

A Protocol for River Rehabilitation

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SUMMARY: A new 14 step river rehabilitation protocol has been developed for use by the NSW Department of Land and Water Conservation that addresses the causes, not the symptoms of river instability in order to recreate an ecologically sustainable river system. This protocol was developed from a review of the Department's previous and proposed river management works in the Williams River catchment in the Hunter Valley following a recommendation of the Healthy Rivers Commission for such research. This review found some poor work practices and concluded that the former river training works treated accelerated channel instability by addressing the problem on a site by site basis with largely structural works. As a result, there were many detrimental environmental impacts on the channel and the riparian zone. The new protocol addresses these identified problems.

MAIN POINTS OF THE RIVER REHABILITATION PROTOCOL:

- Create a multi-functional team to integrate hydraulics, hydrology, geomorphology and ecology in the formulation of an effective river rehabilitation plan.
- Establish the goals and objectives of the rehabilitation plan in a formal 'statement of intent'.
- Adopt an indigenous riparian vegetation rehabilitation program as part of the river rehabilitation scheme.
- Use 'Adaptive Ecosystem Management' to ensure that science-based management actions are effectively monitored and evaluated with adaptive revision of actions based on monitoring information.
- Compare the benefits and successes of the rehabilitation scheme against those predicted before the plan was implemented by undertaking post-project evaluation.

1. INTRODUCTION

The Healthy Rivers Commission was established in 1996 as part of the New South Wales Government's water reform package. Its role, among other things, is to help the community make informed choices and decisions about how to protect and use the rivers of New South Wales by a public inquiry process (Crawford, 1997). The first river investigated by the Commission was the Williams River in the Hunter Valley. The draft report on the Williams River was released in June 1996 (Healthy Rivers Commission, 1996a) and the final report in December 1996 (Healthy Rivers Commission, 1996b). Both reports mentioned community criticisms of past river management activities by the NSW Department of Land and Water Conservation and its predecessors. The Commission concluded that the previous river management works:

"...were undertaken to address significant and widespread flooding and erosion problems and that they may well have been based on the best engineering approaches of the time" (Healthy Rivers Commission, 1996b:36).

The Commission went on to recommend :

"early action by the Department of Land and Water Conservation to determine, as part of the catchment planning process and in conjunction with landholders, whether rehabilitation of the river is required" (Healthy Rivers Commission, 1996b:36).

The final report of the Williams River Inquiry contained a specific goal that the Williams River should have a

stable river bed and banks, with a natural pool and riffle sequence providing optimum in-stream habitat diversity. The Commission recommended that:

"Completion of a comprehensive riverine rehabilitation and management component of the Williams River Catchment Plan be accelerated" (Healthy Rivers Commission, 1996b: 63).

This paper reports the findings of an independent expert geomorphic assessment of past and proposed river management works by the Department in the Williams River catchment and proposes a river rehabilitation protocol to be adopted in the future. This protocol should have more widespread application than just the Williams River and is presented here in the hope that others may apply and improve it. Full details of this work are contained in Erskine (1998). "*River rehabilitation*" refers to the partial return of a river channel to its pre-disturbance structure or function (Brookes and Shields, 1996).

2. THE WILLIAMS RIVER CATCHMENT

The Williams River catchment has a total area in excess of 1000 km² and has the highest rainfall (up to 1500 mm/a) and runoff (352 to 893 mm/a) of any major catchment in the Hunter Valley (M^cMahon, 1969). Chichester River is the largest tributary and is impounded for water supply to Newcastle. Seaham Weir impounds the lower Williams River at the head of the

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former estuary. The Williams River catchment is part of the Southern Barrington hydrologic area that is characterised by a high specific mean annual flood and moderate flood variability (Erskine and Livingstone, 1999). This is unusual for the Hunter Valley (Erskine and Livingstone, 1999).

