

Fluvial Geomorphology and Management of Stream Erosion in the Bunyip Main Drain, Victoria

Sandra O. Brizga¹ Neil M. Craigie² and Scott Seymour³

SUMMARY: The lower 29 km of the Bunyip River was channelised as part of the works carried out in the late nineteenth to early 20th century to drain the Koo-Wee-Rup Swamp. The Bunyip River was formed into a straight drain through the swamp, and this part of the Bunyip River has become known as the Bunyip Main Drain. Roads were constructed on both sides of the drain, on the spoil banks immediately adjacent to the drain. The upper parts of the Bunyip Main Drain have been subject to significant incision, and this incision subsequently migrated many kilometres further upstream through the alluvial reaches of the Bunyip River and its tributaries. Aggradation has occurred in the lower reaches of the Bunyip Main Drain, and in Western Port Bay.

Present key management issues in the upstream part of the Bunyip Main Drain include bank erosion threats to the adjacent roads and levees, maintenance of the integrity of existing bed control structures which are of strategic importance for bed stability, and loss of flood capacity of the drain resulting from vegetation encroachment and sedimentation processes. Environmental quality considerations are also important.

This paper shows how a fluvial geomorphological study incorporating rigorous hydraulic analyses assisted in defining stream management options in this situation. A "risk assessment protocol" was developed to provide a basis for setting works priorities on the basis of the risk of erosion threats to roads and levees in the short to medium term.

THE MAIN POINTS OF THIS PAPER:

- major erosion problems exist on the Bunyip River as the result of historical channelisation works
- fluvial geomorphological analysis has provided a sound basis for determining management options and setting management priorities for the Bunyip River
- hydraulic studies have been a key input to the geomorphological analysis

1. INTRODUCTION

River bank erosion is a universal stream management issue. The upstream part of the Bunyip Main Drain provides a particularly severe example. The river was channelised into a straight earthen drain at the end of the nineteenth century, which triggered severe bed and bank erosion. For much of its length, there are roads and levee banks immediately adjacent to both banks of the Bunyip Main Drain. This infrastructure is threatened in many places by erosion processes within the drain.

The Bunyip main drain serves important drainage and flood protection functions. Socio-economic considerations require that these functions be maintained or enhanced by any new works.

The purpose of this paper is to show how a fluvial geomorphological study, incorporating rigorous hydraulic analyses, was used as a basis for defining stream management options and setting works priorities for the Bunyip Main Drain.

2. THE STUDY AREA

2.1 Overview

The Bunyip River rises in the Great Dividing Range near Beenak. At Bunyip, it has a catchment area of 666 sq. km. Much of the mountainous headwater area remains forested, but the floodplains and valleys have been cleared for agriculture. The lower reaches of the Bunyip River, from the township of Bunyip to Western Port Bay have been channelised. The channelised reach is known as the Bunyip Main Drain. The area of particular interest in this paper is the upstream part of the Bunyip Main Drain, from Bunyip to Cora Lynn (Figure 1).

2.2 History of Bunyip Main Drain

The history of the Bunyip Main Drain is similar to other channelised waterways in the Western Port catchment, such as the Lang Lang River which has been previously documented by Bird (1980). Under natural conditions, the Bunyip River has a

¹ Director, S. Brizga & Associates Pty Ltd, PO Box 68, Clifton Hill 3068, phone (03) 9859 7403

² Director, Neil M. Craigie Pty Ltd, 15 Mulawa St., Croydon Vic. 3136, phone (03) 9725 1053

³ Team Leader, Environmental Planning, Melbourne Water Corporation, Locked Bag 4280, East Richmond, Vic., 3121, phone (03) 9235 2127

