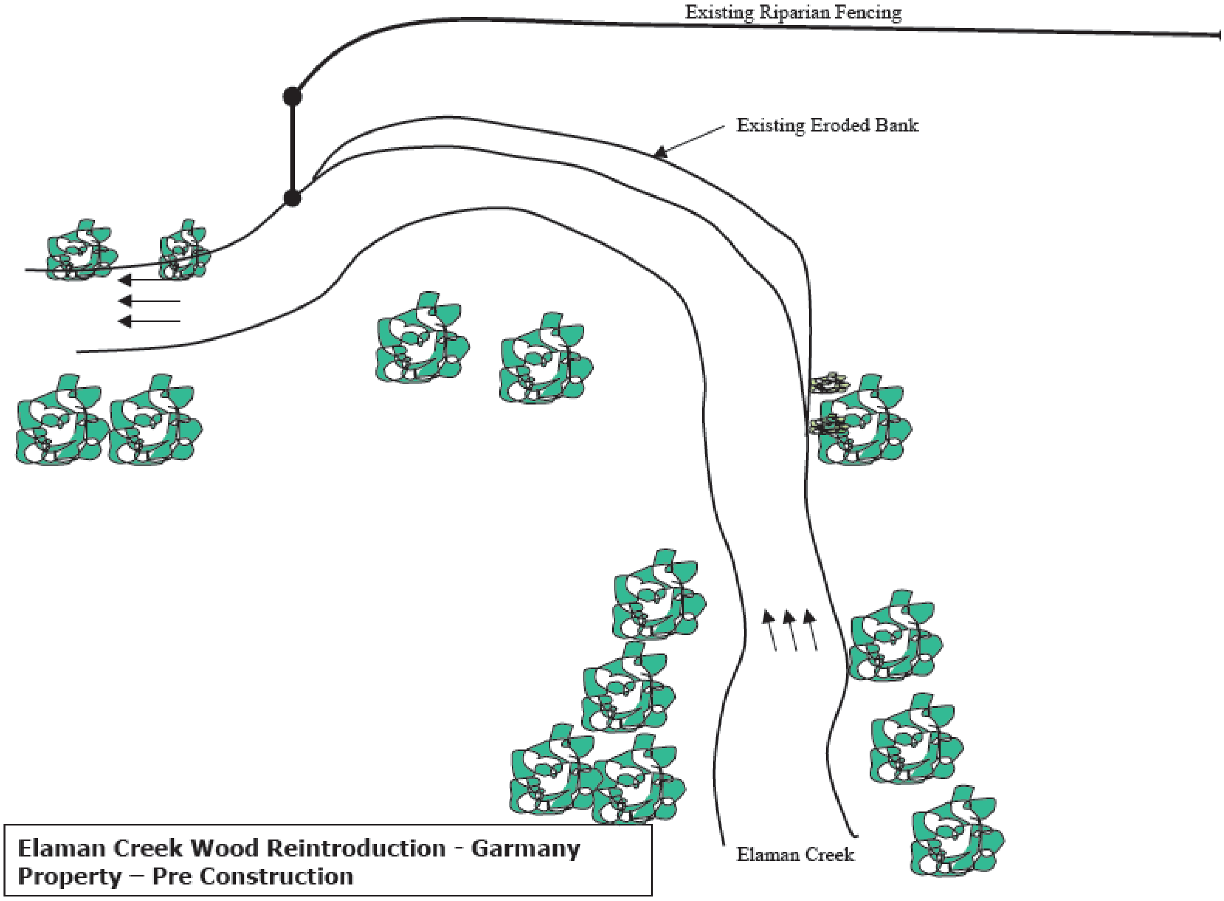

Figure 9. Garmany Site – Pre Wood Reintroduction

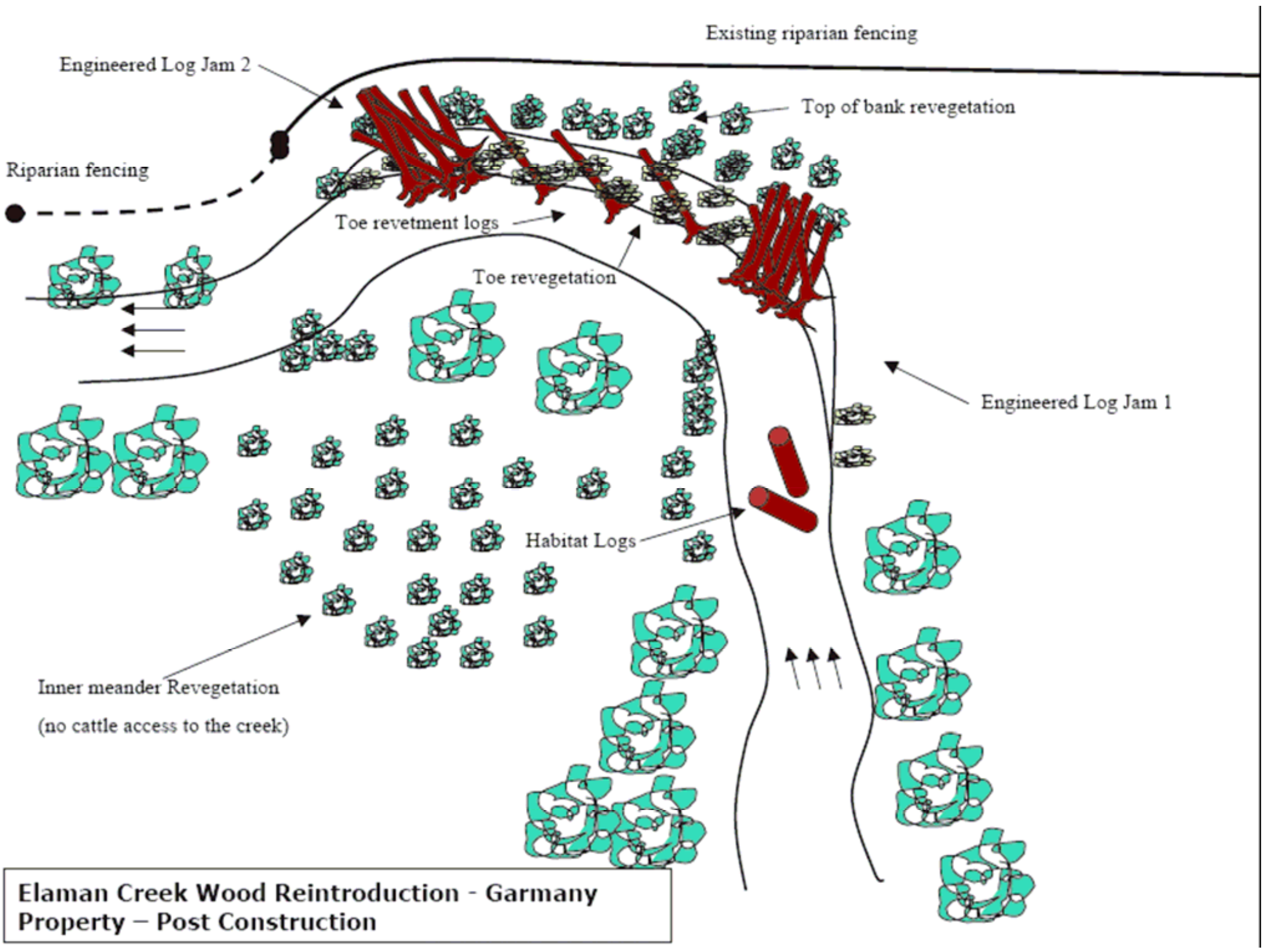

Figure 10. Garmany Site – Post Wood Reintroduction

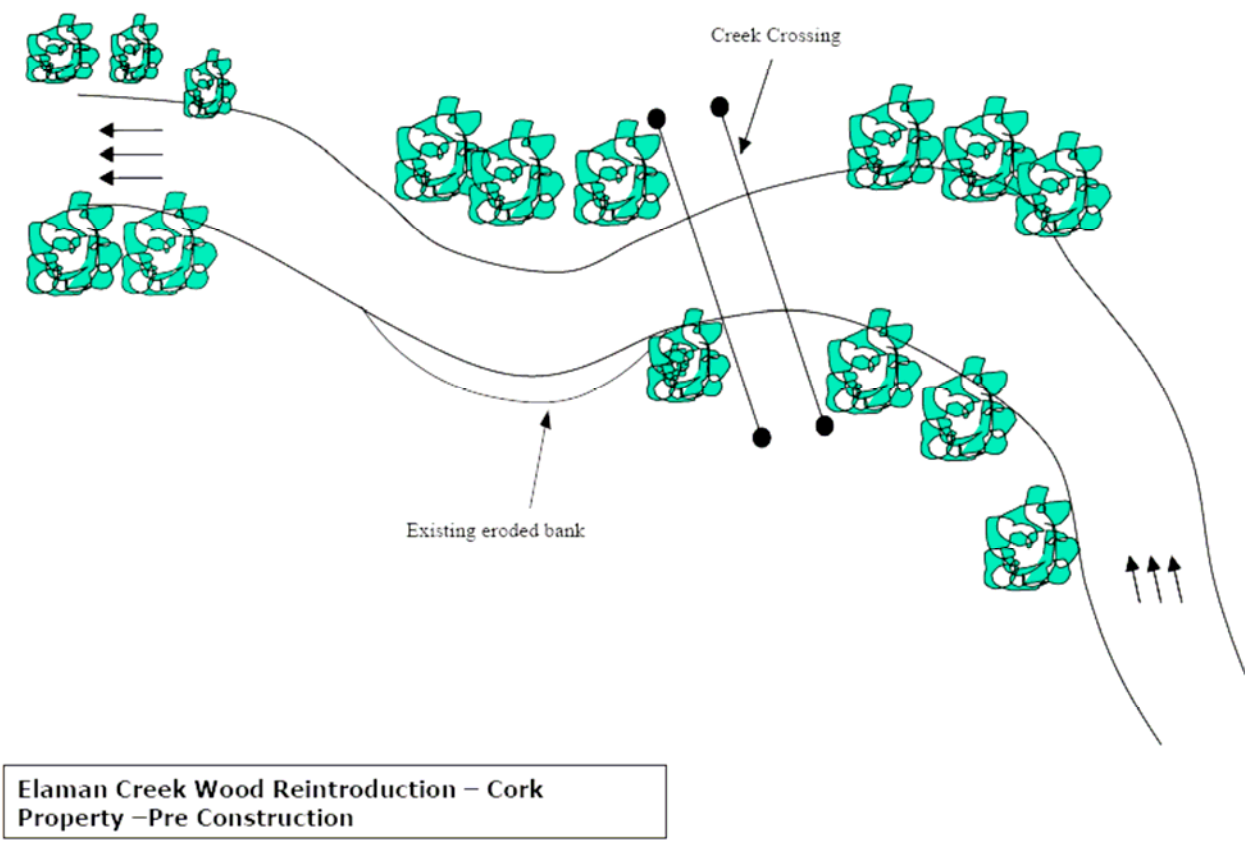

Figure 11. Cork Site – Pre Wood Reintroduction

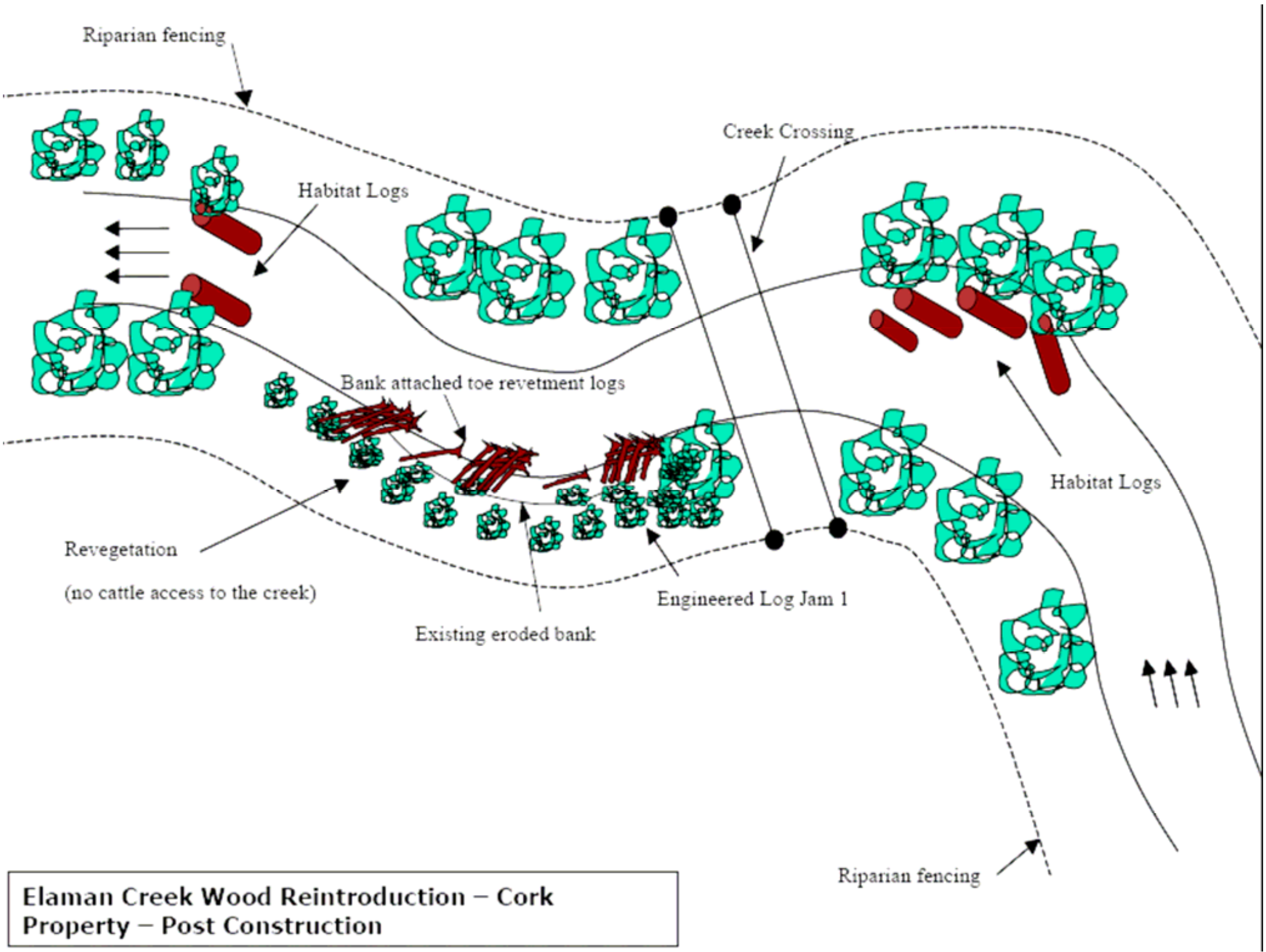

Figure 12. Cork Site – Post Wood Reintroduction

