Obi Obi Creek

Large Woody Debris

Reinstatement Project

2003

ACKNOWLEDGEMENTS

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John & Beverly Pryor	Project site landholder,
Brad Wedlock	Industrial Placement Supervisor,
Dr Nick Marsh	CRC Catchment hydrologist
Ernie Rider	Queensland Parks and Wildlife – Regional Botanist,
Brian Stockwell	Department of Natural Resources and Mines – Resource Manager
Bob Watson	Department of Natural Resources and Mines – Landcare Manager
Stephen Dudgeon	Department of Natural Resources and Mines – Rivercare Officer
Phil Trendell	World Wide Fund for Nature – Mary River Cod Recovery Officer,
Phil Berrill	Mary River Catchment Coordinating Committee – Waterwatch Officer
Mim Coulstock	Barung Landcare – Coordinator,
Maroochy Shire Council	Cr Hermann Schwabe - Councillor
Belinda Clarke	Maroochy Shire Council – Greening Australia Extension Officer,
Kath Kelly	Maroochy Shire Council – Catchment Manager,
Tiaro Shire Council	Cr John Horrex - Mayor
Mandy Botterell	Lake Baroon Catchment Care – Education Officer,
Stuart Bunn	CRC Catchment Hydrology
Peter Brown	Field Assistant
Susan Bryce	Editor of Mary Valley Voice

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1 INTRODUCTION

1.1 Purpose of the Project

The purpose of this project is to use re-introduced timber (Large Woody Debris, LWD) to:

- lessen the erosive processes acting upon the project site's southern bank by increasing the stream's geomorphic diversity back to a level closer to that of a pre-European state (see figure 1 & 2), and to
- provide habitat for the endangered Mary River Cod (*Maccullochella peelii mariensis*).
- Return the stream reach large woody debris loading (i.e. the quantity of submerged timber) to original conditions for reasonably intact Australian rivers.

The aim of this report is to devise a Site Management Plan, which outlines the steps taken in order to implement a successful LWD project. The report outlines the baseline data that is to be collected before project implementation, methodologies for evaluation after project completion and outlines some of the issues encountered along the way. This report details the techniques that have been trialled and refined using the Pryor project site located in the Obi Obi Creek Catchment as a working model.

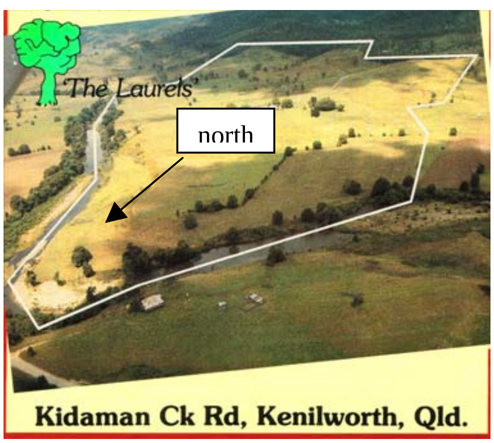


Figure 1: Obi Obi Creek Test Reach - 1982

Figure 2: Obi Obi Creek Test Reach - 2001

1.2 Project Site Location

The headwaters of the Mary River originate in the Conondale Ranges in the Bellthorpe – Maleny region, one hour north of Brisbane in sub-tropical South – east Queensland. This catchment of

9595 sq. km drains north-ward for 300 kilometres emptying into the Ramsar-listed Great Sandy Straits west of Fraser Island, and north-east of Maryborough, at River Heads (Figure 3). The Mary River has several major tributaries including Obi Obi Creek (Mary River Catchment Coordinating Committee, 1997).

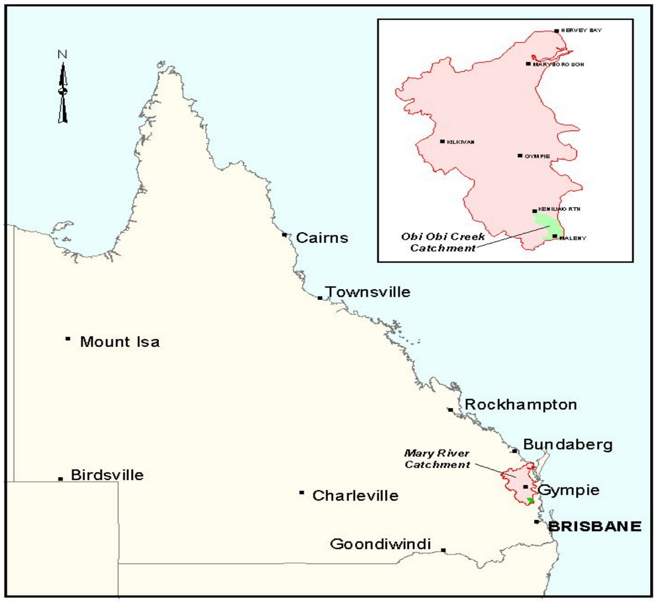


Figure 3. Mary River Catchment.

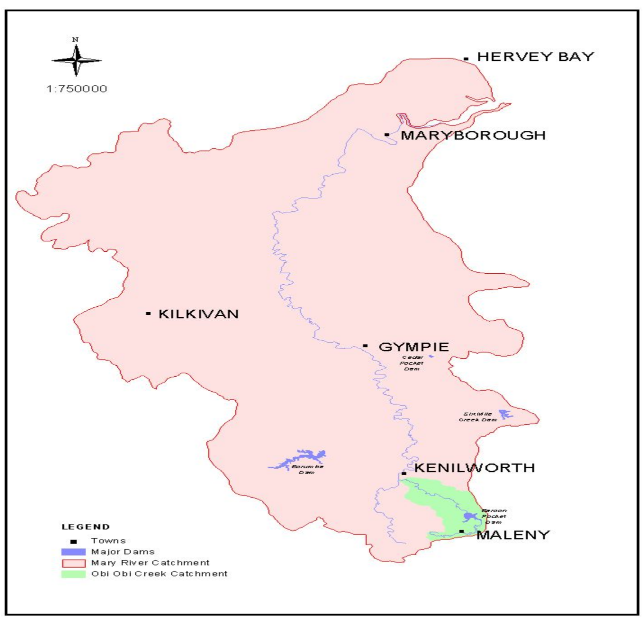


Figure 4: Obi Obi Creek Catchment

Obi Obi Creek drains 202km^2 in the south of the Mary River Catchment (Figure 4), and has a mean annual discharge of 156 000 ML (Stockwell 2001, pp 28). This represents approximately 2.1% of the total Mary Catchment area, and 6.1 % of the total discharge volume of the Mary River.

The lower Obi Obi Creek valley is dominated by the Baroon Pocket Dam, which provides the urban population of the Sunshine Coast with drinking water, as well as supplying irrigation water to a number of dairy-farms and beef grazing farms along the lower Obi Obi Creek. Obi Obi Creek empties its waters into the Mary River at Kenilworth after having flowed 58 kilometres from an area surrounding the township of Maleny.

The area between the downstream floodplains and Baroon Pocket Dam is steep, rugged country with very limited vehicular access. A significant portion of this reach is included within the Kondalilla National Park (MRCCC, 1997).

The large woody debris (LWD) project site is situated in an area called Kidaman Creek, and is located 32 kilometres from the Obi Obi Creek's source. The site is owned by John and Beverley Pryor (see figure 1, 2, 5 & 6). 'The property is a 200 acre cattle grazing property with 1000 metres of Obi Obi Creek frontage. The property has been owned by the Pryors since 1984' (Pryor, J., Pers. Comm. (verbal), 2002).

Figure 5: Obi Obi Creek – Pryor Test Reach (1997)

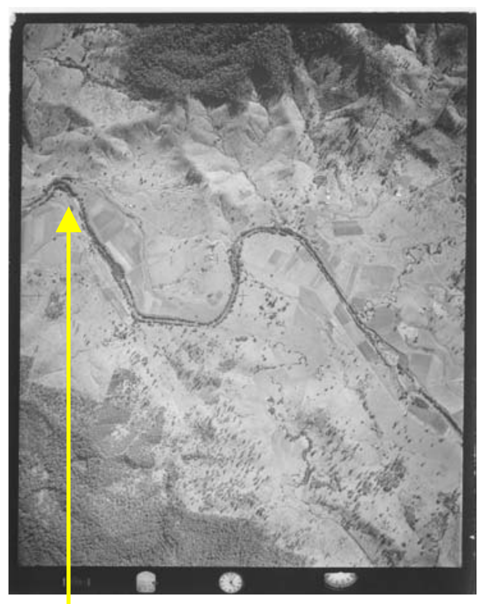


Figure 6: Obi Obi Creek – Pryor Test Reach (1940's)

1.3 Why has this site be chosen?

The project site has been chosen for LWD works as it exhibits an approximate 450 metre incised, over widened, regulated high energy stream (Dudgeon, 2000) with unstable, undercut, rapidly eroding and slumping southern banks to a height of up to four metres (Wedlock, B. pers. Comm (verbal) 2002) see figure 7. Being void of any natural riparian vegetation, the project site is exhibiting an erosion rate of 1.80 metres per year (Pryor, J,. Pers. Comm. (verbal), 2002) see figure 8.

Figure 7: Obi Obi Creek Pryor test reach – looking upstream (island on left)

Figure 9: Obi Obi Creek Pryor test reach – looking upstream (whole reach)

Glenda Pickersgill (World Wide Fund for Nature, Mary River Cod Recovery) identified the Pryor project site as a degraded critical link for the endangered Mary River Cod during the Mary River Cod mapping project. This strategic link exists between the protected Mary River Cod habitat area of the Kondalilla National Park and an area downstream of Obi Obi Crossing No. 2 (Pickersgill 1999), where a local resident recently caught a Mary River Cod (Trendell, P., Pers. Comm. (verbal), 2001).

A stakeholder group was formed to decide appropriate LWD project sites within the Maroochy Shire. Maroochy Shire was chosen for these styles of works because of the important ecological and in-stream value of the lower Obi Obi Creek identified by numerous reports (Pickersgill, 1999; Stockwell, 2001). Maroochy Shire Council were also instrumental in providing assistance to the MRCCC for the first LWD project in Queensland, and were willing to continue this successful work with further projects.

A stakeholder group comprising Maroochy Shire Council, Department of Natural Resources and Mines (DNR&M), the Mary River Catchment Coordinating Committee (MRCCC), Greening Australia representatives and landholders was formed. The stakeholder group held a prioritisation day where the group inspected a number of potential LWD sites within the Shire.

These sites were then prioritised according to its merits of demonstrating the use of LWD for bank stabilization and creation of in-stream habitat. The stakeholder group decided the most appropriate site to demonstrate this set of criteria was the Pryor project site, on Obi Obi Creek.

Mary River & tributaries Rehabilitation Plan

This project site is contained within Obi Obi Creek Reach 4 of the Mary River and Tributaries Rehabilitation Plan and attains a priority as a 'Linking Reach and Significant Remnant Section' (Stockwell 2001, p 71). This Reach contains areas of significant remnant riparian areas which are isolated by degraded linking reaches. It is the aim of the Obi Obi Reach 4 section of the Rehabilitation Plan 'to connect reaches with high recovery potential' (Stockwell 2001, Figure 5.5).

Mary River Catchment Strategy

This project also fits with the Mary River Catchment Strategy under:

- River Bank Stabilisation (RBS5) 5.1 – Developing suitable actions linked with workshops to minimise bank erosion on Obi Obi Creek.
- Wildlife and Natural Environment (WNE2) 2.1 – Finalise and implement the Cod Recovery Plan and Tortoise Recovery Plan.
- Wildlife and Natural Environment (WNE2) 2.3 – Develop and implement shire-wide conservation strategies, including wildlife corridors and links between reserves and national parks.

The MRCCC has consequently targeted this stream for experimental re-snagging after Scott Babakeiffs (visiting Land & Water Australia research fellow from British Columbia, Canada) LWD workshop (held in Kenilworth, December 1999) identified the Obi Obi Creek as suitable for this style of riparian rehabilitative works.

This project site is the second LWD project within the Obi Obi Reach 4 of the Mary River & tributaries Rehabilitation Plan, and will help to implement the Mary Cod Recovery Plan by creating more habitat and breeding opportunities for the Mary River Cod.

1.4 So, what is large woody debris?

Firstly, one must understand that, 'trees and branches that fall into and lodge in our rivers (large woody debris, LWD) are an essential part of the river's ecology (Figure 8). They provide a place for a wide range of plants and animals to live and as water flows over and around snags, they help shape the river' (Koehn et al. 1999, p1). LWD is a key structural habitat component for invertebrates and fish (Harmon et al. 1986), like the endangered Mary River Cod. 'Many fish species use LWD for spawning adhesive eggs e.g. Mary River Cod' (Marsh, Rutherfurd & Jerie 2001, p 391).

Figure 8: Excellent example of large woody debris – Munna Creek, Mary River Catchment

Figure 9: Engineered log-jam – Williams River, Hunter River Catchment (NSW)

Secondly, 'logs branches and other LWD serve important ecological and physical stability functions of in-stream systems. LWD is an essential part of natural healthy stream systems in Queensland (Dudgeon S., pers. Comm (Verbal), 2002). Snags (or LWD) are important for creating a variety of flow conditions that are an essential aspect of the habitat requirements of fish and other river animals' (Dudgeon 2000, p1). Through research undertaken by the Mary River Cod Recovery Team, they identified that 90% of a Mary River Cod's life is spent within 3 metres of a snag (Trendell, P. pers. comm. [verbal] 2002). This variety of flow conditions that LWD creates, typically fast and slow water velocities, scour within the bed and aggregation and deposition zones form the geomorphic and hydraulic diversity of a stream required by different species of in-stream fauna and flora.