The Williams River catchment is located in the North-Eastern Mountains geomorphic region of the Hunter Valley that is a mountainous tract of Devonian marine sediments and Carboniferous terrestrial rocks (Erskine and Fityus, 1998). Erskine (1998) compiled a detailed land use history for the catchment and demonstrated that the greatest changes of hydrologic significance occurred during the nineteenth century when the forests were cleared. Water yields at that time probably increased by up to 250 mm/a. Dairying is the main land use today (Healthy Rivers Commission, 1996b).

The Williams River is a gravel-bed stream with frequent bedrock bars and alternates between closely bedrock-confined and floodplain sections. A meandering pattern is exhibited in most floodplain sections. The major bedforms are pools, riffles and various types of gravel bars in flatter reaches and boulder steps and step pools, cascades, rapids (Grant *et al.*, 1990) and gravel bars in the steeper reaches (Erskine, 1998).

3. PREVIOUS RIVER MANAGEMENT WORKS

Ten major river training schemes (85.86 km of channel treated) have been completed in the Williams River catchment above the original tidal limit at a cost of \$1.048 million (historical prices). River training works were undertaken discontinuously between 1954 and 1991 on various sections of the Williams and Chichester Rivers. Another 25 minor river works had been constructed on the Williams River and 13 on the Chichester River by 1 December 1985 (Erskine, 1986). Further minor works have been undertaken on other tributaries. The length of channel impacted and the cost of these minor works are unknown. At least 48000 introduced trees have been planted and 8000 trees and logs have been removed from the channel. Many small *Casuarina cunninghamiana* and *Callistemon viminalis* have been removed from bars but no attempt was made to keep an accurate tally. More than 9.1 km of bank protection works were constructed, 22 km of channel were cleared of vegetation and 0.76 km of channel were bulldozed with no works installed.

The river training works were undertaken for one or more of the following reasons:

1. to arrest bank erosion;
2. to remove obstructions that partially block the channel and concentrate flows against the banks, thus causing erosion;
3. to provide a stable stream alignment;
4. to protect specific structures, such as road and railway bridges; and
5. to stop a change of river course by alluvial stripping (Warner, 1997).

The aims of the river training works were usually to establish stable banks on a suitable alignment with an adequate waterway free from obstructions. These aims were to be achieved by a range of works, including some or all of the following:

1. selection and installation of a stable channel alignment;
2. construction of grids of brush and/or wire mesh fences anchored to large concrete blocks to help mark the selected alignment;
3. construction of grids of wire mesh fences anchored to steel piles to help mark the selected alignment;
4. construction of rock training walls to mark the selected alignment;
5. establishment of a dense growth of willows and poplars outside the limits of the selected alignment within the grid of brush, mesh or rock fences or behind the rock training walls;
6. establishment of a dense growth of willows and poplars along the toe of the river bank without structural support;
7. clearing or desnagging of trees, shrubs and logs (large woody debris), and dozing of bars and the river bed within the selected alignment;
8. earthworks to relocate the low flow channel to the selected alignment; and
9. artificial cutoffs by constructing pilot channels across point bars or the neck of meander loops.

River training involves the treatment of a reach of river so that both channel alignment and width are controlled between up- and downstream stable sections (Rankin, 1982; Erskine, 1990; 1992; Raine and Gardiner, 1995).

A preoccupation with the large-scale removal of vegetation and large woody debris from channels was apparent with the works. This is easily understood when it is realised that river training evolved from flood mitigation. One of the often stated aims of flood mitigation is to increase channel capacity by carrying out so-called *channel improvements* (for NSW examples, see Reddoch and Milston, 1953; Whitehouse and Clarke, 1983). Improvements meant an increase in flow velocity or an increase in channel size and were achieved by all of the following:

1. removal of snags or desnagging;
2. removal of trees from channels;
3. removal of bars of sand and gravel;
4. artificial cutoffs; and
5. physical enlargement of the river channel (Reddoch and Milston, 1953).