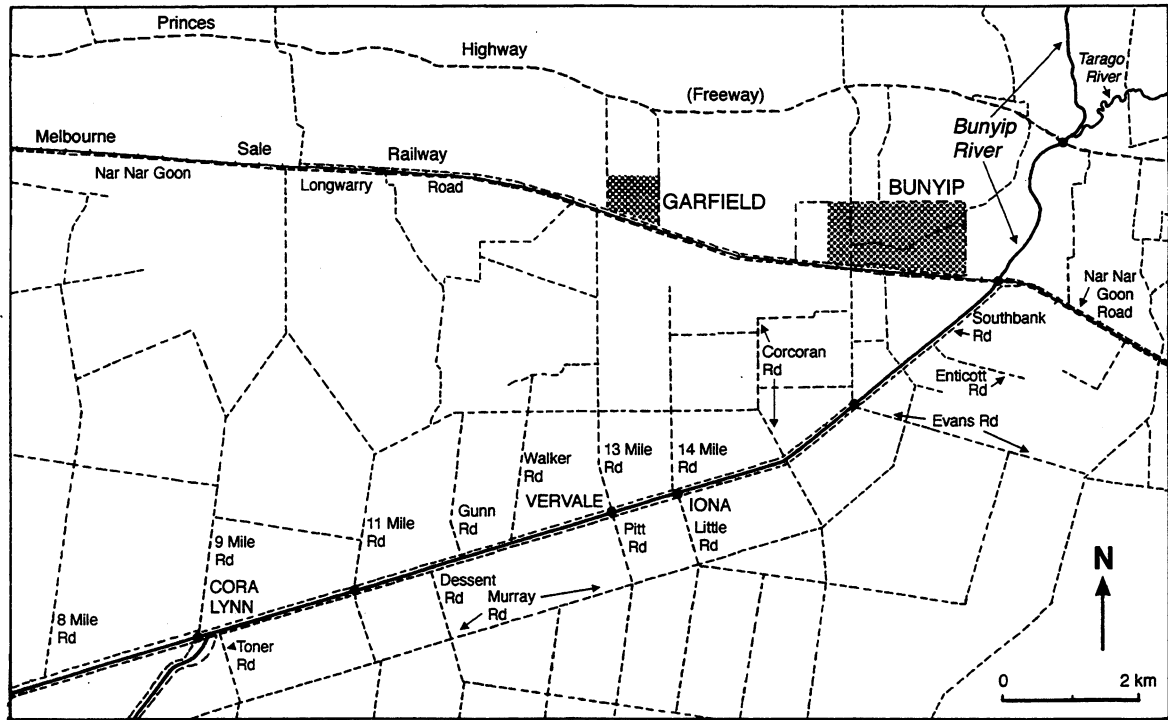


Figure 1. Location map showing the upstream part of the Bunyip Main Drain.

defined channel upstream of Bunyip. Below Bunyip, it discharged into the Koo-Wee-Rup Swamp. Historical survey plans show that the Bunyip did not have a single major channel through the Swamp, rather, there were some minor channels amongst a diversity of wetland habitat types including open water, macrophyte beds, tea tree scrub and swamp woodland. Discharges from the Bunyip catchment into Western Port Bay were filtered through the swamp.

Swamp drainage works, which commenced in 1889, involved channelisation of the Bunyip River to form the main drain through the swamp. Roads were constructed immediately adjacent to the drain, formed out of materials excavated from the drain. Levee banks were also constructed adjacent to the lower reaches of the drain, in the same manner.

Erosion of the Bunyip Main Drain commenced shortly after the initial drainage works, and timber check weirs were installed in the mid 1890s. However, there was significant community pressure to enlarge the drain to minimise flood damage, so further enlargement of the drain (including the removal of the timber check weirs to encourage erosion) was carried out in the late 1890s and early decades of the twentieth century.

Headward erosion initiated within the drain rapidly worked its way upstream of the drain, into unchannelised reaches of the Bunyip River and its tributaries. Incision depths greater than 7 m have been recorded in the upstream part of the study area (East 1935). Further details of the history of the Bunyip Main Drain can be found in Roberts (1985) and Brizga and Craigie (1998).

Bed levels in the Bunyip Main Drain are now controlled by a series of drop structures between Corcorans Road and 11 Mile Road. These structures are of strategic importance for maintenance of bed stability. Some minor bed erosion is apparent upstream of Corcorans Road, above the zone of influence of the uppermost bed control structure.

Sediment inputs to the Bunyip Main Drain from the upstream catchment appear to have varied considerably as the result of the upstream migration of erosion heads, and subsequent stabilisation works. Significant deposition has occurred in the drain below 11 Mile Road. Historically this has been managed by sand extraction. More recently, rates of extraction have decreased as inputs declined.

3. PRESENT MANAGEMENT ISSUES

The present key management issues in the Bunyip Main Drain between Bunyip and Cora Lynn are bank erosion and hydraulic capacity - flood protection. Improved bank stability and maintenance and enhancement of hydraulic capacity are potentially contradictory management objectives.

Bank erosion threatens roads and levee banks which are parallel to the drain, and situated in close proximity to the banks. Typical problems involve bank slumping, and the collapse of the road or levee bank into the drain. Historical records indicate this has been a significant management issue for many decades (Figure 2).