Thirdly, snags (or LWD) are important for maintaining bed and bank stability. They settle in the bed of streams to form 'hard' or control points that are important for reducing potential bed scour and erosion (figure 9). They also help to store sediment and hold pools in the stream system. They are particularly important in sand or loose material beds (Dudgeon 2000, p1).

Two hundred years of de-snagging (a once actively encouraged practice) since the arrival of Europeans has resulted in the degraded river systems seen in all Australian states. 'The practice of de-snagging, or removal of in-stream large woody debris (LWD), has been widespread in Australian rivers throughout the last 200 years' (Brooks et al. 2001, p1). Dudgeon (2000) noted that 'The Land and Water Resources and Research & Development Corporation (LWRRDC) has found that there is little direct evidence to support the argument that de-snagging reduces flood frequency or that it significantly improves the capacity of the river (or streams) to carry floods.' As identified in Gippel et al. (1992), in many rivers almost the entire natural LWD load has been removed, while catastrophic floods still occur.

As a direct result of desnagging Australian streams, Brooks (1999a&c) and Buffington & Montgomery (1999), report that 'there is strong evidence to infer rivers subjected to de-snagging are now wider, deeper and straighter, have substantially higher rates of sediment flux, and bear little of their pre-disturbance morphological diversity.'

'The Australian experience reflects similar situations throughout the world, where very few rivers retain LWD loadings comparable with that of pre-agricultural forested conditions' (Triska 1984; Maser & Sedell 1994; and Brooks 1999a&b). Natural LWD loadings of reasonably intact Australian rivers has been identified by Rutherford et. al (2000) as being between 0.01 m3/m and 0.1 m3/m. An aim of this LWD project was to bring the LWD loading back to an original loading, and to keep the achieved LWD loading on-site, and to increase the loading through new LWD input.

1.5 Partners in project

1.5.1 Griffith University's fish assemblage data

Griffith University was contracted by MRCCC to undertake a fish assemblage for the first trial LWD site at Obi Obi Creek Road Crossing No. 2. The fish assemblage lists fish species identified within the sampling area on Obi Obi Creek.

Although not required to further extend the assemblage to include the current project site, it must be assumed that a high proportion of the fish species sampled at the Obi Obi Creek Crossing

No. 2 site would be present at the Pryor project site. As justification of this line of reasoning, water quality and temperature, hydraulic diversity and riparian vegetation are similar at both LWD sites (Stockwell, B. pers. Comm. [2002]). Some researchers have suggested that changing the in-stream habitat can increase in fish diversity. McDowall (1996), supports this hypothesis, in suggesting that many fish species require LWD as it forms an integral part of their habitat.

In May 2002 Griffith University undertook a Fish Assemblage Study of the Pryor site, but to date the report has not been completed.

1.5.2 DNR&M Rivercare Study for Pryor Project Site

The design for the Pryor project site originated from a DNR&M Rivercare study for the Pryor project site. The DNR&M design was based on Brooks (2001) work in the Williams River (see figure 9), and centred on the use of a series of deflector jams for bank erosion protection coupled with a bed-control structure to increase the riffle-crest height and divert flows into an existing flood-channel (Dudgeon, 2001).

1.5.3 CRC Catchment Hydrology Detailed Design

Nick Marsh (CRC Catchment Hydrology) also provided suggestions for possible stream rehabilitation strategies for the Pryor project site based on the DNR&M Rivercare report for the site. Marsh (2002), stated that the channel bed appears to be vertically stable, and if the target reach was left unattended the meander length would naturally increase.

The aim of the project should be two-fold. Erosion control on the left bank so that riparian vegetation can be re-established, and the secondary goal would be the creation of in-stream habitat complexity using LWD (Marsh, 2002). The impetus for this method was to control erosion by focusing on preventing the removal of material at the toe of the creekbank.

The use of a series of logs across the highest part of the existing depositional island to divert channel flows through an existing flood-channel was also recommended. These logs would form a permeable, roughened section of stream to reduce flow velocity and reduce bank scalloping on the left bank. The existing left-hand channel would then provide a low flow refuge during base-flow conditions.

The second recommendation by Marsh (2002) suggested a continuous revetment along the toe of the bank to facilitate bank protection, followed by riparian revegetation on the toe of the bank (see figure 10). To add further geomorphic complexity to the site the construction of log groynes or engineered log-jams (ELJ) at key locations along the bank revetment could be undertaken (see figure 11). Three engineered log-jams (ELJ) were recommended (Brooks, A. pers comm. (verbal), 2002), with the largest ELJ positioned on the downstream end of the depositional island (where the two base-flow channels meet each other). The log-jams shown in Figure 8 are similar.

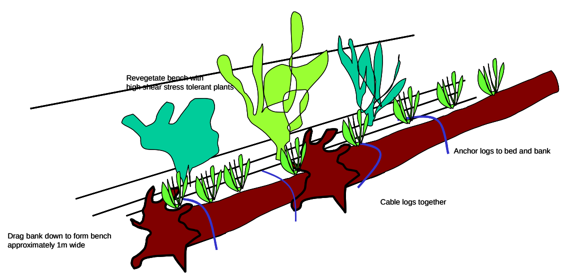


Figure 10: Log revetment design

Figure 11: log revetment placed on Pryor project site, note log groyne in left of picture

METHODOLOGY

1.6 In-stream Assessment

1.6.1 Index of Stream Condition (ISC)

1.6.1.1 The Purpose of ISC

An ISC was chosen for the Pryor project to create a ‘snap shot’ of the site and allow for future re-assessment and indication of success.

The development of an ISC allows a holistic assessment of the health of rivers and streams. The ISC can be used by catchment managers and the community in:

- Benchmarking the condition of specific reaches and/or the whole condition of streams;
- Assessing the long term effectiveness of programs to maintain and rehabilitate streams, as in this LWD Project; and
- Setting priorities to target resources.

The ISC was designed to assess rural stream reaches typically between 10 and 30 kilometres long. However, for this particular LWD project, the ISC has been modified and used to document the condition of the stream before the implementation of the project. This will allow for future re-assessment of this site and will ascertain its successfulness.

For a stream reach, the ISC provides a summary of the extent of changes to:

- Hydrology* (flow volume and seasonality);
- Physical form (stream bank and bed condition, presence of, and access to, physical habitat);
- Streamside zone (quantity and quality of streamside vegetation, and the condition of billabongs);
- Water quality (nutrient concentration, turbidity, salinity and acidity); and
- Aquatic life** (diversity of macro-invertebrates).

NOTE:

* Due to the paucity of hydrological data for the site the Hydrology sub-index is unable to be calculated.

** For the Pryor project site it should be noted that due to restrictions on the availability of AUSRIVAS value only the SIGNAL component of the Aquatic life sub-index can be calculated.

A score is provided for each of these components ('sub-indices'), which is a measure of change from natural or ideal conditions. The ISC is reported as a bar chart that shows the score for each sub-index out of a maximum of ten. The overall score for the ISC is the sum of the 4 sub-index scores, and is out of a maximum of 40.

1.6.1.2 Indicators

There are 15 indicators in the ISC that are used to quantify aspects of stream condition. Related indicators make up each sub-index i.e. Physical Form, Streamside Zone, Water Quality and Aquatic life (Table 1). The indicators determine the actual measurements that are required and these measurements are the basis of the indicator rating.

Table 1 - List of indicators in the ISC.

Sub-index	Indicators within sub-index
Physical Form	Bank Stability
	Bed Stability
	Impact of artificial barriers on fish migration
	In-stream
Streamside Zone	Width of streamside zone
	Longitudinal continuity
	Structural intactness
	Cover of exotic vegetation
	Regeneration of indigenous woody vegetation
	Billabong condition
Water Quality	Total phosphorous
	Turbidity
	Electrical conductivity
	Alkalinity / acidity
Aquatic Life	SIGNAL

Source: Ladson & White (1999), p10.

Calculations used to determine Sub-indices

All calculations for the Sub-indices have used the formulas of Ladson and White (1999), pp 39-74.

1.6.1.3 Determining the ISC reach

- The stream reach was calculated by determining the centre of the test reach, and then marking this central point with a star picket – this becomes the marker for Transect 1 (see figure 12). The next step is to measure 200 metres both up and downstream. The upstream star-picket will mark 'Transect 2', and the downstream star-picket will mark 'Transect 3'. These star pickets will permanently identify the three transects. Each transect runs perpendicular to the flow of the creek, as shown in figure 12. These markers will be constantly referred to in this report.

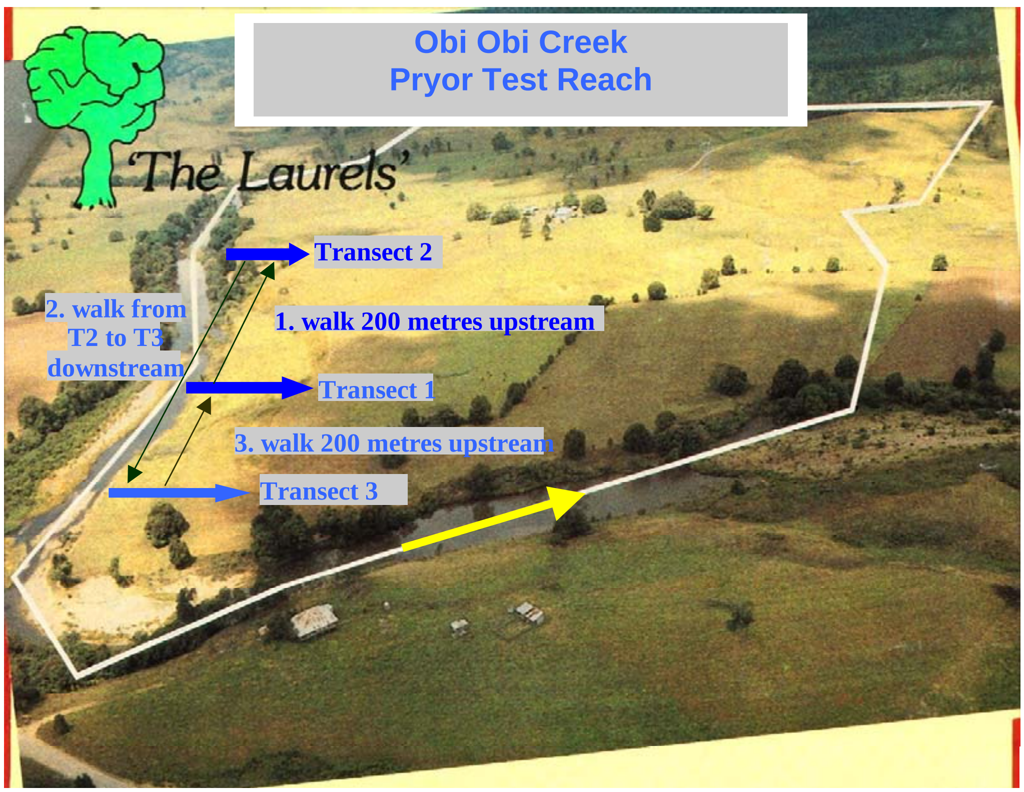


Figure 12. Location of ISC boundaries ISC 2 to ISC 3 at the project site.

In order to complete the ISC, four field data sheets were required to be completed:

- Measuring Site,

- Transect 1,
- Transect 2, and
- Transect 3.

The data sheets are self explanatory and each step is outlined in detail in the ISC field guide. For each of the transect datasheets assessment of bank stability, width of streamside zone (the width of vegetation from the edge of stream to adjacent land use (Ladson and White 1999), structural intactness (the comparison of natural and existing cover of tree layer, shrub layer and ground layer (Ladson and White 1999), cover of exotic vegetation, regeneration of indigenous woody vegetation and livestock access was carried out. For each of the above mentioned assessments either reference photos or schematics were provided as guides in the ISC Reference Manual to aid the collector in making a decision.

1.6.2 Water Quality

Water quality testing at the project site was completed in accordance with Waterwatch guidelines. Tests were carried out using a Palintest 5000 (for nitrates and phosphates) and Horiba U-10 multi-probe portable water testing unit (for acidity/alkalinity {pH}, electrical conductivity {EC}, dissolved oxygen {DO} and temperature). To assure scientific rigour, the following parameters were measured using samples taken from between 9 am and 10 am at the location Transect 1, shown in Figure 3. The ISC required the testing of water for total phosphorus, turbidity, EC and pH. Further testing of water for temperature, nitrates and DO was decided upon due to their effects on the Mary River Cod.

The Palintest 5000 sampling apparatus was washed initially with cold tap water to remove any existing traces from previous tests. At the sampling location Transect 1, the apparatus was again washed in creek water. Samples were taken and the procedure, as outlined Palintest kit was adhered to and the results recorded.

The water testing was performed following Waterwatch guidelines. The turbidity tube was cleaned, the Horiba U-10 calibrated using the calibration solution and then it was positioned in the water ensuring that a constant flow of water washed through it. Date and time were recorded on the data sheets and then the corresponding measures of turbidity, EC, pH, temperature, DO and salinity were recorded.

1.6.3 Macro-invertebrate sampling

'The macro-invertebrate sampling is intended to be a 'catch-all' to detect if anything is affecting the heath of the aquatic ecosystem. A deterioration of the aquatic biota may point to environmental problems' (Ladson & White 1999, p 66).