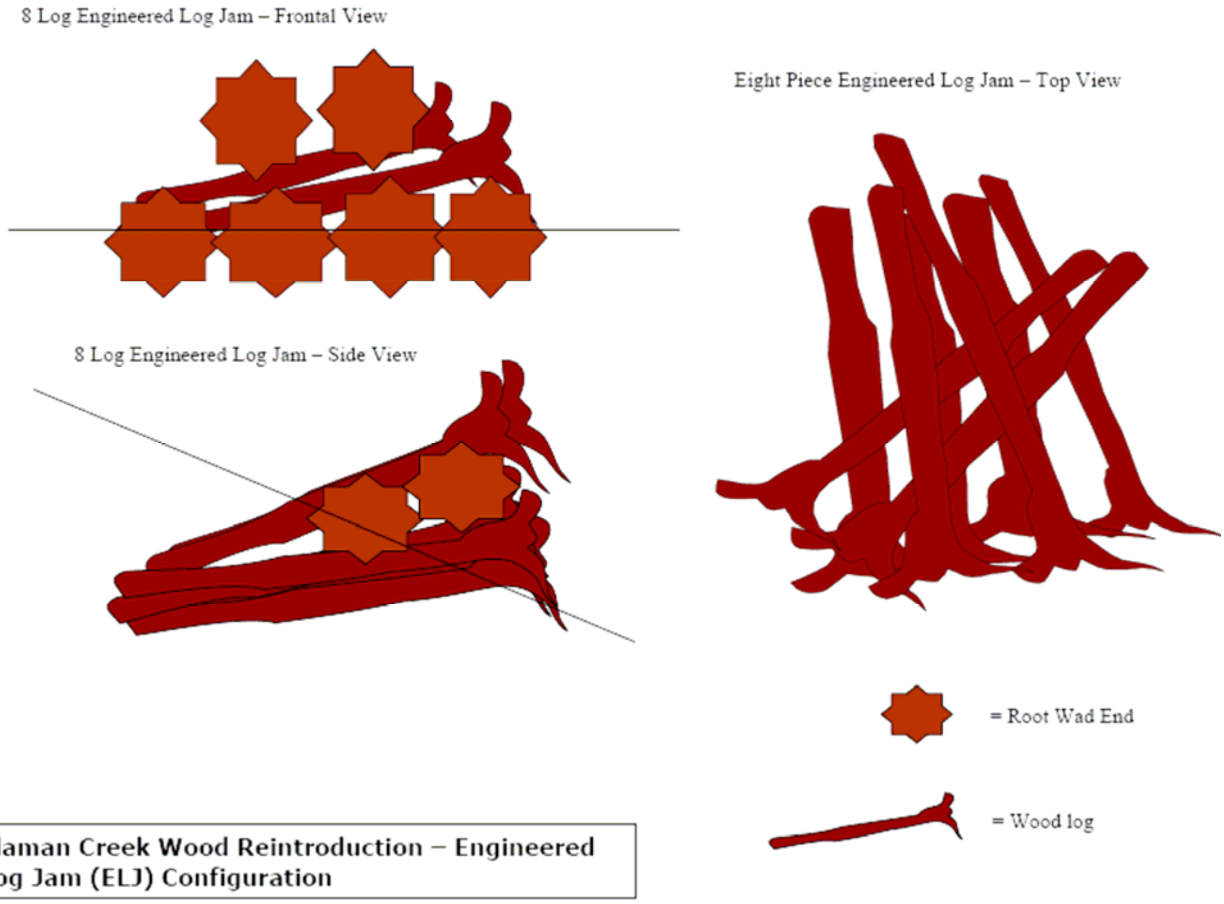

Figure 13. Engineered Log Jam Configuration

WOOD STABILITY ANALYSIS

The mass required to anchor any wood is determined by the drag and friction forces acting upon the wood in the stream as well as the buoyancy of the wood. To help in choosing the appropriate logs for the ELJ's and revetment logs, the D'Aoust and Millar (1999) methodology was used. This method combines the masses required to counter root wad drag, log buoyancy and lift and drag, to produce a total mass required to anchor the wood. By ranking the values obtained, individual logs were chosen on their ability to withstand the three forces (see Appendix 5).