A.F. Reddoch, a former Commissioner of the Water Conservation and Irrigation Commission, helped to pioneer the development of river training in NSW and held a number of views that continued to influence river management in NSW well into the 1980s. Some of these views were:

1. "The existence of snags in a river channel not only leads to retardation of the flow but may also divert it towards the bank and, because of this, is frequently the cause of serious river bank erosion commencing" (Reddoch and Milston, 1953: 250);
2. "River channel clearance probably gives a greater benefit in the way of alleviating flooding than any other form of river improvement work involving similar expenditure. For the proper preservation of many of our alluvial flats, large sums of money will have to be spent on clearing work of this nature" (Reddoch and Milston, 1953: 250); and
3. "To be effective in reducing flood levels over an appreciable length of river, a number of cut-offs **must** (our emphasis) be constructed and a reasonable reduction in length obtained" (Reddoch and Milston, 1953: 251).

Furthermore, Reddoch also perceived the need to maintain river channels of adequate capacity by removing accumulations of silt and gravel (Reddoch and Milston, 1953). While most of the above claims are strictly true, they do not reflect a multi-disciplinary approach to the problem of river restoration. As a result, short term flood mitigation benefits were disproportionately weighted at the expense of longer term biogeomorphic and ecological detriments.

4. EFFECTIVENESS OF RIVER MANAGEMENT WORKS

River training in the Williams River catchment was always intended to address the immediate problems of channel instability, particularly bank erosion and associated damage to infrastructure and land, and channel obstructions. This is clearly stated in essentially all of the proposals for river training works. Bank erosion was **never** evaluated in a wider context of the causes of channel instability but was always treated as a symptom or site-specific problem for a reach of river of greatly variable length. Although a catchment focus was advocated for restoration of the whole Hunter catchment in 1948 (Huddleston *et al.*, 1948) and was implemented by the creation of the former Hunter Valley Conservation Trust in 1950 (now the Hunter Catchment Management Trust), it was not practised for river management works. This is ironic because the Trust partly funded the river training works.

River training works treated accelerated channel instability by addressing the problem on a site by site basis with largely structural works. There was no attempt to identify causative factors let alone address them. Furthermore, there has been a complete lack of post project evaluation. Poor work practices included:

- the extensive removal of gravel armour layers, and boulder and log steps (Grant *et al.*, 1990), resulting in the initiation of bed degradation. Up to 0.6 m of degradation was recorded and up to 15 years were

required before the channel stabilised after the disturbance (Erskine, 1998);

- wholesale loss of pools by degradation and the removal by bulldozing of boulder and log steps (Erskine, 1998);
- excessive removal of large woody debris and trees;
- planting of enormous quantities of exotic trees;
- extensive dozing of the channel to remove bars, particularly mid-channel bars; and
- a lack of consideration of the needs of fish and riparian vegetation.

Seeding willows (Cremer *et al.*, 1995) were also found during the field work for this project.

5. RIVERCARE PLANNING ACTIVITIES

Rivercare refers to an interactive process between landowners and the Department of Land and Water Conservation for ecologically sustainable river management (Gardiner, 1996). The purpose of the program is to address contemporary channel instability problems, such as bank erosion, floodplain stripping, sedimentation and riparian vegetation management, so as to produce stable, well vegetated rivers (Gardiner, 1996). Plans have been prepared for two sections of the Williams River.

The works proposed on the Upper Williams Rivercare Plan are similar to those previously completed as river training works. In some cases, these did not work and should not be repeated. Boulder steps (Grant *et al.*, 1990) are present today and were formerly more common. The recreation of these steps by the return of boulders to the channel as river-spanning ribs should be attempted, where possible. This should stop the bed degradation that is still occurring.

The works proposed on the Williams River Rivercare Plan upstream of the Seaham Weir pool are similar to those previously completed as part of a river training scheme. This indicates that the earlier works did not achieve all of their stated aims. Alluvial stripping (Warner, 1997) is still a problem despite the completion of large scale vegetation clearing and large woody debris removal from the river channel. As the earlier works did not succeed, floodplain revegetation should now be attempted instead (Warner, 1997; Erskine, 1998).