The 10 metre kick-test and 30 minute sorting was used to representatively sample the macro-invertebrates at the project site (Berrill, P., pers. comm. (demonstration), 2001). This method requires the person sampling to walk backwards, upstream for 10 metres, kicking and disturbing the bed of the stream while holding the net, submerged in the water at their feet. The net is to be held vertically out from the body, in the water as close as possible to the feet ensuring all disturbed material is collected. Following this collecting procedure, the contents of the net are emptied into a shallow, white sorting tray filled with approximately 10mm of water. All of the macro-invertebrates and bed material caught in the kick-test are placed in the trays. As a means of measuring the sorting effort, the macro-invertebrates are picked from the tray for 30 minutes, after which all bugs are identified, recorded and released.

Samples are to be taken from both the water's edge and in the deeper channel from pools and riffles between the boundaries of the ISC (see figure 12).

The macro-invertebrate ranking technique SIGNAL, as used by the ISC, is used to accurately rate the health of the stream at the project site. Simply for a means of comparison and for experience (knowing that the SIGNAL method is the more accurate) two methods for sampling macro-invertebrates (SIGNAL and the Waterwatch method) were used to determine which method could be easily and effectively used to sample the health of the waterway.

The simpler Waterwatch method of ranking assigns a 'Pollution Sensitivity Score' of between 1 to 10 (10 being very sensitive) to the collected species of macro-invertebrates (Foster 1994). A score of 10 indicates that the particular species is only able to survive in the highest quality of water, whereas an assigned score of 1 implies that the species is able to tolerate water of poor quality.

Once all species have been identified and assigned a Pollution Sensitivity Score, these scores are added and then divided by the sum of the different taxa groups. This answer can then be checked against a stream health table, resulting in a stream health rating of poor, moderate and good.

The Aquatic life sub-index of the ISC assessment uses the SIGNAL index to assess the health of a stream's macro-invertebrate species. Ladson and Lindsey (1999), state that 'the SIGNAL index has been developed for eastern Australia by Chessman (1995). In SIGNAL, numerous families of widespread macro-invertebrates have been awarded sensitivity grades by Chessman, based on published information and his personal observations'. These sensitivity scores are added then divided by the number of families sampled deriving a figure which is then compared to the ISC signal indicators and given a corresponding rating of 0 to 4.

1.6.4 Aquatic flora and algae survey

An aquatic flora and algae survey was undertaken within the ISC boundary (Figure 12). An in-stream walk downstream located the species present at the project site. All aquatic plant species were sampled and identified (Sainty & Jacobs 1994) on site. Unidentified samples were sent to Ernie Rider (QPWS Regional Botanist) for identification.

1.7 Riparian Zone Rehabilitation

1.7.1 Vegetation Sampling

Two methods of vegetation sampling were utilized in this project. The first being the streamside zone sub – index as used in the ISC to give a simple, broader indication of ‘exotic vegetation cover and indigenous woody vegetation regeneration’ (Ladson & White 1999, pp 43-54).

The second method uses very detailed identification using the methodology described below. The findings of the second method are used to assist in a more representative riparian zone replanting.

Seven (7) sites were sampled both upstream and downstream of the project site. Two (2) sites (Obi Obi Creek Road crossing No. 3 and 4) however, were very disturbed. Other surveys were carried out at the Coolabine Rd crossing (one sample), Obi Obi Creek Road crossing No. 2 (two samples) and Pryor’s northern bank.

The final vegetation survey was completed in the Kondalilla National Park below the Baroon Pocket Dam with assistance by Queensland Parks and Wildlife Service Regional Botanist Ernie Rider.

The aim of the vegetation samples was to consistently identify (utilising a recognized scientific sampling method) the existing riparian flora species of the Obi Obi Creek Catchment.

The species identified in these quadrats will help guide the correct species for revegetation of the Pryor project site. Samples were taken using a recognised consistent quadrat sampling technique as designed by Greening Australia, Tiaro.

Quadrat Design

Five, 5 metre by 3 metre quadrats, in a line perpendicular to the creek were used to record every plant species that was either included in, or overhung the quadrats at four representative sites along the Obi Obi Creek (Figure 13).

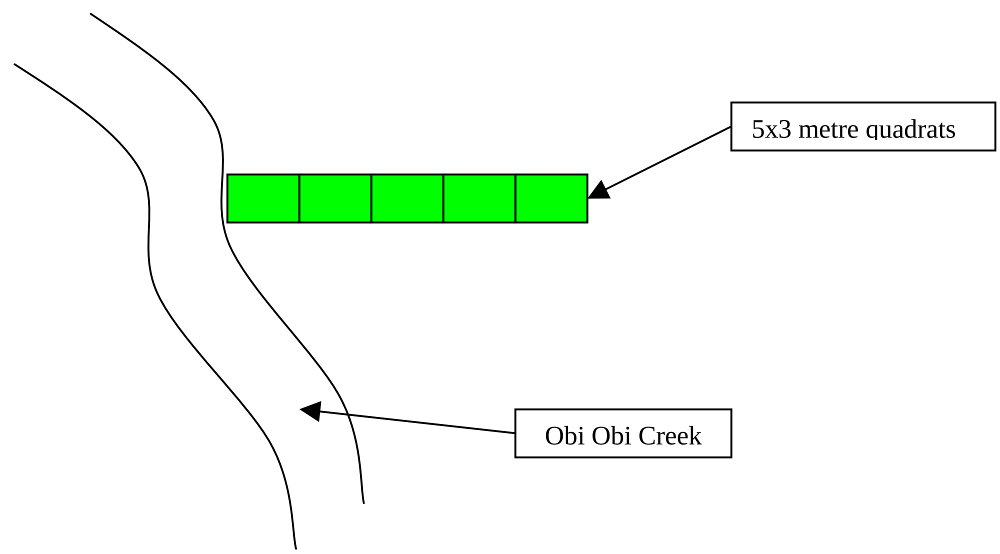


Figure 13. Showing the 5x3 metre quadrats perpendicular to the Creek.

This sampling method ensures a consistent sampling technique that is able to be repeated with a high level of confidence, thus ensuring representative samples of the flora species of the Obi Obi Creek Catchment.

Upon arrival to a new site, the quadrats were measured and marked consistently, in accordance with Greening Australia's guidelines. By laying rope on the ground around the four corner marks, the quadrat perimeter, the area to be recorded became easily identifiable. Having a hard line on the ground ensured objectivity regarding whether or not to include a particular plant, as is commonly experienced when marking only the four corners and using line–of–site.

Having marked out all quadrats a detailed description of the site was recorded onto the data collection sheets**.** An accurate GPS easting and northing is recorded allowing for future reference to these sites should the need arise.

Starting with the first quadrat (the first from the water's edge) every plant (native or exotic) and weeds of concern located in or over-hanging the quadrats were identified and recorded onto the data sheets. Almost all native riparian species were identified using the keys from the identification book, 'Trees and shrubs in Rainforests of New South Wales and Southern Queensland (Williams 1984). Unidentified species were referred to Ernie Rider (Queensland Parks and Wildlife Service – Regional Botanist) for official identification. Samples were taken from a healthy plant, marked, and sealed in a zip-lock bag.

Following the plant identification, cover abundance for the quadrat was recorded. Using the Braun – Blanquet Cover Abundance method. Values were assigned as 'percentages of cover' for all of the following:

- Foliage Projective Cover,
- Bare Earth,
- Litter Cover, and
- Weed Cover.

1.7.1.1 FOLIAGE PROJECTIVE COVER (FPC)

Foliage Projective Cover is described best as the percentage of projective foliage cover by the vegetative canopy of plants covering the quadrat in question. For example, using the 'Braun-Blanquet Cover Abundance', should the total FPC of the canopy cover greater than 75% of the quadrat area (leaving 25% of the sky visible), the highest score of 5 is assigned to that quadrat. Moreover, should the total FPC of the canopy cover fall between 0 – 5% of the quadrat area, a score of 1 is assigned to the quadrat and noted on the data sheet.

1.7.1.2 BARE EARTH

As with all of the Cover Abundance attributes relating to the first quadrat, the 'Braun-Blanquet Cover Abundance' is again used to measure the percentage of visible bare earth within the quadrat. A rating of 1 to 5 is noted in the data sheet.

1.7.1.3 LITTER COVER

Litter cover is comprised of fallen vegetative matter; leaves, fruits and berries, branches and bark from the surrounding vegetation. Litter cover and bare earth are complimenting so that when vast expanses of bare earth are apparent, normally very little litter cover is expected. Likewise, when a healthy layer of litter covers the ground relatively less bare earth is exposed. Litter cover is an important rapid assessment indicator of an ecosystem's health. As is the case with most healthy vegetation, a score of 5 is awarded should over 75% of the area within the quadrat be covered with litter.

1.7.1.4 WEED COVER

It is important to note percentage cover of species, percentage cover and abundance of weeds in the quadrats, as this affects the management plan and weed control strategies of the plantings of riparian species at the revegetation site adjoining the LWD Project. Grasses are considered a weed in this instance as they vigorously compete with young seedlings (Wedlock, B., Pers. Comm. (verbal), 2001). When assessing weed cover, firstly a score is again assigned using the Braun-Blanquet Cover Abundance method, of 1 (0-5% cover) to 5 (> 75% cover).

The percentage weed cover attribute was broken down into a further category of the percentage cover of dicotyledonous weed species and monocotyledonous species, allowing an insight into the quadrats cover of grasses (monocots) and other often more hardy (dicot) weed species. This allows for the identification of the potentially devastating weed species such as Cats Claw Creeper (*Macfadyend unquis-cati*) and Madeira Vine (*Anredera cordifolia*) and the devising of a strategy to manage the weed populations.

For example, if a score of 5 was assigned for the weed cover (greater than 75% weed cover of the quadrat), and of that 75% weed cover, 80% was grass. The percentage of monocot weeds would be recorded on the data sheet as 80%. It follows then that the percentage of dicot weeds would be recorded as 20%, making up the 100% total of the 75% weed cover.

The procedure above was completed for all sampled sites.

1.7.2 Weed Identification

The project site's southern bank has been improved for pasture and has no existing riparian vegetation as is highlighted in figure 1 & 2. The dominant flora species found on site was Kikuyu Grass. For later comparison (of the current pasture to the future revegetation), an extensive weed survey on the project site's southern bank, between ISC 2 and ISC 3 (approximately 430 m) was compiled (see figure 12). A riparian planting from ISC 2 downstream to ISC 3 upstream is planned for this bank, following the completion of on-ground works.

The weed sampling was carried out using the same technique as the vegetation sampling. Five, 5 by 3 metre quadrats, perpendicular to the Obi Obi Creek were sampled. This will be used as a benchmark when further monitoring is carried out. All weed samples unable to be identified on-site, were tagged and placed in sealed marked plastic bags for identification by Ernie Rider (Queensland Parks and Wildlife (QPWS) – Regional Botanist).

A further study identifying potential invasive 'weeds of concern' to the project site was undertaken. These weeds will inevitably invade the project site as their propagules wash downstream in future flood events. Eight study areas were selected, two each at Obi Obi Creek Crossings No. 1, 2, 3 and 4. These sites were chosen due to their ease of access and because they are sites which are continually disturbed, with poor riparian vegetation and are known to accomodate the weeds in question.

From each of the crossings, a 200 metre walk away from the bridge, both up and downstream, allowed for a visual identification of the weeds. Unidentifiable weed species were given to Ernie Rider (Queensland Parks & Wildlife Service - Regional Botanist) for identification.

1.7.3 Revegetation Strategy – appropriate width

To determine the appropriate riparian planting width of the Pryor project site, a number of measurements need to be taken of the site using Abernathy & Rutherford (2001) recommendations, as well as consulting the landholder on the rate of erosion experienced at the site (Pryor, J., Pers. Comm. (verbal), 2001). The formula shown below (Abernathy & Rutherford, 2000) is used to form part of the set of proposed recommendations to formulate the land required for the riparian zone revegetation.

Three factors need to be considered when determining the appropriate planting width. These are listed below:

1. 'Basic allowance' – The basic allowance for riparian plantings should not be less than 5 metres,
2. Height allowance – height of the bank is measured vertically from the bank toe to the bank crest,
3. Establishment allowance - The establishment allowance is determined by multiplying the erosion rate by the time required for the plantation to mature.

The following equation, using the above measurements determines the width of land required for riparian planting:

Basic allowance + height allowance + (erosion rate x revegetation maturity) = riparian width.

Obi Obi Creek Pryor Test Reach (2001) –
note very bad erosion on right of photo

1.8 Large Woody Debris Design

1.8.1 Adaptive Management Project Design

The LWD project at the Pryor project site was designed by Department of Natural Resources and Mines (DNR&M), Rivercare Officer Stephen Dudgeon, with further recommendations and designs by Nick Marsh (CRC Catchment Hydrology) and Brad Wedlock (see figure 14). The project aims to arrest the erosive processes acting upon the southern bank while increasing in-stream habitat for the endangered Mary River Cod. This design was modeled and developed on Brooks (2001) work in the Williams River, NSW (figure 9).

The adaptive management design incorporates four complementing engineered woody log jams, three being deflector jams (of varying sizes) and one a double log sill structure (see figure 15) being strategically positioned in the Obi Obi Creek to increase the in-stream geomorphologic diversity (Dudgeon 2001).