The engineered log jams and the individual revetment logs were analysed using Brooks methodology for determining a factor of safety analysis for each structure. The calculations are based on the knowledge that a log structure will fail when:

- The buoyant force of the logs exceeds ballast weight
- Scour undercuts the structure
- The net imposing force on a structure exceed the net resisting forces (Brooks, 2003)

The principal parameters needed for these calculations are:

- Cross section area of structure located in the flow
- Drag forces (velocity of stream (m/s))
- Volume and weight of logs
- Buoyant force (dry density of logs)

Two final values for each log jam and revetment log were derived, a factor of safety against buoyancy and a factor of safety against sliding. Failure of a structure will occur if the factor of safety value falls below one. The values for each of the ELJ's and revetment logs are shown in Tables 5 and 6 below, along with an illustration, detailing each of the ELJ's Factor of Safety Values (Figures 14 and 15). The calculations are based on a burial depth of 1m for each EJL. Each of the ELJ's produced a factor of safety values above one, and compare well with Dr A. Brooks (2003) results (despite these ELJs being significantly smaller than those of Brooks). The logs used in each of the ELJs are detailed in Appendix 6.

Garmany Wood Reintroduction Site

Engineered Log Jam Number 1	**Engineered Log Jam Number 2**	**Revetment Log Number 1**	**Revetment Log Number 2**	**Revetment Log Number 3**
FSB Factor of safety for Buoyancy	FSB Factor of safety for Buoyancy			
FSB = WBL/FB	FSB = WBL/FB	FSB = WBL/FB	FSB = WBL/FB	FSB = WBL/FB
67.5	**62.09**	**192.2**	**245.4**	**105.2**
FSS Factor safety for sliding	FSS Factor safety for sliding			
FSS = FFS/FD	FSS = FFS/FD	FSS = FFS/FD	FSS = FFS/FD	FSS = FFS/FD
1.61	**2.28**	**1.97**	**1.99**	**2.08**

Table 5. Garmany Site ELJ's and Revetment Logs Factor of Safety Values

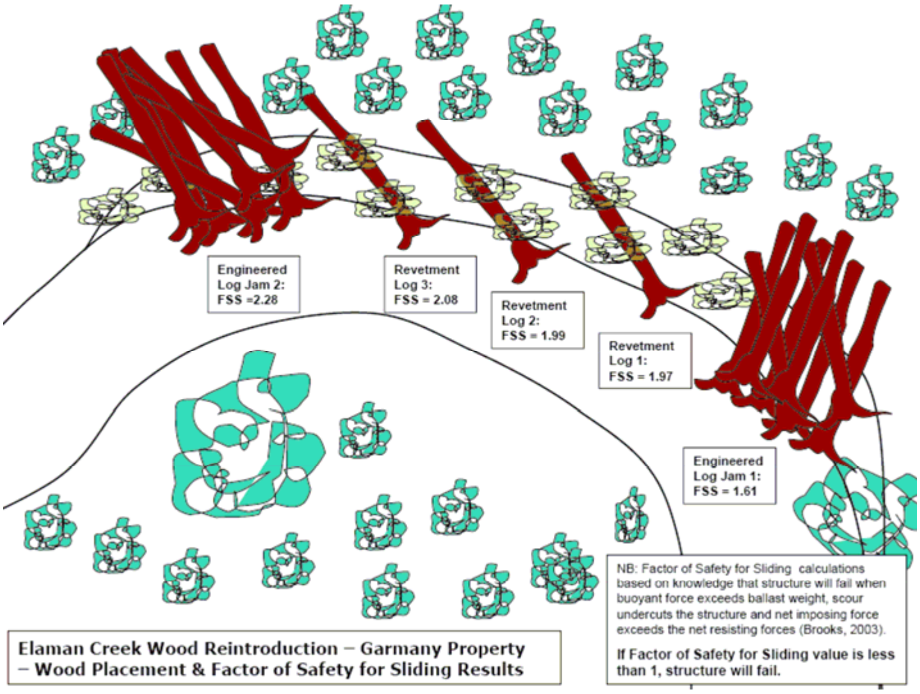

Figure 14. Garmany Site ELJ's and Revetment Logs Factor of Safety Values

Cork Wood Reintroduction Site

Engineered Log Jam Number 1	**Engineered Log Jam Number 2**	**Engineered Log Jam Number 3**	**Revetment Log No. 1**	**Revetment Log No. 2**
FSB Factor of safety for Buoyancy	FSB Factor of safety for Buoyancy	FSB Factor of safety for Buoyancy		
FSB = WBL/FB	FSB = WBL/FB	FSB = WBL/FB	FSB = WBL/FB	FSB = WBL/FB
37.55	**55.6**	**40.29**	**107.8**	**115.03**
FSS Factor safety for sliding	FSS Factor safety for sliding			
FSS = FFS/FD	FSS = FFS/FD	FSS = FFS/FD	FSS = FFS/FD	FSS = FFS/FD
1.66	**1.96**	**1.85**	**3.18**	**3.2**