6. A SUGGESTED RIVER REHABILITATION PROTOCOL

Based on the above work, it is concluded that previous river management works did not, and current Rivercare planning activities often do not, address the causes of river instability. Therefore, it is recommended that a river rehabilitation planning protocol should be implemented that is different to the current process. Some criticisms have been outlined above that indicate that there is no explicit attempt to address catchment factors in the present scheme and that there are some

fundamental shortcomings with river management practices. Kondolf and Downs (1996: 144) came to the same conclusion for overseas practices and expressed the problem thus:

“It has been argued that the failure of many traditional river channel management schemes results from the treatment of symptoms instead of causes, and this can be summarised as an inability to incorporate the catchment context into their plans. Consequently, the most obvious departure in new river channel management practices compared with traditional techniques has been an increase in the degree to which catchment-wide or part-catchment-wide multidisciplinary scientific appraisals form the basis of design. Attempts at river restoration need fundamental hydrological information and a catchment-level and historical study basis, interpreted by an experienced geomorphologist, to ensure a sustainable project. ‘Cookbook’ design guidelines tied to a classification scheme and implemented by staff with only a brief training in geomorphology will more likely result in further degradation of channel conditions rather than ecological improvement.”

Geomorphology forms the basis of this protocol because ecological recovery is contingent upon an understanding of, and the creation of, appropriate geomorphic processes and stream morphology (Erskine *et al.*, 1990; Erskine, 1993; Brookes and Shields, 1996; Kondolf and Downs, 1996; Thorne *et al.*, 1996). Brookes and Shields (1996) argued that an abiotic goal is a more suitable end point for stream restoration than a biotic one because geomorphic surfaces form the template for the establishment of ecological communities.

Various river restoration and rehabilitation protocols have been proposed by Brookes (1990), Newbury and Gaboury (1993), Brookes and Shields (1996) and Stanford *et al.* (1996). None of these are directly applicable to NSW rivers so a new scheme is proposed below.

The proposed river rehabilitation protocol involves the following 14 steps.

1. Establish Goals and Objectives

All river rehabilitation activities should be carried out in the context of an overall plan with well-defined objectives that should be used to evaluate the benefits and successes of the scheme (Erskine, 1993). The objectives can be summarised in a “statement of intent” (Brookes, 1990).

2. Classification of the Study Reach

All sections of river to be covered by a rehabilitation plan should be classified into geomorphologically homogeneous reaches using an appropriate scheme. Kellerhals *et al.* (1976) and Rosgen (1994), among

others, have proposed such schemes. However, it must be stressed that there is no universally acceptable scheme and any classification will require modification to suit rivers different to those used to derive the scheme (Kondolf and Downs, 1996). Different reaches are often subject to different biogeomorphic processes and hence require different management strategies and works (Thorne *et al.*, 1996; Downs and Thorne, 1996; Moon *et al.*, 1996). Classification should also be used to collect baseline data essential for design and project evaluation purposes. Appropriate baseline data should include that needed to complete the classification, to undertake the design of any works and to commence monitoring activities. A prescriptive set of data is not proposed here because it will vary between rivers and reaches. Kondolf and Downs (1996) correctly emphasise that, due to **equifinality**, it is not always possible to infer correctly the causes of a particular channel type solely from its morphology, as attempted by some ecologically based classifications (Rosgen, 1994). Nevertheless, the process is important for evaluating the significance of local factors in determining river instability.

3. Catchment Audit

A catchment level analysis of the biophysical and cultural characteristics of the drainage basin is essential to evaluate linkages between catchment processes and river instability. This can be expressed as “work local but think catchment”. Such analyses can be conducted by GIS and digital terrain models, where necessary and where the data exist.

4. Historical Analysis

Historical channel changes for the section of river being covered must be determined to establish and understand the links between catchment controls, local factors and river channel changes, if any exist (Erskine, 1986; Kondolf and Downs, 1996). Furthermore, this information is needed to assess whether the pre-disturbance channel form can be reinstated (i.e. river restoration) or whether a different morphology must be designed because of altered catchment conditions (i.e. river rehabilitation).

5. Address Causes not Symptoms

To improve river health and ecological integrity it is essential that the causes of river instability are addressed. This may need both catchment and river works/strategies (Erskine, 1994). Furthermore, catchment works will often induce secondary channel responses that will require subsequent river works (Erskine, 1994).