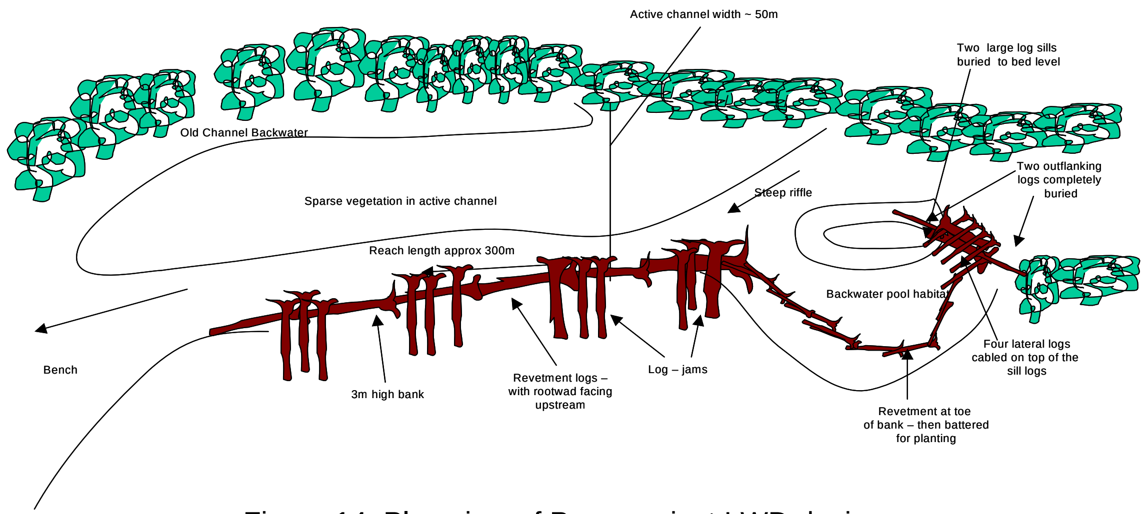


Figure 14: Plan view of Pryor project LWD design

Figure 15: Constructing the double log sill structure to raise riffle crest height and divert base-flows into a secondary channel.

1.8.2 Timber Description

When assessing a piece of timber for its use in any LWD project, four criteria must be met and should be described in the project design (Dudgeon S., pers. Comm (verbal) 2002). These criteria (Marsh, N., Pers. Comm. (email), 2001) are as follows:

- Appropriate size;
- Attached rootwad
- Weight and density;
- Native or exotic

1.8.2.1 APPROPRIATE SIZE (length and girth)

This criteria relates to the overall length and average girth of the log. When sourcing timber for LWD works logs should be as long as is practical to transport and should have average girths not less than an average of 400mm unless otherwise stated in the project design.

1.8.2.2 ATTACHED ROOTWAD

It is imperative that all LWD have attached a substantial rootwad. A substantial rootwad is one such that weighs equally as much as the remaining log. There is little need to remove any dirt or other such ground material still attached to the rootwad as this only increases the weight of the rootwad.

1.8.2.3 WEIGHT and DENSITY

The weight of a log is a function of its combined length, girth and density. As stated above all sourced logs should be as long and possible and possess the greatest possible girth as possible and thus be heavy. Only dense hardwood timbers, generally *Eucalyptus* sp. (at least 1000kg/m3) should be used in LWD structures.

1.8.2.4 NATIVE vs. EXOTIC

Native timbers should always be used to construct LWD structures as some exotic species may exhibit non-favourable characteristics like those of Camphor Laurel (Friend 1999). Although it is believed that some exotic species may negatively impact upon stream health (Friend 1999), there have been no studies (to the authors knowledge) into the possible effects that exotic timber have on in-stream aquatic fauna. Therefore, the 'precautionary principle' must be applied and only native timber used in LWD projects. Moreover, few exotic timbers parallel the densities found in native timbers (Babakaiff, S., Pers. Comm. (verbal), 1999), and consequently if used will be unable to perform like native Australian timbers.

1.8.3 Transport of sourced timber to project site.

Two flat bed and one low-loader semi trailers were used to transport the sourced LWD for the project site. Prior to the transporting, safe haulage routes were determined as detailed in Appendix 3 'The transport technicalities of shifting LWD'.

1.8.4 Existing LWD Loading of the project site.

The full 'census method' (Marsh, Jerie & Gippel 1999) was used to assess the current LWD loading at the project site. 'The full census method involves recording the diameter and length of each piece of LWD above a pre-determined threshold size within a quadrat or known stream area' (Harmon et al. 1986). The stream area surveyed for existing LWD was between the 400m ISC boundaries (see figure 12). The threshold size depends on the intention of the study (Marsh, Jerie & Gippel 1999, p1). Although the intention for the project site was to assess all of the LWD in-stream, 'a lower limit of 0.1 m diameter and a minimum length of 1m' was used as recommended by Gippel, Finlayson & O'Neill (1996), and Hogan (1987) as timber smaller than this provides minimal benefits to both erosion control and fish habitat.

Starting at ISC 3 (upstream) and walking down stream to ISC 2 then back to ISC 3 (Figure 12) ensured all current LWD in-stream was recorded. For each LWD, the diameter at both ends, its length and orientation to stream flow were recorded (Results - 2.1.2).

Calculating the in-stream LWD loading (Marsh, N., Pers. Comm. (email), 2002) involves the calculating of two factors between the boundaries of ISC 2 and 3. This results in a measurement of the volume of timber in cubic metres (m^3) for every unit surface area of water (m^2). The first factor is the calculation of the volume of timber in Obi Obi Creek and is found by applying the formula of $\pi r^2 h$ where:

$\pi = 3.142$,

r = the average radius of the log in metres, and

h = the length of the log in metres.

The second factor involves calculating the surface area of water between the boundaries. Having calculated both, the volume of LWD is divided by the surface area of water.

1.8.5 Initial bed and bank survey

The initial bed and bank survey of the project site on Obi Obi Creek was completed by DNR&M Rivercare officer Stephen Dudgeon, Brad Wedlock (MRCCC), Kath Kelly (Maroochy Shire Council) and Luke Brown (University of Queensland, Gatton).

The 'Big Toe Method' (Parfait 1999, p 500) is a simple technique to obtain the bed particle size distribution, 'It consists of walking in a zigzag path across the river (or stream in this case) and picking up the particle in contact with the big toe of the right foot' (measurement in centimeters of cobbles through the X, Y and Z axis)

This method was used to calculate stream power through the riffle zones. The survey of the bed was carried out from the top of the highest riffle crest (1st riffle in the project site) through the pools, and second riffle zone to the third (bottom) riffle of the project site. This survey determined the slope or gradient of the project site, which then allowed the calculation of the stream power through the project site. The raw data was then processed by the computer program "The Geomorphic Assessor" which analysed the stream power and tractive stress at Obi Obi Creek cross section No. 1 & 2 .

1.9 Consultation Techniques

The '12-step procedure for stream rehabilitation', (Rutherfurd, Jerie and Marsh), was adapted to be used as the base methodology ensuring directed, continual and positive consultation techniques with all stakeholders. Each of the 12 steps was assessed as to whether or not a form of consultation would be required. Once identifying a step which potentially requires consultation, one or more of the consultation techniques from Table 2 were assigned to that step.

Consultation Technique	Description	Location

Verbal communication and interaction.	Simple day-to-day communication and involvement of stakeholders, commonly project officers; MRCCC, Council, Greening Aust. & DNR&M representatives; landholders; contractors, community and any other interested parties.	Anytime, any place – in the office on the farm and in the street.
Informative stream walks	Educational on-site communication. Explaining vegetation, hydrology, project location and design and other general queries. Designed to specifically target all mentioned above.	Usually at the project site but occasionally other locations in close vicinity to the project site.
Site evaluations	Very detailed assessment of potential sites. Usually involves locating sites on maps and visits to the site for evaluation of MRCCC, DNR&M, Greening Aust., Councillors & Council environmental officers and representatives.	Both in meetings and at the potential project sites.
Communication and involvement with the landholder.	Building an ownership and appreciation with the landholder. Involving them in the project design, construction and maintenance. Explaining scientific processes using simple concepts.	On-site
Media	Through the use of media community awareness, understanding and appreciation of the project can be gained.	Articles in local papers and community papers.
Shire councils	Continually update interested personnel through reports, general conversation, meetings and project site visits.	In the office and at the site

Table 2. Common Consultation Techniques.

2 RESULTS

2.1 Instream Assessment

2.1.1 Index of Stream Condition

The ISC results detailed below (Physical Form, Streamside Zone, Water Quality, Aquatic Life and Impact of artificial barriers on fish migration Sub-indexes) have been adapted from Ladson and White (1999, pp 35-76).

2.1.1.1 Physical Form Sub-index

Table 3. Ratings for bank stability.

	Indicator rating		
Pryor's measuring site	Transect 1	Transect 2	Transect 3
Southern Bank	0/4	1/4	0/4

Table 4. Ratings for bed stability.

Pryor's measuring site	Indicator rating
Southern Bank	2/4

Table 5. Ratings for instream physical habitat.

Pryor's measuring site	Indicator rating
Southern Bank	2/4

Table 6. Ratings for artificial barriers to fish migration.

Pryor's measuring site	Indicator rating
Southern Bank	2/4

Table 7. Calculation of Physical Form Sub-index score.

Pryor's measuring site	Score
Southern Bank 10/16[1/3(0+1+0)+2+2+2)]	3.92/10

Physical Form Sub-index (Value rounded to 0 decimal places)	4/10

2.1.1.2 Streamside Zone Sub-index

Table 8. Ratings for width of streamside zone.

	Indicator rating		
Pryor's measuring site	Transect 1	Transect 2	Transect 3
Southern Bank	0	0	0

Table 9. Ratings for longitudinal continuity.

Pryor's measuring site	Indicator rating
Southern Bank	0

Table 10. Ratings for structural intactness.

	Indicator rating		
Pryor's measuring site	Transect 1	Transect 2	Transect 3
Southern Bank	0	0	1

Table 11. Ratings for exotic vegetation.

	Indicator rating		
Pryor's measuring site	Transect 1	Transect 2	Transect 3
Southern Bank	3	2	0

Table 12. Ratings for regeneration of indigenous woody vegetation.

Pryor's measuring site	Indicator rating
Southern Bank	0

Table 13. Calculation of Streamed Zone Sub-index score.

Pryor's measuring site	Score
Southern Bank 10/19[1/3[(0+0+0)+(3+2+0)+(0+0+1)]+0+0+0]	1.0

Streamside Zone Sub-index	1/10

2.1.1.3 Water Quality Sub-index

Table 14. Calculation of Water Quality Sub-index score.

Parameter measured	ISC rating
Total Phosphorus	2/4
Turbidity	4/4
Electrical Conductivity	4/4
pH	4/4
Water Quality Sub-index score	**9/10**

Aquatic Life Sub-index

Table 15 shows the macro-invertebrates sampled at the Pryor's project site and their respective ISC rating. This result is based on only the SIGNAL evaluation as no AUSRIVAS data was available for this area. It was therefore decided to use a multiplication factor of 20/8, double the recommended 10/8 (Ladson and White 1999, p74) so as to ensure an ISC result for the project site that is able to be compared against the ISC classification scheme (Table 17).

Table 15. List of sampled Macro-invertebrates at Pryor's project site, Obi Obi Creek.

Date of Collection: 20th October 2001.
State of Creek: Extreme low-flow

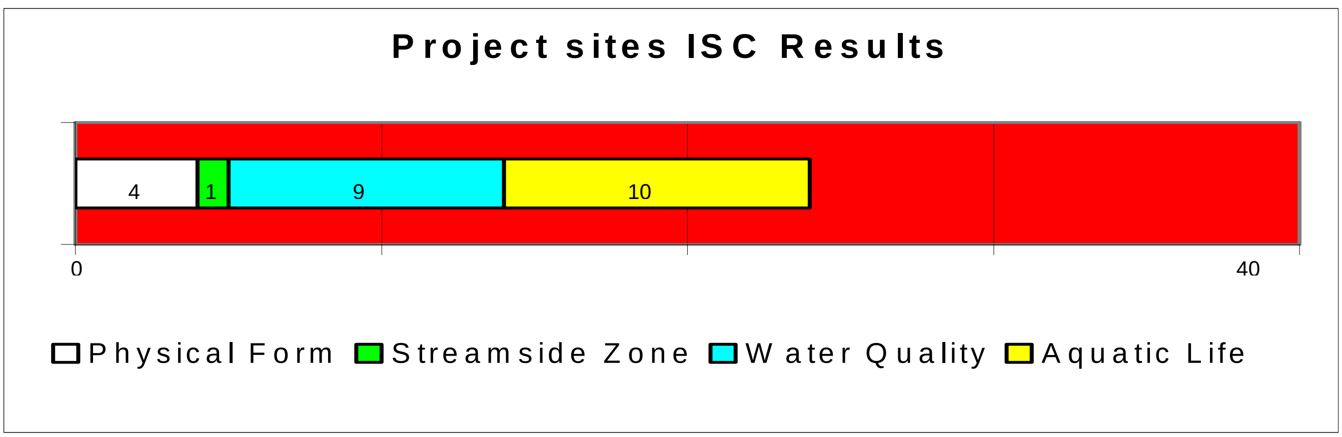
Common Name	Order	Family Name	ISC Rating
Caddisfly Larvae	Trichoptera	Leptoceridae	7
Damselfly Nymph	Odonata	Isostictidae	7
Damselfly Nymph	Odonata	Coenagrionidae	7
Dragonfly Nymph	Odonata	Corduliidae	7
Fingernail Clam	(Class Bivalvia)	Corbiculidae	7
Freshwater Prawn	Decapoda	Palaemonidae	5
Freshwater Shrimp	Decapoda	Atyidae	6
Mayfly Nymph	Ephemeroptera	Leptophlebiidae	10
Mayfly Nymph	Odonata	Baetidae	5
Midge Larvae	Diptera	Chironomidae	1
Stonefly Larvae	Plecoptera	Notonemouridae	8
Water Boatmen	Hemiptera	Corixidae	5
Water Snail	(Class Bivalvia)	Thiaridae	7
Whirligig Beetle	Hemiptera	Gyrinidae	5
Whirligig Larvae	Hemiptera	Gyrinidae	5
Total of sensitivity grades			**92**
Number of families			**15**
SIGNAL value			**6.1**
ISC rating			**4**
Adjusted ISC score			**10**

Total ISC Score

The ISC evaluation of the project site gives a score out of 40 due to the exclusion of the hydrology Sub-index. The overall ISC score from the Pryor project site has been multiplied by a factor of 1.25 to give a score out of 50 instead of an incomparable result of 40.