Table 5. Cork Site ELJ's and Revetment Logs Factor of Safety Values

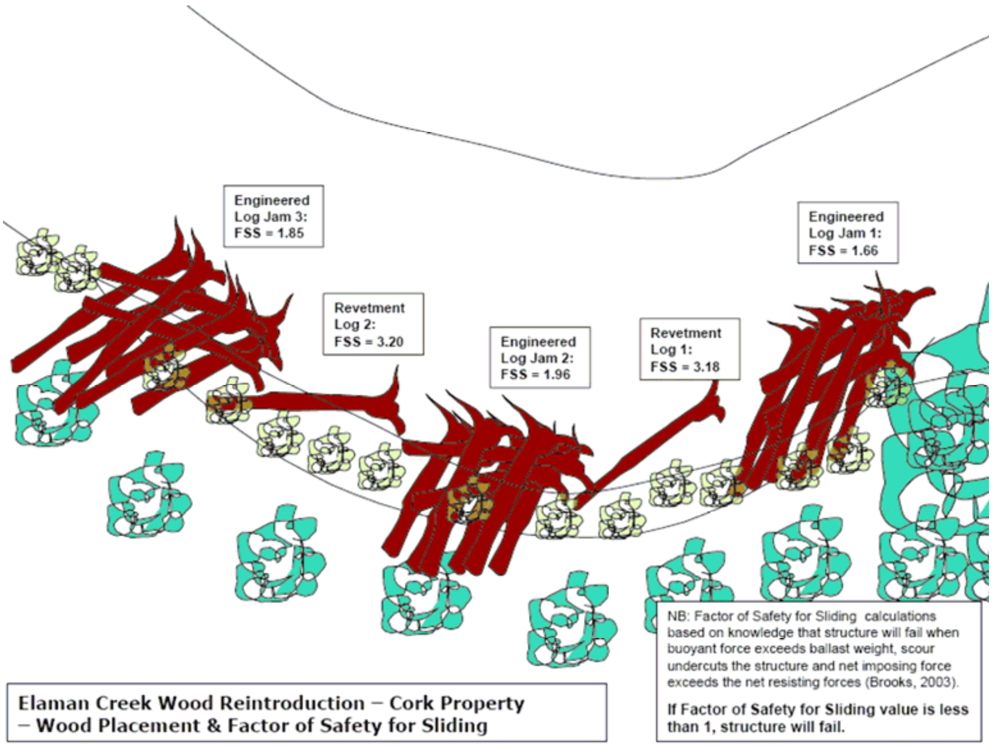

Figure 15. Cork Site ELJ's and Revetment Logs Factor of Safety Values

EXPECTED OUTCOMES OF WOOD REINTRODUCTION

It is expected that the wood reintroduced into Elaman Creek in the form of ELJ's and revetment logs will protect the scoured bank from stream flow, while also initiating erosion on the inside bend, where gravel is currently being deposited. The wood on the outer bend will protect the eroding bank, while also slowing the flow of the stream, thus creating deposition on the outside bend. It is hoped that over time the channel will move towards the inner bend, taking the pressure off the scoured bank. It is not believed any problems will be caused by the loss of material from the inner bend.

The revetment logs will protect the bank from flow associated with secondary currents that may be caused by the presence of the ELJ on flow. Using the theory that the length of bank protected is approximately 3-5 times the width of the structure exposed to flow, it is calculated that all of the scoured bank will be protected by the two ELJs and revetment logs.

The initial ecological benefit of the wood reintroduction will be the establishment of biofilm on the logs. This biofilm consists of microscopic bacteria, fungi and algae and can process carbon and other nutrients that contribute to ecological processes such as production and respiration, the basis for natural food chains (Cottingham, et al, 2003).

Both the engineered log jams and the revetment logs will also provide structural habitat for Elaman Creek's larger aquatic life. Once biofilm has established on the wood an increase in diversity and number of macroinvertebrate and native microphyte populations is expected, thus an increase in breeding of fish at the site may occur. The total number of fish species and individuals and the number of large bodied fish (including Mary River cod) is expected to increase post-restoration, although large scale increases in fish biomass may take some time.

The diversity of instream habitat created by the reintroduction of the wood will have major benefits for all aquatic life at the site. It is expected that small scour pools will form around the reintroduced wood, creating diversity in channel and bed habitat, a characteristic crucial for increasing aquatic species diversity.

The reduction of sediment from the scoured bank as a result of the wood protection will have benefits in terms of decreasing sedimentation in Elaman Creek and the Mary River.

The transport of logs to the sites, placement and construction of the wood and ELJ's as well as wages for design and supervision of the project had a project expenditure of approximately $17,900.

POST-CONSTRUCTION SITE PHOTO'S AND SITE DESCRIPTIONS

Cork Site – Hollow habitat log placement in pool upstream of eroded bank

Garmany Site – Engineered log jam number 2

Garmany Site – Engineered log jam number 2 from top of bank (note tree planting on upper bank and *lomandra longifolia* planted on steeper bank)

Garmany Site – Looking downstream at engineered log jams 1, 2 & 3 and revetment logs.

Garmany Site – Looking upstream at engineered log jams 1, 2 & 3 and revetment logs.

Garmany Site – Looking downstream at engineered log jams

Garmany Site – Looking downstream at engineered log jams 1, 2 & 3 and revetment logs.

Cork Site – Looking downstream at engineered log jams 1, 2 & 3 and revetment logs.

Cork Site – Looking upstream at engineered log jams 1, 2 & 3 and revetment logs.

Garmany Site – Looking downstream at engineered log jams 1, 2 & 3 and revetment logs.

STREAMBANK FENCING AND OFF STREAM WATERING POINTS

Both of the wood reintroduction sites have incorporated an essential streambank fencing and off stream watering component. At the Garmany site, 300 meters of fencing was erected along Elaman Creek around and downstream of the wood reintroduction site. At the Cork site, 1000 meters of fencing was erected around and downstream of the wood reintroduction site. Pipe, trough and pumps were provided at both sites for the off stream watering of cattle from the now protected creek.

By preventing cattle form accessing the creek, less nutrients and sediment will be entering the creek and native riparian vegetation will have a chance to regenerate and recreate a healthy riparian vegetation buffer zone. This will greatly benefit the native fish species in Elaman Creek.

Riparian fencing at Cork Site

REVEGETATION OF WOOD REINTRODUCTION SITES

Once the wood reintroduction and construction at the sites was completed, both the Garmany and Cork sites were revegetated with local native riparian plant species. Barung Landcare's Jonathan Waites managed the revegetation of both of these sites.

1114 trees were planted at the Garmany site by the Barung Landcare Green Corps team and a Conservation Volunteers Australia team. At the Cork site, 540 trees were planted by the Woodford Folk Festival Green Corps team and another Conservation Volunteers Australia team. Rainsaver gel was used for all of the tree plantings and each tree was thoroughly mulched to improve their survival rate. The trees were all well watered immediately after planting.

The predominant riparian species planted at the two sites were:

- *Lomandra longifolia*
- *Acacia melanoxylon*
- *Eucalyptus tereticornis*
- *Melia azedarach*
- *Ficus coronata*
- *Casuarina cunninghamii*
- *Toona australis*
- *Callistemon salignus*
- *Araucaria bidwillii*
- *Commersonia bartramia*
- *Waterhousia floribunda*

Initially, Millet seed was spread over the area where soil was left exposed from the log jam construction as a temporary measure to hold the soil until the revegetation was undertaken.

During revegetation *Lomandra longifolia* was densely planted along the bank where the soil had been disturbed. The riparian tree species were planted on the mid to upper sections of the bank. Once established, the roots of the trees will assist in holding soil and stabilising the bank. The shade over the stream from the established trees will provide the cool water temperatures required by many of our native aquatic life, including our recreational fishing species.

As already mentioned Powerlines crossed the creek at both of the sites. Underneath these powerlines plant species that grow only to 10m were planted.

Upper bank revegetation at Cork Site

Conservation Volunteer Australia team members planting *Lomandra longifolia* on the steep sections of the Garmany site

COMMUNITY AND SCHOOL EDUCATION

This project has had a significant community education component. Three separate field days have been held with the Conondale State School, Widgee State School and Maleny River School with the assistance of the Barambah Environmental Education Centre. The education component of this project has links with the QDPI Recreational Fishing Program operating through the Environmental Education Centres.

Each of the field days began with an introduction session delivered by Mark Cridland (Barambah Environmental Education Centre) based on a very hands-on approach to explaining connections in our freshwater ecosystems.