6. Identification of a Reference Reach

A reference reach is a relatively natural channel that is used to provide a rehabilitation template for the section of river included within the rehabilitation plan. It should be similar to the pre-disturbance state of the treated reach (Kondolf and Downs, 1996). Channel geometry scaled from the reference reach is a starting point to estimate the dimensions of the channel for rehabilitation works (Kondolf and Downs, 1996).

7. Identification of a Design Discharge

The reference reach and the section of channel to be treated should be investigated to determine bankfull, effective and characteristic discharges. Following this investigation a design discharge needs to be selected and used for the design of the channel geometry of the treated section.

8. Integrate Hydraulics, Hydrology, Geomorphology and Ecology: Create a Multi-Functional Team

This represents the minimum team required to formulate a rehabilitation plan. Rehabilitation planning is a multi-disciplinary task and should be undertaken by a team, even if only by way of review of plans prepared by an individual. Community consultation also needs to be included in the rehabilitation planning process. Community ownership of the plan is essential to guarantee long term success.

9. Let the River Do Most of the Work

A more sustainable outcome is likely if the river effects most of the work. Earthworks should be kept to a minimum so as to avoid excessive physical disturbance, particularly of gravel armour layers and boulder steps. Better designed works will require less bulldozing.

10. Do Not Plant Cultured Stock

Stanford *et al.* (1996) concluded that no greater myth exists than that which maintains that habitat loss can be replaced, if not enhanced, by artificial propagation. The stocking of rivers with native and alien fish has irresponsibly compromised native food webs around the world and has been called the **Frankenstein Effect** (Stanford *et al.*, 1996). The planting of willows and poplars should be seen in the same light. An indigenous riparian vegetation rehabilitation program should be adopted as part of the river rehabilitation plan (Webb and Erskine, this volume).

11. Environmental Impact Assessment

The Environmental Planning and Assessment Act (1979) and Regulations (1980) in NSW require that the environmental effects of the rehabilitation plan are assessed before any works start. This should be conducted by the rehabilitation officer but reviewed by a panel that also assesses the complete plan. This legal step has not been practised thoroughly to date.

12. Monitoring and Auditing

The effects of all restoration plans should be routinely monitored to ensure that they achieve their objectives. Furthermore, it should also be established that the planned works were completed as designed. Good design and successful works require a detailed understanding of the reasons why particular works have succeeded. This has not been done in the past.

13. Use Adaptive Ecosystem Management

According to Stanford *et al.* (1996), adaptive ecosystem management is an iterative, step-wise approach where science-based management actions are effectively monitored and evaluated with adaptive revision of actions based on the continuously collected information.

Five years planning horizons are appropriate provided there are annual reviews of the management actions based on monitoring data.

14. Post-project evaluation

This is an essential step in the evolution and development of cost-effective and innovative approaches to river management. It should involve a comparison of the benefits and successes of the scheme against those predicted before the plan was implemented (Erskine, 1993). The minimal changes in river training practices in NSW over the last 40 years and their repackaging as Rivercare programs, reflects no post-project evaluation rather than the success of the standard works.

It is realised that the suggested protocol is general on details but comprehensive in scope. There seems to be a philosophy that river rehabilitation is a cheap process that does not require much work. If a rehabilitation plan is prepared and implemented according to the above protocol this will not be the case. Furthermore, the preparation of a plan is a difficult task that is beyond the capability of most graduates. A formal postgraduate qualification in "*River Rehabilitation*" is needed and professional development courses must be developed by experienced potamologists who keep abreast of recent developments in the field. This has not occurred to date.

7. CONCLUSIONS

The above review found that past river management works and proposed Rivercare works on the Williams River treated accelerated channel instability by addressing the problem on a site by site basis with largely structural works. There was no attempt to identify causative factors let alone address them. Furthermore, there was a complete lack of post project evaluation. Recommended changes to present river management works and plans so that future operations address the causes not the symptoms of river stability are contained in a proposed 14 step river rehabilitation protocol. This protocol recognises that fluvial systems are dependent on local processes that are often catchment determined.

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