Table 16. Sub-index scores for the project sites ISC.

Sub-index	ISC score (out of a possible 10)
Physical Form	4
Streamed Zone	1
Water quality	9
Aquatic Life (SIGNAL only)	10
ISC project Total	24/40
Adjusted ISC Total	30/50



Graph 1. ISC bar graph of results.

Table 17. Overall ISC classification scheme showing the position of the Pryor project site.

Overall ISC Score	Stream Condition
45 – 50	Excellent
35 – 44	Good
25 – 34	**Marginal**
15 – 24	Poor
< 14	Very Poor

2.1.2 Water Testing

When reviewing the water testing results (Table 18) over the five month period and comparing them to the ANZECC Guidelines they all suggest a healthy ecosystem.

Site	pH	EC (ms/cm)	Turbidity (NTU)	Temperature (^oC)	Date	Time
T1	7.14	.136	0	19.9	7 Sept	0900
T1	7.31	.139	0	20.2	4 Oct	0930
T1	7.21	.137	1	21.6	29 Oct	0900
T1	7.20	.136	0	19.8	7 Nov	1000
T1	7.63	.130	1	24.5	10 Dec	0940
T1	8.70	.122	2	31.7	03 Jan	1000
T1	7.60	.121	0	27.6	23 Jan	0935
AVERAGE	**7.54**	**.132**	**.57**	**23.6**		

Dissolved Oxygen Average: 8.16.

Table 18. Water testing results.

The pH readings of Obi Obi Creek ranged between 7.14 and 8.7 depending on the month, falling between the ANZECC guidelines for pH of 6.5 – 9.0.

Electrical Conductivity in the Obi Obi Creek was an average of 0.132 ms/cm, far below the maximum of 1.5 ms/cm.

The ANZECC guidelines suggest that turbidity should not vary more than 10% in any given 1 hour period. Never in the 5 months of recording did the Obi Obi's turbidity readings fluctuate more than 10% in the 10 minute testing intervals.

Dissolved oxygen, measured more than 2 mg/ L, above the ANZECC guidelines. The DO reading at the site was 8.16 mg/L. It should be noted that due to measuring apparatus failure incorrect readings where obtained for DO prior to the correct reading of 8.16 mg/L. These readings were discarded.

2.1.3 Macro-invertebrate Pollution Score (Waterwatch component)

Table 19 shows the aquatic macro-invertebrates samples collected from the project site and their respective Waterwatch rankings.

Date of Collection: 20th October 2001.
State of Creek: Extreme low-flow

Common Name	Order	Waterwatch Ranking
Caddisfly Larvae	Trichoptera	10
Damselfly Nymph	Odonata	4
Damselfly Nymph	Odonata	4
Dragonfly Nymph	Odonata	4
Fingernail Clam	(Class Bivalvia)	3
Freshwater Prawn	Decapoda	4
Freshwater Shrimp	Decapoda	4
Mayfly Nymph	Ephemeroptera	10
Mayfly Nymph	Odonata	10
Midge Larvae	Diptera	4
Stonefly Larvae	Plecoptera	9
Water Boatmen	Hemiptera	1
Water Snail	(Class Bivalvia)	2
Water Flea	Cladocera	5
Whirligig Beetle	Hemiptera	5
Whirligig Larvae	Hemiptera	5
TOTAL		84

Table 19. List of sampled macro-invertebrates at Pryor's Farm, Obi Obi Creek.

The project site, having a Taxa Richness of greater than 9 and a Sensitivity Score greater than 4.5, the Waterwatch evaluation suggests that the project site is healthy (Table 20).

Table 20. Rating of stream health using sampled macro-invertebrates.

<table>
<tr><td colspan="2">Rating Categories</td><td colspan="3">Sensitivity Score (S)</td></tr>
<tr><td rowspan="4">Taxa Richness</td><td></td><td>S > 4.5</td><td>3.5 < S > 4.5</td><td>S < 3.5</td></tr>
<tr><td>x > 9</td><td>Good</td><td>Moderate</td><td>Moderate</td></tr>
<tr><td>3 ≤ x ≤ 9</td><td>Moderate</td><td>Moderate</td><td>Poor</td></tr>
<tr><td>x < 3</td><td>Moderate</td><td>Poor</td><td>Poor</td></tr>
</table>

2.1.4 Aquatic Flora and Algae survey

Table 21 shows the identified aquatic flora in-stream at the Pryor project site located between ISC 3 and ISC 2:

Table 21. Identified Aquatic Flora.

Common Name	Scientific Name
Water milfoil	*Myriophyllum verrucosum*
Curly leafed pond weed	*Potamogeton crispus*
Clasped pondweed	*Potamogeton ochreatus*
Eel weed	*Vallisneria nana*
Hydrilla	*Hydrilla verticullata*

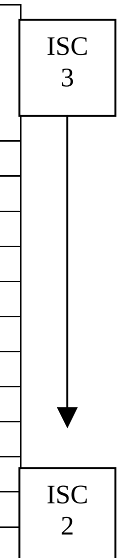
All of the aquatic flora sampled are common in the Obi Obi Catchment (Stockwell, B., Pers. Comm. (email), 2002).

2.1.5 Current Project Site LWD Loading

Table 22 below summarises the current LWD at the project site sampled from ISC 3 through to ISC 2:

Table 22. Current project site LWD loading.

LWD description I (individual)* LJ (log jam)**	Length (m)	Diameter 1 (mm)	Diameter 2 (mm)	Average Diameter (mm)	Volume (m^3) ($\pi r^2 h$)	Description & orientation to flow
LJ	4	200	400	320	0.32	P, SUB
LJ	3	200	200	200	0.09	Up, SUB
I	8	300	400	350	0.77	P, ½
I	4	250	300	290	0.26	P, SUB
I	3	250	450	280	0.18	P, SUB
I	8.3	400	550	500	1.63	P,
I	5.6	300	400	300	0.40	P, ½, RT
I	3.8	150	150	150	0.07	PL, ½, RT
I	17	250	500	400	2.14	P
I	6.6	200	200	200	0.21	DN
I	3	100	450	350	0.29	P, SUB
I	4.4	300	450	340	0.40	P, SUB, H
I	10	200	470	300	0.71	½, P



* denotes a single log and ** denotes a log forming part of a log jam (Marsh, et al. 2001).
P – Perpendicular PL – Parallel UP – Facing upstream DN – Facing downstream
SUB – Submerged ½ - Half submerged RT – Rotting H - Hollow

The current LWD loading between ISC boundaries 2 and 3 is 0.0007 m^3/m^2 (below average for reasonably intact Australian rivers [Rutherford et. al, 2000]).

2.2 Riparian Zone Rehabilitation

2.2.1 Vegetation Sampling

Two flora species lists were compiled after the vegetation sampling was completed. One species list was produced of the riparian forest and rainforest below the Lake Baroon Spillway. The second species list was developed for the riparian zone flora of the lower Obi Obi Creek, thereby combining the Spillway list with the four riparian zone sampling sites of the lower Obi Obi Creek. See Appendix 1.

The sampling of these two areas revealed that the Lake Baroon Spillway exhibits a highly diverse ecosystem made up of 86 species, while the lower Obi Obi Creek Catchment shows very low species diversity with only 14 species.

The Lake Baroon Spillway vegetation assessment identified one plant species, *Quintinia sieberi* at its northern limit and *Litsea leefeana* at its southern limit. Also identified were two other species near their northern limits, *Akania bidwillii* and *Notelaea ovata*.

As expected, due largely to its poor diversity, no species were found nearing their limits in the four sites assessed on the lower Obi Obi Catchment vegetation assessments.

No rare or threatened plant species (under the *Nature Conservation Act* 1992) were identified.

The common riparian species identified were:

- *Waterhousia floribunda* (Weeping Lilly-pilly)
- *Ficus coronata* (Sandpaper Fig)
- *Aphananthe phillipensis* (Axe-handle Wood or Rough-leaved Elm)
- *Castanospermum australe* (Blackbean)
- *Cinnamonum camphora* (Camphor Laurel)
- *Cryptocarya triplinervis* (Three-veined Laurel)
- *Mallotus phillipensis* (Red Kamala)

2.2.2 Weed Sampling

The results of the quadrat weed sampling on the project site southern bank are shown in Table 23 below.

Species Name	**Common Name**
Imperata cylindrica	Blady grass
Hydrocotyle spp.	Penny weed
Trifolium repens	White clover
Gamochaeta spp. (Gnaphalium)	Cudweed
Rumex brownii	Swamp dock
Conyza bonariensis	A Fleabane
Axonopus compressus	Carpet grass
Cirsium vulgare	Spear thistle Scotch thistle
Baccharis halimifolia	Groundsel bush
Pennisetum clandestinum	Kikuyu grass
Dichondra repens	Kidney weed
Ciclospermum leptophyllum (Apium leptophyllum)	Slender celery Wild carrot
Verbena officinalis	A Verbena
Vicia sativa var. angustifolia	Narrow leaf vetch
Carduus thoermeri	Nodding thistle
Sida rhombifolia	Sida retusa Patty's lucerne Common Sida

Table 23. Common weeds on Pryor's southern bank.

Sixteen common weeds were identified on the projects southern bank (Table 23). These weeds pose a threat to the revegetation on the southern bank through their ability to out-compete riparian species during the establishment phase of the revegetation.

2.2.3 Weeds of Concern

Table 24 lists the 'weeds of concern' for the project site as identified by the vegetation sampling of Obi Obi Creek Crossings No. 1, 2, 3 and 4:

Common Name	Scientific Name
Madeira Vine	*Anredera cordifolia*
Solanium	*Solanium pseudacapicum*
Green Leaved Desmodium	*Desmodiem intortum*
Moth-vine	*Araujia sericifera*
Reed	*Schoenoplectus validus*
Sedge	*Cyperus* sp.
Duckweed	*Spirodella* sp. (aquatic)
Setaria Grass	*Setaria* sp.
Cat's claw creeper	*Macfadyena unguis-cati*

Table 24. Weeds of concern identified along Obi Obi Creek.

2.2.4 Revegetation Strategy – appropriate width

Using Abernethy (1999) the appropriate planting width is to be a minimum of 14.4 metres, based on a basic allowance of five metres, a height allowance of four metres, and erosion rate of 1.8 metres and a three year maturity of the riparian species.

Figure 16: Appropriate riparian tree-planting width, without the basic allowance of 5 metres. In some instances this is impractical due to loss of good agricultural land to revegetation by the landowner.

2.3 Large Woody Debris Design

2.3.1 Transported LWD Timber

Table 25 describes the dimensions of the 30 logs with attached rootwads that have been hauled to the project site in October 2001.

Length (m)	Diameter 1(m)	Diameter 2 (m)	Average (m)	Volume (m^3) ($\pi r^2 h$)
9	.500	.500	.500	1.77
9.1	.450	.900	.720	3.71
9.5	.840	1.200	1.000	7.46
9.9	.450	.600	.520	2.10
9.9	.400	.900	.810	5.10
10	.480	.700	.520	2.12
10	.620	.850	.680	3.63
10	.430	.600	.500	1.96
10	.480	.740	.630	3.12
10	.350	.500	.400	1.26
10	.450	.600	.590	2.73
10.1	.460	.560	.470	1.75
10.1	.650	1.000	.890	6.28
10.2	.400	.600	.500	2.00
10.3	.370	.510	.450	1.64
10.3	.780	.900	.800	5.18
10.3	.450	.650	.590	2.82
10.3	.300	.480	.400	1.29
10.3	.520	.780	.600	2.91
10.4	1.000	1.400	1.200	11.76
10.5	.300	.500	.360	1.07
10.5	.480	1.000	.795	5.23
10.8	.300	.510	.480	1.95
10.9	.400	.500	.400	1.37
11	1.100	1.800	1.300	14.6
11	.400	.700	.490	2.07
11	.465	.700	.560	2.71
11	.380	.550	.500	2.16
11	.600	.800	.620	3.38
12	.470	.800	.600	3.39
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46

9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
9.5	.840	1.200	1.000	7.46
				212.96

Table 25. Description of the timber used to increase the LWD loading of the project site.

The October 2001 transported LWD alone, without the LWD currently in place would result in a LWD loading between ISC boundaries 2 and 3 of 0.038m^3/m^2.