The students were then split into four groups, which rotated between the four activities listed below:

Macroinvertebrate Sampling:-

- Students pick and sort sample of macroinvertebrates from local Creek
- Collect and identify as many species as possible
- Complete signal score sheet and discuss final score

Water Quality Sampling and Riparian Assessment:-

- Students use water testing equipment to measure temp, pH, EC, DO and Turb of water sample from local Creek
- Students fill out water quality testing sheet
- Students discuss each parameter, and compare to water quality guidelines
- Students identify dominant riparian vegetation
- Students fill out and discuss riparian assessment data sheet

Native Fish Species Identification:-

- Students identify fish species from fish collected from local Creek
- Students discuss each type of fish and their place in the ecosystem/food chain

Recreational Fishing Demonstration:-

- Demonstration of sustainable recreational fishing
- Types of equipment
- Correct types of bait
- Correct handling
- Species ID
- Catch and release methods

Conondale State School students practising recreational fishing skills and Macroinvertebrate sampling

The field days have allowed students to understand the many problems our native fish populations are encountering, such as sedimentation, lack of in-stream habitat and barriers to fish movement. The field days have encouraged a local interest in our native fish populations and have demonstrated sustainable freshwater fishing practices to the students.

In the future, today's children will be responsible for our waterways and the fish that inhabit them. By educating these children, we hope to foster an ethic of care for improving our streams for native fish and the sustainable fishing of our streams for many years to come.

Releasing Mary River Cod fingerlings with Conondale State School students

Sustainable recreational fishing instructions by Mark Cridland (Barambah Environmental Education Centre)

MARY RIVER COD FINGERLING PRODUCTION AND RELEASES

As part of this project, funding was supplied to the Noosa District Community Hatchery to assist in the raising of Mary River Cod fingerlings. The hatchery has been in operation for over 40 years, and have now nearly perfect the art of raising Mary River Cod, producing an average or 50,000 Mary River Cod fingerlings every year. Brood stock are collected from around the Mary River catchment to produce fingerlings with a healthy genetic diversity.

Initially 300 Mary River Cod fingerlings were released with the Conondale State School students. The Mary River Cod fingerling release created a great deal of enthusiasm and interest amongst the students and within the wider community.

Unfortunately this was to the only environmental release of Mary River cod fingerlings for the 2006 season. A severe storm hit the Lake Macdonald area (where the hatchery is located) on 16th of December. The hatchery sustained quite severe damage, losing part of the roof. The power was also cut for a long period, meaning no aeration for the fingerlings. When safe from the storm, staff returned to the hatchery and those fingerlings that survived were immediately released into Lake Macdonald, as they would not last much longer in the damaged hatchery.

Due to this unfortunateevent, the release of Mary River cod fingerlings into Elaman Creek to enhance the existing fish stocks did not occur. The project and hatchery staff were all extremely disappointed at the loss of the 2006 fingerlings, as much work had gone into the breeding and rearing processes. Plans are now in place for fingerlings to be released into Elaman Creek as soon as the Hatchery resumes operations and new fingerling stocks are produced.

Mary River cod fingerling release with the Condondale State School students

MONITORING AND EVALUATION

This report has detailed the pre-construction assessment of the Elaman Creek wood reintroduction site. The following ongoing monitoring will be undertaken:

Monitoring	Method	Frequency	Responsible Group
General stream and riparian condition (including macroinvertebrates, water quality bank stability)	Index of Stream Condition	12 months	Mary River Catchment Coordinating Committee
Condition (growth) and diversity of riparian vegetation	Corridors of Green Vegetation Assessment	2 years	Mary River Catchment Coordinating Committee
Fish species abundance and diversity	Electro-fishing and data analysis	3 years	Department of Primary Industries Fisheries
Geomorphic stability (bed and channel changes, movement of logs)	Stream surveying (DTM)	2 years	Mary River Catchment Coordinating Committee

REFERENCE LIST

Koehn, J., Rutherfurd, I., Humphries, P., & Crook, D., 1999, Snags : a valuable resource, Cooperative Research Centre for Fresh Water Ecology.

Simpson, R. R., & Mapleston, A.J., 2002, Movements and habitat use by the endangered Australian freshwater Mary River cod, Maccullochella peelii mariensis, Environmental Biology of Fishes, 65: 401-410.

Keller, E.A., & Macdonald, A., 1995, River Channel Change: The Role of large Woody Debris, Changing River Channels, John Wiley and Sons Ltd.

Brooks, A., 1999, Large Woody Debris and the Geomorphology of a Perennial River in South-East Australia, Second Australian Stream Management Conference, Cooperative Research Centre for Catchment Hydrology, Adelaide, South Australia.

Brooks, A., 2003, Technical Report on the Design of Large Woody Debris Erosion Control Structures on the Williams River NSW, Centre for Riverine Landscapes, Griffith University, Nathan, QLD

Cottingham, P., Bunn, S., Price, P., Lovett, S., 2003, Managing Wood in Streams, River and Riparian Land Management Technical Guideline Number 3, Land and Water Australia, Canberra.

Dudgeon, S., 2000, Obi Obi Creek large woody debris habitat Restoration Project, Department of Natural Resources, North Coast Region, Queensland, Australia.

Buffington, J.M., & Montgomery, D.R., 1999, Effects of hydraulic roughness on surface textures of gravel-bed rivers, Water Resources Research, vol. 35.

Erskine, W.D. & Webb, A.A., 2003, Desnagging to Resnagging: New Direction in River Rehabilitation in Southeastern Australia, River Research and Applications, 19: 233-249.

Gippel, C.J., 1999, Methods for assessment of large woody debris in rivers for management purposes: case study of Edward river, NSW, Second International River Management Symposium Speaker Papers 134-137.

Ladson, A.R., & White, L.J., 1999, An Index of Stream Condition: Reference Manual, Department of Natural Resources and Environment, Waterways Unit, Melbourne.

Freshwater Biological Monitoring, Department of Natural Resources and Mines, 2001, Australia – Wide Assessment of River Health: Queensland AusRivAS Sampling and Processing Manual, Environment Australia, Canberra, ACT.

Foster, D., 1994, Waterwatch Queensland Technical Manual, Department of Primary Industries, QLD,

Rutherfurd, I.D., Jerie, K., & Marsh, N., 2000, Some Observations on the Amount and Distribution of Large Woody Debris in Australia, Rip Rap, LWRRDC's Riparian Lands Management Newsletter, Edition 16.

Marsh, N., Jerie, K., & Gippel, C., Sampling Large Woody Debris Loading in Streams: A Comparison of the Line-Intersect and Census Methods.

Brooks, A., 2003, Technical Report on the Design of Large Woody debris Erosion Control Structures on the Williams River, NSW, Centre for Riverine Landscapes, Griffith University, QLD.