Another fourteen (14) logs were sourced from Buderim and Peregian in October 2002 with an average volume of 7.46 m3, equalling 104.44 cubic metres of timber.

The total LWD loading equalling 212.96 cubic metres (including the LWD currently in place in-stream). The surface area of the Pryor project site is 2855 sq. metres. The LWD loading between ISC boundary 2 and 3 (see figure 12) is 0.0746 m3/m2.

Figure 17: Timber used in the LWD project

Figure 18: Timber used in the LWD project – note height of root-wad

2.3.2 Loading in-stream following Project Implementation

Using the above transported timber, together with the existing LWD, the LWD loading following project implementation of the site will be 0.0746 m^3/m^2.

2.3.3 Scour Depth

The results of the Geomorphic Assessor (Parfait 1999) have calculated the scour depth of the stream to be ½ metre around the structures placed in-stream.

2.4 Consultation Techniques

Shown below are the Consultation Techniques used to maximize communication with stakeholders. These Consultation Techniques are sorted according to the Procedure for Stream Rehabilitation steps, (Rutherfurd, Jerie & Marsh 2000) that are representative of this LWD project.

Step 1. What are your goals for rehabilitating your stream?

- Verbal communication and interaction,
- Informative stream walks (figure 17),
- Site evaluations, and
- Communication and involvement with the landholder.

Figure 19: consultation techniques – informative creek walks

Step 2. Who shares your goals for the stream?

- Verbal communication and interaction,
- Informative stream walks,
- Site evaluations,
- Communication and involvement with the landholder,
- Media, and
- Shire Council.

Step 3. How has your stream changed since European settlement?

- Verbal communication and interaction,
- Site Evaluations, and

- Communication and involvement with the landholder.

Step 7. What are your specific and measurable objectives?

- Verbal communication and interaction,
- Informative stream walks, and
- Communication and involvement with the landholder.

Step 8. Are your objectives feasible?

- Verbal communication and interaction,
- Communication and involvement with the landholder, and
- Shire councils.

Step 9. What is the detailed design of your project?

- Verbal communication and interaction,
- Informative stream walks, and
- Communication and involvement with the landholder.

Step 11. How will you plan and implement your project?

- Verbal communication and interaction,
- Communication and involvement with the landholder.

3 SITE MANAGEMENT PLAN

3.1 In-stream Monitoring

3.1.1 Findings from Index of Stream Condition

The ISC highlights that the ‘Physical Form’ and especially ‘Streamside Zone’ of the Pryor project site, are much degraded (see figures 2, 5, 7 & 9).

The results of the ‘Physical Form’ index supported the findings of Dudgeon (2001) when he reported that the banks where unstable, undercut, rapidly eroding and slumping (see figure 2). ISC assigned a score of 0 – “Extreme erosion with an unstable toe with no woody vegetation, very recent bank movement and steep bank surface” (Ladson and White 1999). Also only marginal in-stream physical habitat exists with the current LWD loading.

While highlighting a below average rating of ‘Physical Form’, the ISC also highlighted the degraded ‘Streamside Zone’.

Having no riparian vegetation on the southern bank and limited species on the northern bank (although marginal stands exist outside of the transects), the ISC rating of 1/10 for the project site, proves the importance of the site’s proposed revegetation.

The results have shown the extent of degradation with the site scoring averages of 0/4 for all of the indicators except for the exotic vegetation. If not for the ratings of 9/10 and 8/10 for ‘Water Quality’ and ‘Aquatic Life’ respectively, one could have been excused for completely overlooking the need for works at the site, based solely on the justification of the Titanic Theory.

The ‘Water Quality’ and ‘Aquatic Life’ results, contribute positively to the end ratings, resulting in an overall ISC of the Pryor project site classification being marginal.

The works intended for the project site will measurably increase both ‘Physical Form’ through the introduction of in-stream LWD, and the ‘Streamside Zone’ with the revegetation of the southern bank. Should another ISC be completed in five years time, Physical Form together with the

Streamside Zone indices, are expected to increase to ratings like those of Water Quality and Aquatic Life.

3.1.1.1 Findings from Macro-invertebrate Sampling

Every attempt was made to sample the macro-invertebrates ensuring a result representative of the project site. For the most part following rigorous scientific sampling procedure (Berrill, P., Pers. Comm. (demonstration), 2001) ensured this. However, having limited prior experience in the identification of macro-invertebrates, various expected species may have been overlooked, thus excluding them from the compiled species lists. It therefore follows that the species list for the project site should be used only as an indication or guide to the potential diversity of the site.

However, when assessing the sampled macro-invertebrates using the Aquatic Life Sub-index of the ISC, the result scored the highest possible index of four. This suggests that even with the knowledge that some species may have been overlooked, the site is very diverse.

3.1.1.2 Findings from Water Testing

All of the water testing results are within the limits of the ANZECC Guidelines and exhibit trends which are common in like streams throughout the Mary River Catchment.

However, the test results for December and January are, for no apparent reason elevated. For example, all previous pH figures range from 7.14 to 7.20, with temperatures in the high 19 to low 20 degrees Celsius, and turbidity readings between 0 and 1. The results then indicate that for December and January, the pH becomes much more alkaline with a reading of up to 8.70, coinciding with increased turbidity and very high water temperature.

Foster, in the Waterwatch Queensland Technical Manual (1994) provides three generalised possible explanations for the elevated pH:

1. The pH of natural waters is largely determined by the geology and soils of the catchment,
2. Increasing salinity causes increases in pH, and
3. The photosynthetic activities of plants and algae can cause significant variations in pH.

The first example of geology being a determinant in water pH could be explored at the project site, and if the parent material and soils were found to be alkaline tests would either prove or disprove the above mentioned suggestion.

During the period of heightened pH salinity remained unchanged with a reading of zero, ruling out the possibility of Foster's second explanation.

Foster's third finding probably best explains the project site's elevated pH readings (Berrill, P., and Wedlock, B., Pers. Comm. (site evaluation), 2002). Foster (1994, p21) found that, 'the photosynthetic activities of plants and algae can cause significant variations in pH', he continues in stating, 'this happens over the 24-hour daily cycle. It is due to the removal of dissolved carbon dioxide (which causes acidity) from the water by plants. As with DO, highest pH values usually occur mid-afternoon'. It was noted that both at, and upstream of the project site, the Obi Obi Creek has many aquatic plant species thriving in its waters (Table 21) which would have the effect on pH explained by Foster's third finding.

3.2 Riparian Zone Assessment & Rehabilitation

3.2.1 Findings from Vegetation Sampling

The vegetation sampling which culminated in the previously discussed species lists (Vegetation Sampling - 3.2.1), highlights the rapid decrease in species richness from the upper to lower Obi Obi Catchment. Species richness declined from 86 species observed below the Baroon Pocket Dam, to a total of just 14 species for the combined Pryor project site, Obi Obi Ck Crossing No.2 and Coolabine study areas, a reach of approximately 10 km.

The aim of the vegetation sampling was to identify the most suitable species for revegetation of the Pryor project site. The vegetation sampling also identified the closest areas of remnant riparian vegetation that could potentially provide a 'seed sink' for natural regeneration of species of the Pryor project site.

Surrounding the Pryor project site are numerous vegetation remnants of varying sizes, but most remnant riparian rainforest patches are very small and fragmented.

3.2.2 Revegetation Design

The revegetation design is based on the guidelines developed by Kooyman (1996) for rehabilitating rainforest, particularly riparian rainforest.

The Pryor revegetation project site is currently dominated by kikuyu / paspalum pasture grass. The distance to the nearest remnant is 500 metres, which is approximately 2 hectares in size. The distance to a large seed source forest is greater than 10 kilometres.

Kooyman (1996) states that if significant remnant vegetation (200 hectares or greater) surrounds or borders the revegetation site, the species selection should be dominated by short-lived pioneer species. Pioneer plantings are totally reliant on seed input from the adjacent forests to add diversity and to mature. This planting design is called a ‘Pioneer Planting’.

If significant remnant vegetation does not exist near the revegetation site, the plant species diversity needs to be brought onto the revegetation site, as there is very little chance of natural regeneration, as seed dispersal will be minimal. Species selection in this case should be dominated by longer-lived late secondary and mature-phase species, as there is little chance of mature phase recruitment. This planting design is called a ‘Late Succession / Mixed Species Planting’.

In the case of the Pryor project site the following guidelines should be followed:

Planting Design – Late Succession / Mixed Species / Riparian Alliance adaptive planting

Objective: This trial demonstrates primarily the need to stabilize streamside zone as quickly and effectively as possible, through the use of high density, late succession mixed species based on the existing riparian alliance (*Castanospermum – Waterhousia* alliance). It recognizes the site constraint of a low likelihood of recruitment from external sources, while acting as a seed source for the broader landscape. Issues such as frost, periodic inundation, and seasonal drought are addressed through the use of this planting design (see figure 18).

The planting species selection is dominated by frost tolerant riparian species, such as *Waterhousia floribunda, Callistemon viminalis, Casuarina cunninghamii, Grevillea robusta* (See Appendix ?).

Figure 20: Considerations such as frost is a major determinant for revegetation. This photo was taken of the frost on-site at 10am during July 2002

3.2.3 Project Site Weeds & Control

Shown in Table 23 (Results) are the weeds identified at the project site's southern bank and their respective means of chemical control. The control methods listed in the table have been adapted from those outlined in the Queensland Department of Primary Industries, 'Suburban Weeds' (Kleinschmidt 1996) publication.

Although not always listed as a mechanism of eradication, glyphosate commonly eradicates almost all of the identified weeds and will be used exclusively as the main weed control for the revegetation strategy.

Species Name	**Common Name**	**Method of eradication / control**
Imperata cylindrica	Blady grass	Regular mowing or spraying with 2,2-DPA
Hydrocotyle spp.	Penny weed	Plants are susceptible to 2,4-D sodium or MCPA + dicamba
Trifolium repens	White clover	Spraying with mecoprop or MCPA + dicamba
Gamochaeta spp. (Gnaphalium)	Cudweed	Controlled by hand weeding or spraying using bromoxynil + MMCPA
Rumex brownie	Swamp dock	Spraying with amitrole or MCPA + dicamba or mecoprop
Conyza bonariensis	A Fleabane	Spot spaying with glyphosate or MCPA + dicamba
Axonopus compressus	Carpet grass	Spot spraying with glyphosate
Cirsium vulgare	Spear thistle Scotch thistle	Spraying with 2,4-D amine or sodium
Baccharis halimifolia	Groundsel bush	Seedlings can be hand pulled, plants to be sprayed or cut-stump with 2,4-D amine, 2,4-D acid, glyphosate or triclopyr
Pennisetum clandestinum	Kikuyu grass	Spot spraying with glyphosate or 2,2-DPA

Dichondra repens	Kidney weed	Spraying with 2,4-D sodium or chlorthal-dimethyl
Ciclospermum leptophyllum (Apium leptophyllum)	Slender celery Wild carrot	Spraying with MCPA + dicamba or spot spraying with glyphosate
Verbena officinalis	A Verbena	Cultivation or sprayed with dichlorprop
Vicia sativa var. angustifolia	Narrow leaf vetch	Hand pulling or spraying with atrazine
Carduus thoermeri	Nodding thistle	Spraying with picloram, dicamba, glyphosate
Sida rhombifolia	Sida retusa Patty's lucerne Common Sida	Mature plants dug or pulled out, seedlings sprayed with 2,4-D amine or fluroxypyr

Table 26: Identified weeds and their control

3.2.4 Future Weed Threat and Control

The numerous invasive 'weeds of concern' (Table 24) identified at the disturbed Obi Obi Creek Crossings pose a very real threat to, and could jeopardise the successful regeneration of native species on the project site.

The main weeds of concern in the lower Obi Obi Creek to impact on the Pryor project site are:

- Camphor Laurel
- Madiera Vine
- Small & Larged-leaved Privet

The control methods listed in the table have been adapted from those outlined in the "Common Weeds of Northern NSW Rainforest" by The Big Scrub Rainforest Landcare Group.

Scientific Name	Common Name	Control Method
Cinnamomum camphora	Camphor Laurel	• Seedlings: hand-pull or spray (1:50 + LI700); • Saplings: Cut, Scrape & Paint or basal bark (1:1.5); • Trees: Frill & Inject (1:1.5) or Cut, Scrape & Paint (1:1.5)
Anredera cordifolia	Madiera Vine	• Ascending vines stems: Scrape & Paint;

		scrape to fibres and paint (100%); • ground infestations: spray (1:50 LI700); • hand-weed tubers and small vines bag and compost under black plastic.
Ligustrum lucidum & *Ligustrum sinese*	Large-leaved Privet & Small-leaved Privet	• Seedlings: spray (1:50 + LI700); • Saplings: Cut Scrape & Paint (1:1.5); • Trees: Frill & Inject (1:1.5).

Table 27: Environmental Weeds of the lower Obi Obi Creek, and their control.

Camphor Laurel it seems is purely out-competing the valuable native riparian species. In many cases Camphor Laurel is all that is stabilizing the creek bank. However, due to the shallow nature of its root system (compared to native species) is not the most ideal species for pure bank stabilization.

Camphor Laurel has been identified as having a significant impact on the lower Obi Obi Creek. As justification of this point, one of the last thriving stands of diverse, pre-European native riparian vegetation present in the Obi Obi Catchment, the Baroon Pocket study area, is void of Camphor Laurel. It can be concluded that the Camphor Laurel is being out competed due to the diverse nature of this balanced ecosystem and is therefore unable to establish and exploit niches as the case in the lower Obi Obi Creek.

Small and Larged-leaved Privet seems to be able to cope with low light conditions, and thus competes with native shrub species of the riparian rainforest under-storey (Big Scrub Rainforest Landcare Group, 1998).

Madiera Vine appears to be spreading along the roadside and creeklines of the Obi Obi district (Wedlock, B. pers. comm. (verbal), 2001). At present only small outbreaks of Madiera Vine occur, with most outbreaks still at a manageable stage.

Continual monitoring by MRCCC staff and the landholder must be maintained at the revegetation site if native canopy cover is to occur. Should the establishment of invasive weeds occur they must be eradicated immediately (following the control methods outlined in Table 27) so they do not compete with the replanted riparian vegetation. Once native canopy cover is established monitoring should continue but may only need to be carried out at less regular intervals.

3.2.5 Stream Side Fencing

Three options exist that can be used on this project site. They are detailed below:

- A 4-strand barbwire conventional fence, that is set back from the creek to prevent damage from flooding.
- A 2-strand hotwire electric fence, this style of fence can be dropped quickly prior to a flood event, and is light and easy to re-erect. The flexibility of this style of fence makes it suitable for riparian zones, as they can be easily moved closer to the creek or further away. However some maintenance is required to ensure grasses and groundcovers do not create contact and earth the electrical system, thereby reducing effective charge (Figure 19).

Figure 21: Typical 2-strand hotwire electric fence on the Mary River, Goomong

- A permanent drop-fence can be erected. This style of fencing can be constructed of galvanized pipe, with the posts concreted in the ground. Each post has a hinge at the base, with a pin. By releasing the pin the fence can hinge downwards and be dropped down prior to a flood event. Another method of constructing a drop-fence is to use ordinary strainer and split posts, but instead of wiring these up, smaller posts (like tomato stakes) are wired up, like a fence, and these tomato stakes are then wired to the strainer and split posts using low tensile wire. This allows quick and easy cutting of the low tensile wire from the posts prior to a flood event (Figure 20).

Figure 22: Typical drop-down fence on the Mary River, Tiaro

The use of stream side fencing acts to remove the degradation caused by cattle.

3.2.6 Off – stream Watering

A number of options can be used at this site. The option selected will depend on the cost-effectiveness, impact on the project site, and landholder suitability. The options are:

1. Reticulation system involving pumping water to the tank and gravity feeding troughs in individual paddocks that are denied access to water.
2. Reticulation system from existing dam to troughs in paddocks denied access to water
3. Cattle completely denied access to creek, thus utilizing water from existing dams.
4. Cattle corralled into small section of creek bank on stable inside bend of creek.

3.3 Large Woody Debris Design

3.3.1 Project Design

Although there is now an increase in the understanding of the benefits of using LWD as a means of erosion control and increasing in-stream habitat, there are few scientific guidelines regarding the positioning of timber so that it will replicate the benefits as seen under natural conditions.

However, in his 1997 paper the leading researcher of LWD, Tim Abbe has observed that, 'natural woody debris jams exhibit distinctive patterns in the position and orientation of logs of various sizes.' The design of the Pryor LWD Project has been modeled on successful experimental LWD structures from the Williams River in central NSW (see figure 9).

Figure 23: 1st major log-jam from water level

Figure 24: 2nd log-jam below riffle

Figure 25: 1st riffle; pre-construction of double log sill

Figure 26: 2nd riffle; pre-construction of large woody debris upstream

Figure 27: 1st riffle; 9 months post construction

Figure 28: 2nd riffle; 9 months post-construction, note log-jam on right

As a means of maximizing success and minimizing risk, the LWD project has been designed, 'using variations in log orientations and the structural attributes of natural jams' (Abbe, Montgomery & Petroff 1997, p 810). Nevertheless, there are no guarantees of success as this work is still in its infancy and purely experimental. It is intended that upon completion of the in-stream works, the constructed LWD structure will replicate the design in figure 14. The project successfulness depends entirely upon the seasonal variability in flow regimes. Will enough time have elapsed to allow the engineered woody deflector jams and log sills to settle and become secure before a high energy 1 in 50 year flood?

Documented in Marsh, Rutherfurd & Jerie (2001), Mary River Cod are known to use LWD for the spawning of their adhesive eggs. He continues by stating that, 'LWD (also) creates hydraulic diversity by creating areas of high velocity, low velocity and turbulent flow. The local velocity fluctuations produce small scour and depositional areas around the LWD providing variations in water depth' (see figure 29 & 30). Variations which due to de-snagging are now rare and which prove vital in providing habitat favorable to the Mary River Cod. Moreover, this deposition of stream bed material is intended to reverse the erosive processes acting upon the exposed face of the southern bank, which together with the extensive riparian revegetation will render this southern bank stable. In support of this statement, Brooks (1999) states that, 'The presence of LWD near the bed and banks of a channel provides roughness to the flow, effectively educing the net energy of the flow which in turn reduces the ability of the stream to erode the bed and banks'.

Figure 29: Showing length of under-cut bank generated by turbulence from root-wad

Figure 30: Approximately 60 cm of under-cut bank created by scour from the root-wad

Although now exhibiting relatively high diversity, the increased LWD loading of the project site is expected to foster an increase macro-invertebrate diversity as, 'LWD provides a stable substrate for algae and macro-invertebrates (Gowns et al. 1999; Hilderbrand et al. 1997)'.

3.3.2 LWD Loading

There is little benefit of increasing the LWD loading of streams if the current loading meets the recommended minimum of $0.01m^3/m^2$ to $0.1m^3/m^2$ (Rutherfurd et al. 2000). Therefore, it was necessary to determine the current LWD loading of the project site.

Rutherfurd (et al. 2000), suggests that most reasonably intact Australian streams should have a LWD loading between $0.01m^3/m^2$ to $0.1m^3/m^2$. The project site LWD loading was measured throughout the active channel (430m) and found to be $0.007\ m^3/m^2$, far less than Rutherfurd's recommendation.

It was calculated that the combined transported and existing LWD would bring the project's LWD loading to $0.0387m^3/m^2$ – which is towards the lower limit for reasonably intact Australian streams (Rutherfurd et al. 2000), but more promising than the existing LWD load.

3.3.3 Tractive Stress and Scour

'The tractive stress is the force acting on the streambed measured in Newtons per square metre' (Parfait 1999, p 500). Put simply, tractive stress is best described as the ability of the stream to move large objects such as rocks and LWD, and stream velocity is very important as this is an indication of stream energy. 'For non-cohesive materials, the size of particle that will start moving is directly proportional to tractive stress' (Parfait 1999, p 500).

This proves vital in the design of any LWD structure because stream energy is directly proportional to the potential of a stream to induce LWD movement. It follows then that if a stream has high energy levels, (and thus a heightened potential to move LWD) the structure must utilize very large dense timbers and be keyed into the banks to resist movement and failure. As is the case for the Pryor project site. 'An alluvial channel is stable if the physical properties of the material are such as to withstand the tractive stress' (Parfait 1999, p 500), and this is one reason for the use of in-stream LWD at the Pryor site – to assist in making the channel stable.

The Geomorphic Assessor's (Parfait 1999) analysis of the Pryor project site proved critical in the design of the LWD as it computed the predicted scour depth to be ½ metre. Thus, for the basal logs to be successful in creating scour in the stream bed (and keeping it there), they must be buried to a depth no less than 0.5 metre. If, for example the basal logs were buried to a depth of only 0.4 and the scour depth was 0.5 metre, the scour (which is needed to create the deeper pools which are a requirement of the cod) would over time, undermine and cause the collapse of the engineered log jams.

3.3.4 Timber Description

The sourcing of the quantity of appropriate timber for the LWD project proved extremely difficult. For the project to be a success the design required the sourcing of 60 logs, all of which must meet certain criteria. When assessing a piece of timber for its use in any LWD project, four criteria must be met:

- Appropriate size;
- Attached rootwad
- Weight and density;
- Native or exotic

3.3.4.1 APPROPIATE SIZE (length and girth)

This criteria relates to the overall length and average girth of the log (Dudgeon, S., Pers. Comm. (verbal), 2001). These two attributes are ultimately dependant upon the role of the log in the Woody Jam. For example, if the log is to form part of a submerged basal structure then obviously it can stretch no wider than the stream. However, it must have enough length and girth to cease the onset of scour in the stream bed and must remain in situ in the event of a flood.

Furthermore, should a log be used as a lateral or any other part of the LWD structure exposed to stream flow, it is essential to have as much length and girth and therefore weight as possible, to lessen its mobility potential. The girth or circumference of the log varies again depending upon its role in the LWD structure. The average girth per log length for this LWD project is 500mm. Very few logs average less than this with two of the biggest logs recording an average girth of 1400 millimetres. More often than not, the only restriction imposed upon the length (and sometimes girth) of a log is the legal permissible overhang (if any) on a semi-trailer. It is for this reason that all timber sourced for this project was sized to a length of 11 metres, allowing for two large logs, with opposing rootwads per trailer.

3.3.4.2 ATTACHED ROOTWAD

It is imperative that all LWD have attached a substantial rootwad (Dudgeon, S., Pers. Comm. (verbal), 2001). A log with an attached rootwad potentially has twice the weight of a comparatively similar log lacking a rootwad. The rootwad in it own right weighs as much as the log itself and this was proven by the positioning of the excavator log grabs during loading. For the excavator to successfully "grab" and place the balanced log on semi trailer, the operator positioned the grabs as close to the rootwad as possible, thus proving the distribution of weight throughout the entire log (see Figure 31 & 32).

Figure 31: Note front-end loader and excavator lifting log onto truck

Figure 32: Note lifting point of log with excavator

Why then is the rootwad so important for this particular LWD project?

- Firstly, this attached rootwad, in almost all cases, doubles the potential weight of the log in the stream by providing much needed ballast and total log stability which lessens the likelihood of the structure becoming mobile.
- Secondly, the rootwad assists in the cumbersome efforts of interlocking the timber in-stream – an essential component in any successful LWD structure, which again lessens the chances of the structure moving in a flood event.
- Finally, the rootwad in this particular instance will aid in providing in-habitat needed for the survival of the endangered Mary River Cod.

3.3.4.3 WEIGHT and DENSITY

The heavier the timber (combination of length, girth and density of timber) the less likely it is to become mobile during a flood. Lessening the likelihood of LWD movement is critical when considering the following:

1. Should the moving LWD collide with rigid structures like roads, bridges, pump sites and even existing riparian vegetation, there is the increased possibility that they (the roads, bridges etc.) could be destroyed by way-ward LWD;
2. Due to the high costs of implementing such LWD structures, once in place it is intended that they will remain in place; and
3. Unexpected movement could result in unexpected and undesired scour and erosion in particular areas which was not part of the design of the LWD project.

As mentioned above weight is a function of total length, girth and density. When sourcing logs for a LWD structure, hardwood timbers including Iron Bark, Spotted and Blue Gum and Pink Box are of highest priority, as these timbers' per unit volume have the greatest density and thus the greatest weight.

3.3.4.4 NATIVE vs. EXOTIC

Very few exotic species exhibit the required attributes that so many native Australian hardwood timbers demonstrate. Only small numbers of exotics attain the 400 millimetre average minimum girths, little manage the 11 metre trunks, and few parallel the high densities found in native species. One unfortunately common exotic species present at the project site is Camphor Laurel, *Cinnamonum camphora*. Camphor laurel boasts many like attributes to that of native hardwoods except that the fruits, leaves, branches and roots contain an aromatic chemicals called Sathrole (Friend 1999) and Ketone. These chemicals poison the in-stream lower order aquatic life at the bottom of the food-chain, which in-turn effects the higher order predators such as the endangered Mary River Cod.

3.4 Consultation techniques

For any project to be a success, consultation and communication between the project manager and all stakeholders is as important as the project design itself. The instant that communication among stakeholders breaks down, confidence and support of the project diminishes. Being aware of this, excellent communication techniques were maintained between all stakeholders, from the very start of the project through to project completion. This consultation and communication, whether it be in the form of day-to-day involvement of the landholder, the many reports presented to MRCCC working groups and project officers, or the coordinating of experts on-site, established a real sense of ownership among all stakeholder groups. This sense of ownership highlights the self-motivated interest and willingness of the stakeholders in comprehending the usefulness of this Queensland first, innovative scientific environmental management tool.

There were six consultation techniques identified as being used repeatedly throughout the Pryor's LWD project:

1. Verbal communication and interaction,
2. Informative stream walks,
3. Site evaluations,
4. Communication and involvement with the landholder,
5. The use of media, and
6. Shire councils.

Verbal communication and interaction

This consultation technique is used extensively every day with all stakeholders while describing the project, how it works, what is involved in implementing it and its location in the Obi Obi Creek, while justifying the works on the Obi Obi with other like projects around the world. The ability to enlighten skeptics and those criticising the LWD project that it will meet the objectives is also required.

Informative stream walks

This consultation technique requires an educational and enthusiastic on-site explanation to stakeholders. While explaining the theories of the LWD project, the ability to answer any impromptu questions raised by the stakeholders is imperative in maintaining a high level of confidence in the project. Using good positive communication the presenter's knowledge of the principles of LWD functions will be understood by all present stakeholders. At all times communication must be maintained at a level familiar to that of the landholder.