D'Aoust, S.G.D, & Millar, R.G., 1999, Large Woody Debris Fish Habitat Structure Performance and Ballasting Requirements. British Columbia, Watershed Restoration Program, BC Ministry of Environment, Lands and Parks and Ministry of Forests.

Stockwell, B.R., 2000, The Mary River and Tributaries Rehabilitation Plan, A review of river processes, fluvial geomorphology and ecological concepts and their application to a river rehabilitation plan for a major south-east catchment, Mary River Catchment Coordination Committee, QLD.

Appendix 1: Water Quality Data From Elaman Creek

Stream:	Elaman Creek
Date:	20/07/2006
Site:	Garmany Wood Reintro
Temperature:	12.6
pH:	7.49
Electric Conductivity (ms/cm):	0.405
Turbidity (NTU):	5
Dissolved Oxygen (mg/l):	6.56
Filt Reactive Phosphate (mg/l):	0.12
Nitrate (mg/l):	0.35

Stream:	Elaman Creek
Date:	20/07/2006
Site:	Cork Wood Reintro
Temperature:	15.1
pH:	7.42
Electric Conductivity (ms/cm):	0.36
Turbidity (NTU):	3
Dissolved Oxygen (mg/l):	6.71
Filt Reactive Phosphate (mg/l):	0.11
Nitrate (mg/l):	0.5

Appendix 2: Corridors of Green Vegetation Assessment of Elaman Creek Wood Reintroduction Sites (Transect 1)

Date	Project Name	Watercourse/Location	Quadrat Location (m)	Quadrat No.	Foliage Projective Cover	Bare Earth	Litter Cover	LC - BE	Weed Cover	Weed Score (inverted 5=1, 4=2, 3=3, 2=4, 5=1)	Weeds - % dicot	Weeds - % monocot	Litter Depth (cm)	Plant Species	Planted or Remnant	height <2m	height >2m	Shrub Diversity Score (No of spp, out of 5, more than 5 given a 5)	Tree Diversity Score (No of spp, out of 5, more than 5 given a 5)	Recruits	No. of recruits	No. of recruits Score (0=0, 1-5=1, 6-10=2, 11-15=3, 16-20=4, >20=5)	Recruit Diversity Score (1 recruit spp=1, 2=2, 3=3, 4=4, 5=5, >5=5)	Weeds of Concern	Weeds of Concern Diversity Score (1 or 0 weed spp=5, 2=4, 3=3, 4=2, 5=1, >5=0)	Comments	Ground Cover Diversity Score (1 spp=1, 2=2, 3=3, 4=4, 5=5, >5=5)	C&D Quadrat Score (out of 40)	Total Score (out of 45)
20/07/2006	Cork Wood Reintro	Elaman Creek	0-5	1	1	1	1	0 0	5	1	0	100	0					0	0			0	0	Pasture Grass	5		1	8	8
20/07/2006	Garmany Wood Reintro	Elaman Creek	0-5	1	1	1	1	0 0	5	1	0	100	0											Pasture Grass	5		1	8	8

Appendix 3: Macroinvertebrate Assessment of Elaman Creek Wood Reintroduction Sites

Garmany Wood Reintroduction Site

Order	Common Name	Sub-order	Family	SIGNAL 2 Sensitivity Grade	Number of Specimens	Weight Factor	Grade x Weight Factor
Ephmeroptera	May Fly		Leptophlebiidae	8	9	3	24
	May Fly		Baetidae	5	6	3	15
	May Fly		Prosopistomatidae	4	6	3	12
Decapoda	Fresh shrimp		Atyidae	3	9	3	9
	Fresh prawn		Palaemonidae	4	6	3	12
Odonata	Damsel fly		Isosticidae	3	3	2	6
	Dragon Fly	Anisoptera	Libellulidae	4	5	2	8
	Dragon Fly	Anisoptera	Gomphidae	5	4	2	10
Plecoptera	Stonefly		????	8	1	1	8
Trichoptera	Caddis fly		Leptoceridae	6	20	4	24
	Caddis fly		Hydroptidae	8	1	1	8
			Calamoceratidae	7	3	2	14
			Hydropsychidae	6	3	2	12
Hemiptera	Water Strider		Plidae	2	3	2	4
	Water Boatman		Corixidae	2	30	5	10
	Water scorpion		Nepidae	3	2	1	3
Diptera	True fly		Chiromidae	3	4	2	6
Acariformes	Water mite		Eylaidae	5	50	5	25
Totals						17	60
	Average (SIGNAL Score without abundance weighting):			4.8			
	SIGNAL 2 SCORE =	3.53					

Garmany Wood Reintroduction Site

Order	Common Name	Sub-order	Family	SIGNAL 2 Sensitivity Grade	Number of Specimens	Weight Factor	Grade x Weight Factor
Hemiptera	Water Strider		Plidae	2	2	1	2
	Water Boatman		Corixidae	2	5	2	4
Ephmeroptera	May Fly		Leptophlebiidae	8	10	3	24
	May Fly		Baetidae	5	20	4	20
Odonata	Dragon Fly	Anisoptera	Gomphidae	5	2	1	5
Decapoda	Fresh shrimp		Atyidae	3	5	2	6
	Fresh prawn		Palaemonidae	4	4	2	8
Trichoptera	Caddis fly		Leptoceridae	6	30	5	30
	Caddis fly		Calamoceratidae	7	2	1	7
Plecoptera	Stonefly		????	8	1	1	8
Acariformes	Water mite		Eylaidae	5	10	3	15
	Water mite		Anisitsiellidae	7	10	3	21
Gastropoda	Fresh snails		Lymnaeidae	1	3	2	2
Coleoptera	Beetles		Hydrophilidae	2	4	2	4
Bivalva	Fresh mussels		Sphaeridae	5	2	1	5
Diptera	True fly		Chiromidae	3	2	1	3
Totals						12	50
	Average (SIGNAL Score without abundance weighting):			4.6			
	SIGNAL 2 SCORE =	4.17					