Site evaluations

The ability to communicate on a professional level with representatives from Council, Greening Australia, DNR&M and MRCCC both in meetings and in the field, allowed for quick accurate site evaluations. This ensured that the LWD works was situated at the site where it would be of most environmental benefit.

Communication and involvement with the landholder

The landholder had the final say in whether or not to proceed with the project. It stands to reason then, that if the landholder felt left out of the design by not being able to provide input and voice their concerns about the project, it would have failed. The scientific nature of the design proposals was explained such that they made sense to the landholder and any feedback from the landholder was considered very important in the design of the project.

The use of media

The avenue of local newspapers and community news papers was used to increase public awareness about the LWD project in their creek the Obi Obi. Having articles in these papers the locals could relate to the location of the works and be made aware that their community was having a great deal of time and money spent on one of their degraded recreational areas. Feedback from the community was continually forth coming both appreciative of the project and negative. This avenue of public awareness lead to continually increasing Verbal communication and interaction through detailed explanations to the public in the street, to shop keepers and via numerous telephone calls.

Maroochy Shire Council

Being one of the major sponsors of these engineered LWD projects the Maroochy Shire Council was continually reported to with project updates. Representatives from the council were involved in the Informative stream walks and Site evaluations along with continual Verbal communication and interaction through telephone and email conversations.

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Appendix 1

Vegetation Assessment of Obi Obi Creek Catchment

The Obi Obi Catchment Large Woody Debris Re-instatement Project by the Mary River Catchment Coordinating Committee

Composite Flora List

by Ernie Rider, Luke Brown & Brad Wedlock

Key to species codes

sp. - Plant identified to genus level only
* - Exotic species
C - Common protected species

Geographic distribution limits according to Queensland Herbarium records

NL - Northern Limit
SL - Southern Limit
NN - Near Northern Limit (within 30')
- not previously recorded in Wide Bay pastoral district by the Queensland Herbarium
@ - not previously recorded in South Eastern Queensland Biogeographic Region by the Queensland Herbarium

TOTALS
Species/Subspecies = 100

Limits
Northern = 1
Southern = 2
Near Northern = 2

ANGIOSPERMS : DICOTYLEDONS

Akaniaceae
Akania bidwillii Turnip wood NN

Anacardiaceae
Euroschinus falcata Ribbonwood, cudgerie

Apocynaceae
Parsonsia straminea Monkey rope

Araliaceae
Polyscias elegans Celerywood

Polyscias murrayi Pencil cedar

Asclepiadaceae
Marsdenia lloydii Corky milk vine

Asteraceae
* Ageratina riparia Mistflower
Ozothamnus sp.

Burseraceae
Canarium australasicum

Casuarinaceae
Allocasuarina torulosa Forest oak, Rose she-oak

Celastraceae
Denhamia celastroides Denhamia
Hedraianthera porphyropetala Hedraianthera

Cunoniaceae
Schizomeria ovata Crabapple

Elaeocarpaceae
Elaeocarpus grandis Blue Cuandong, Coolan
Sloanea australis Maiden's blush

Epacridaceae
Trochocarpa laurina Tree-heath

Euphorbiaceae
Cleistanthus cunninghamii Cleistanthus
Glochidion ferdinandi Cheese wood
Mallotus philippensis Red kamala

Eupomatiaceae
Eupomatia laurina Bolwarra

Fabaceae
Austrosteenisia blackii Blood vine
Castanospermum australe Moreton bay chestnut
Derris involuta Native derris
Hovea longipes Scrub hovea
Millettia megasperma Native wisteria

Grossulariaceae
Quintinia sieberi Brown possumwood NL, #

Lauraceae

*	Cinnamomum camphora	Camphor laurel	
	Cinnamomum oliveri	Oliver's sassafras	
	Cryptocarya glaucescens	Silver sycamore	
	Cryptocarya laevigata		
	Cryptocarya triplinervis	Three-veined cryptocarya	
	Endiandra discolor	Domatia tree, Rose walnut	
	Litsea leefeana	Brown bolly gum	SL
	Neolitsea dealbata	White bolly gum	

Meliaceae

	Melia azedarach	White cedar
	Toona ciliata	Red cedar

Mimosaceae

	Acacia bakeri	Blake's wattle
	Acacia melanoxylon	Blackwood
	Acacia penninervis	Mountain hickory

Moraceae

	Ficus coronata	Sandpaper fig
	Ficus fraseri	White sandpaper fig
	Ficus obliqua	Small-leaved fig
	Maclura cochinchinensis	Cockspur thorn
	Streblus brunonianus	Whalebone tree

Myrtaceae

	Acmena smithii	Lillypilly
	Backhousia myrtifolia	Grey myrtle, Carrol
	Corymbia gummifera	Red bloodwood
	Corymbia intermedia	Pink bloodwood
	Eucalyptus grandis	Flooded gum, Rose gum
	Eucalyptus microcorys	Tallowwood
	Eucalyptus pilularis	Blackbutt
	Lophostemon confertus	Brush box
	Syncarpia glomulifera subsp. glomulifera	Turpentine
	Syzygium australe	Brush cherry
	Syzygium oleosum	Blue lilly pilly
	Waterhousea floribunda	Weeping

Oleaceae

	Notelaea ovata		NN

Pittosporaceae

	Pittosporum rhombifolium	White pittosporum

Rhamnaceae

	Alphitonia excelsa	Red ash
	Alphitonia petriei	Pink ash, White ash

Rosaceae

	Rubus moluccanus	Molucca raspberry

Rubiaceae

	Morinda jasminoides	Morinda

Rutaceae

	Acronychia oblongifolia	Common acronychia
	Flindersia schottiana	Bumpy ash, cudgerie

Sapindaceae

	Cupaniopsis parvifolia	Green-leaved tamarind
	Guioa semiglauca	Native tamarind
	Jagera pseudorhus	Foambark
	Mischarytera lautereriana	Corduroy tamarind
	Mischocarpus pyriformis	Yellow pear-fruit
	Sarcopteryx stipata	Steelwood

Simaroubaceae

	Ailanthus triphysa	White bean

Ulmaceae

	Aphananthe philippinensis	Rough leaved elm

Vitaceae

	Cissus antarctica	Water vine
	Tetrastigma nitens	Native grape, Three leaf vine

Winteraceae

	Tasmannia insipida	Pepper bush

ANGIOSPERMS : MONOCOTYLEDONS

Agavaceae

	Cordyline rubra	Red-fruited palm lily

Arecaceae

	Calamus muelleri	Lawyer vine

Commelinaceae

*	Commelina benghalensis	

Cyperaceae

C	Gahnia sieberiana	Sword grass

Liliaceae

	Dianella caerulea	Blue flax lilly, blue berry lilly	

Poaceae

	Oplismenus aemulus	Creeping shade grass	

Smilacaceae

	Geitonoplesium cymosum	Scrambling lily	
	Ripogonum album	Supplejack	#
	Smilax australis	Barb wire vine	
	Smilax glyciphylla	Sweet sarsaparilla	

Xanthorrhoeaceae

	Lomandra hystrix	Longleaf matrush	#
	Lomandra longifolia	Spinyhead matrush	
C	Xanthorrhoea sp.		

Zingiberaceae

	Alpinia caerulea	Native ginger	

ANGIOSPERMS

Dipsacaceae

	Cephalaria syriaca		#, @

GYMNOSPERMS

Podocarpaceae

	Podocarpus elatus	Brown pine, She pine	

Zamiaceae

C	Macrozamia miquelii	Zamia palm, wild pineapple	

PTERIDOPHYTES

Adiantaceae

	Adiantum aethiopicum	Common maidenhair	

Aspleniaceae

C	Asplenium nidus	Bird's nest fern	SL, #, @

Blechnaceae

	Blechnum nudum	Fishbone water fern	
	Doodia sp.		

Cyatheaceae

	Cyathea australis	Rough tree fern	
	Cyathea leichhardtiana	Prickly tree fern	

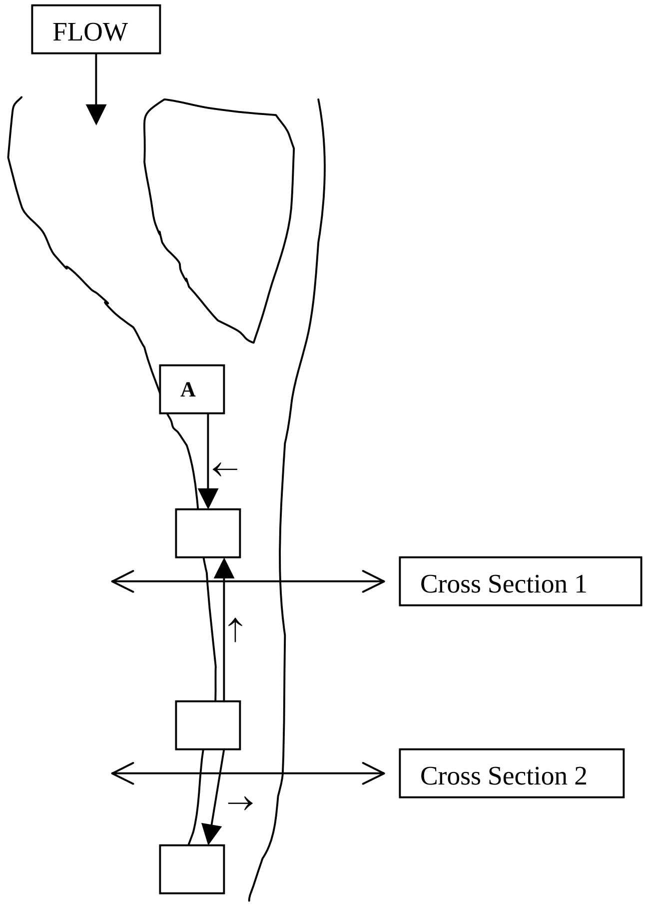
Polypodiaceae

C	Platycerium bifurcatum	Elkhorn
	Pyrrosia confluens	Felt, Robber fern

APPENDIX 2

SURVEY OF SITE – Obi Obi Creek (Pryor)

Creek Elevation 110m



Site 1	**Height**
Height of Dumpy	1.58
Top	2.76
Middle	2.42
Bottom	2.08
Rise	0.84
Distance (Run)	68
Slope	0.012
Site 2	
Height of Dumpy	1.68
Top	2.03
Middle	1.62
Bottom	1.22
Rise	0.06
Distance (Run)	81
Slope	0.0007
Site 3	
Height of Dumpy	1.68
Top	2.17
Middle	1.73
Bottom	1.3
Rise	0.05
Distance (Run)	87
Slope	0.0006
Avg Slope - Reach	0.004

Cross Section 1

Recording	0	1	2	3	4	5
Angle (^{o})	0	3.5	4	3.5	2.5	-4
Distance	0	14	20	31	40	44

(m)						
X	0	14	20	31	40	44
Y	0	0.86	1.4	1.9	1.7	3.07
Elevation	110	109.4	108.6	108.1	108.3	113.07

APPENDIX 3

The transport technicalities of shifting LWD

Due to the sheer size and weight of the timber required, as outlined in design (Dudgeon, S., Per. Comm. 2001) it was decided that in order to make the transportation of timber as cost effective and as safe as possible the hiring of two (2) flat bed and one (1) low-loader semi trailers would be required. Using large trailers allowed for a total log length of 11 metres and a maximum permissible width of the rootwad of 2.4 metres. Although the total permissible log length for these trailers is 12 metres, the cutting of the logs at 11 allowed for two large logs per trailer when positioned with rootwads at opposite ends of the trailer. Moreover, where the positioning of large logs on the flat beds allowed for a smaller log on top, (making a one-on-two pyramid-like structure) this was done. However, the loading and securing of timber in this fashion, required heightened awareness. With a log propped on top of the two lower logs the chance of logs becoming unstable and rolling off was increased dramatically.

In deciding the best hauling route from Blowers Road Tiaro, to project site (see map), three considerations as outlined below were accounted for:

1. Other road users,
2. Haul road layout and topography, and
3. The drivers and machinery.

Once loading was complete and tied down, all loose material, including bark, dirt and rocks from the rootwad, were swept from the trailer. Prior to loading the excavator shook loose any material still attached to the rootwad. Approximately ten (10) kilometers from the loading site saw the trucks hauling down single lane, rarely used roads which allowed all other material to shake loose. Before merging onto the Bruce Highway another check was made for any potentially dangerous material on the trailers. The Imbil – Kenilworth road and the Skyring Creek – Kenilworth Road made up the two possible haulage routes to the project site. The former was decided against as it formed part of the matrix of tourist drives in the Mary Valley. In addition to this, unlike the Imbil – Kenilworth road, the latter did not require the trucks to negotiate a steep and low visibility range.

APPENDIX 4

How to determine minimum riparian zone establishment widths.

Minimum riparian zone widths are calculated individually for each site on the basis of the present site conditions (observed bank geometry) and the past erosion history (measured or estimated bank erosion rate). The basic allowance for the width of any riparian plantation designed for bank stabilization should not be less than 5 metres measured onto the floodplain from the bank crest. As banks become higher they become less stable. Hence, in addition to the basic allowance, it is recommended that the width of riparian strips also include a height allowance not less than the height measured vertically from the bank toe to the bank crest. Time must be allowed for the plants to grow before they can begin to stabilize the bank, so where banks are actively eroding an establishment allowance should also be included in the final riparian zone width. The establishment allowance is determined by multiplying the erosion rate by the time required for the plantation to mature. (Abernethy, B. 1999).