Appendix 4: Characteristics of Wood Reintroduced at Wood Reintroduction Site

Elaman Creek LWD

Cork Log Measurements

No	Length	Ave Circum	Root Wad Height	Ave Diameter
1	11.7	1.75	1.7	0.557324841
2	12.6	1.3	1.8	0.414012739
3	14.5	1.2	0.9	0.382165605
4	13.2	1.15	0	0.366242038
5	9.7	1.21	1	0.385350318
6	11.5	1.65	1.1	0.525477707
7	8.3	1.3	0	0.414012739
8	11.1	1.27	0.7	0.404458599
9	9.5	1.6	1.8	0.50955414
10	10.6	1.4	1.8	0.445859873
11	9.7	1.46	1.5	0.464968153
12	9.1	1.45	1.8	0.461783439
13	8.2	1.3	1.4	0.414012739
14	10.4	1.35	1.7	0.429936306
15	14.3	1.4	1.1	0.445859873
16	11.8	1.35	1.8	0.429936306
17	11.4	1.45	1.3	0.461783439
18	9.6	1.4	1.5	0.445859873
19	11.4	1.35	1.7	0.429936306
20	12.2	1.6	1.8	0.50955414
21	11.3	1.7	1.65	0.541401274
22	11.3	1.5	1.6	0.477707006
23	12.1	1.35	1.5	0.429936306
24	11.4	1.35	1.5	0.429936306
25	9.4	1.8	2	0.573248408
26	11.2	1.6	1.3	0.50955414

Elaman Creek LWD

Cork Log Measurements

No	Length	Ave Circum	Root Wad Height	Ave Diameter
1	10	1.3	2.15	0.414012739
2	10	1.2	0.9	0.382165605
3	8.8	1.25	1.4	0.398089172
4	9.4	1.38	1.8	0.439490446
5	10.7	1.45	2.1	0.461783439
6	10.6	1.55	1.9	0.493630573
7	10.1	1.2	2	0.382165605
8	10.6	1	1.8	0.318471338
9	9.2	1.12	2	0.356687898
10	10.1	1.34	1.4	0.426751592
11	10.3	1.2	1.9	0.382165605
12	10.2	1.42	1.6	0.452229299
13	9.1	1.17	1.2	0.372611465
14	12.8	1.3	1.8	0.414012739
15	9	1.15	0	0.366242038
16	10.3	1.26	0.9	0.401273885
17	10.8	1.27	1.4	0.404458599
18	10.3	1.8	1.4	0.573248408
19	9.7	1.08	0.8	0.343949045

Appendix 5: Mass to Anchor Calculations for Elaman Creek Wood Reintroduction Site

Garmany Wood reintroduction Site:

Mass to counter root wad drag	Rank	Mbl (mass to counter buoyancy)=	Rank	Mdblb (mass to counter boulder lift and drag)	Rank	Total Mass to Anchor (Ms) = Mdrw + Mbl + Mdblb	Rank
41795.62065	1	1007.770402	18	32286.59228	1	74727.88665	1
39874.24274	5	847.862078	6	31381.25821	5	72050.00923	5
36167.1136	7	794.5082763	5	29317.47512	7	66041.06717	7
36167.1136	9	726.6695705	14	29272.68556	9	65912.15346	9
32640.82002	6	671.4975095	12	27569.47527	6	61058.15737	6
32640.82002	11	645.6737195	1	27405.75883	11	60596.58431	11
29295.36202	4	622.1798612	4	25632.43398	14	55654.46556	14
29295.36202	8	581.0202505	10	25572.92476	4	55490.46663	4
29295.36202	14	560.9594273	17	25456.25638	8	55169.29796	8
23146.9527	12	556.4784515	7	21967.06975	12	45785.51997	12
17721.88566	3	550.0054599	11	18714.7055	18	37444.36157	18
17721.88566	10	488.2004904	16	18429.3419	10	36732.24782	10
17721.88566	17	472.3542981	9	18415.87317	17	36698.71827	17
17721.88566	18	458.1872005	3	18346.79502	3	36526.86788	3
13020.1609	13	433.5200147	2	14987.32284	13	28410.06971	13
7323.840504	2	417.6795654	8	10447.34985	16	18259.39084	16
7323.840504	16	402.585975	13	10398.5419	2	18155.90242	2
5786.738176	19	340.7502521	19	8885.559831	19	15013.04826	19
0	15	333.3714228	15	1275.798366	15	1609.169789	15

Cork Wood reintroduction Site:

Mass to counter root wad drag	Rank	Mbl (mass to counter buoyancy)=	Rank	Mdblb (mass to counter boulder lift and drag)	Rank	Total Mass to Anchor (Ms) = Mdrw + Mbl + Mdblb	Rank
36167.1136	25	1111.321344	1	29554.1927	25	66723.45634	25
29295.36202	2	1016.17079	21	25785.25171	20	56076.1651	20
29295.36202	9	1002.15004	25	25675.26876	9	55772.58726	9
29295.36202	10	995.5513735	20	25630.41725	16	55648.90576	16
29295.36202	12	922.0213485	6	25627.04523	2	55639.60993	2
29295.36202	16	866.0645828	26	25618.78562	10	55616.84192	10
29295.36202	20	830.1323928	15	25592.5749	12	55544.60619	12
26130.73958	1	807.5550628	22	24024.61494	1	51266.67586	1
26130.73958	14	801.9564754	9	23776.06388	19	50596.46351	19
26130.73958	19	734.3265036	17	23745.88667	14	50515.24078	14
24616.24169	21	723.1264926	16	23068.68212	21	48701.0946	21
23146.9527	22	717.2026904	2	22050.64495	22	46005.15272	22
20344.0014	11	702.6942765	10	20227.23058	23	41272.76431	23
20344.0014	18	701.5323278	23	20204.32908	24	41214.13093	24
20344.0014	23	689.6600602	19	20202.53375	11	41209.53531	11
20344.0014	24	665.800457	24	20169.11003	18	41124.00118	18
17721.88566	13	663.000165	11	18348.83007	13	36531.92785	13
15280.6055	17	656.6692741	12	16951.90241	26	33098.57248	26
15280.6055	26	638.6145304	14	16859.57134	17	32874.50334	17
10940.55186	6	615.0152317	3	13802.22384	6	25664.79705	6
10940.55186	15	610.8897513	18	13730.85568	15	25501.53994	15
9041.7784	5	519.7093843	8	11883.33965	5	21360.16926	5
7323.840504	3	488.9447535	4	10560.10904	3	18498.96477	3
4430.471416	8	461.2121208	13	7707.446225	8	12657.62703	8
0	4	435.0512053	5	1646.909201	4	2135.853955	4
0	7	392.875526	7	1423.420161	7	1816.295687	7

Appendix 6: Logs to be used in each ELJ at Elaman Creek Wood Reintroduction Site

Garmany

ELJ 1

1	5	
4	8	12
17	3	13

ELJ 2

11	14		
18	10		
16	2	19	15

Revetment Logs	7	9	6

Cork

ELJ 1

25	20		
12	1		
5	15	6	17

ELJ 2

9	16		
19	14		
3	8	7	4

ELJ 3

2	10		
21	22		
11	18	13	26

Revetment Logs	24	23