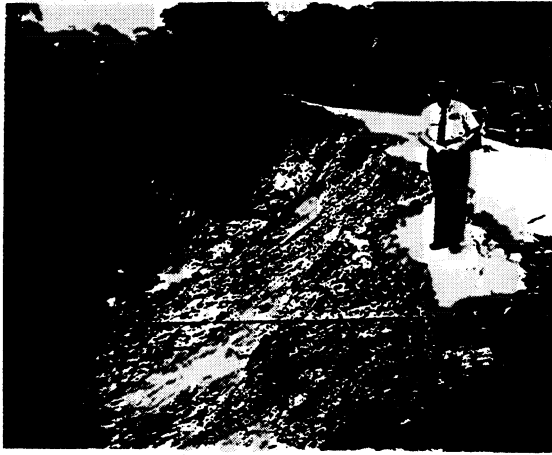


Figure 2. Photograph of the southern bank of the Bunyip Main Drain between Vervale and Iona in 1953, showing collapse of the adjacent road due to bank erosion. Source: DNRE Rivers and Streams Photograph Collection.

Drainage and flood protection are important management issues, as the former swamp lands have been developed as high value agricultural land. Concerns exist regarding deterioration of flood protection due to loss of hydraulic capacity in the drain resulting from vegetation encroachment and sedimentation, as well as reductions in the protection offered by levees resulting from structural problems and bank erosion threats.

The purpose of the study discussed in this paper was to develop a sound understanding of the geomorphological processes contributing to the management issues outlined above, as a basis for developing effective management strategies.

4. GEOMORPHOLOGICAL AND HYDRAULIC ANALYSIS

4.1 Hydraulics

The hydraulic characteristics of the Bunyip Main Drain between Bunyip and Cora Lynn were examined using a HEC-RAS model. The model was constructed using 80 cross sections to represent a total stream length of 14 km. A model run was carried out to characterise existing hydraulic conditions. Other runs were also carried out to examine possible management options. The modelling is discussed in detail by Brizga and Craigie (1998).

The modelling showed that the present capacity of the Bunyip Main Drain varies considerably through the study area (Table 1). Between Cora Lynn and 13 Mile Road, the drain capacity appears sufficient to contain at least the 5 year ARI flood, while further upstream the channel has ample capacity to contain the 10 year ARI flood. Hydraulic loadings in the drain are high, particularly in the more deeply incised area between 13 Mile Road and the Thompsons Drain confluence. As a result of the confinement of flood flows, stream power is high, which means that flood flows have high potential to erode the channel boundaries.

4.2 Geomorphology

Geomorphological processes operating in the Bunyip Main Drain were examined on the basis of site inspections, analysis of aerial photographs and satellite imagery, historical documentary data sources, a review of existing geotechnical data, and the results of the hydraulic analysis discussed in Section 4.1 above. The discussion here focuses on information relevant to bank erosion.

A large number of factors were found to be contributing to the bank erosion observed in the Bunyip Main Drain. Some of the more important factors are outlined here. In-stream hydraulic loadings are high due to the steep gradient of the channel and confinement of floodflows of significant magnitude. In many places, the banks of the drain are steeper than a stable batter slope, as the result of oversteepening due to historical bed incision and meandering.

It is common for artificially straightened rivers to develop a more sinuous channel patterns, and the Bunyip is no exception. The pattern of erosion and deposition in the Bunyip Main Drain indicates erosion at outer banks and deposition on inner banks of incipient meanders. The natural tendency for the drain to deviate from a straight line is exacerbated by the deflection of flows by fallen trees and inappropriately located willows.

The bank sediments are sandy, weak and permeable. Moisture transmission during and after floods appears to be an important factor in slumping. The banks are subject to surcharge loadings from adjacent roads and levee banks, and further weakened by vibrations caused by road traffic, including large trucks. Deliberate modifications of the banks for irrigation pump access and rubbish dumping also contribute to erosion.

5. MANAGEMENT OPTIONS

Bank erosion problems generally arise from a conflict between erosion processes, and the existence of a significant asset in close proximity to the river banks. The problem can be resolved by halting the erosion, or by relocating the asset further away from the river banks.

Both types of options were considered in relation to the Bunyip Main Drain. The high hydraulic loadings in this river channel mean that works to halt bank erosion would involve relatively heavy structural measures such as rock lining. Non-structural measures would involve the relocation of assets further away from the river banks. A combination of these measures is likely to be necessary.

A risk assessment protocol has been developed to determine the need and degree of urgency for measures to deal with bank erosion along various parts of the Bunyip River, and this was used in the

Reach	Capacity at natural surface level (m ³ /s)	Capacity at top of levees (m ³ /s)	Full channel capacity conditions		
			Main channel velocity (m/s)	Main channel power (N/m/s)	Main channel shear (N/m ²)
Thompsons Drain confluence to 1 km upstream of Gippsland Railway	>250	>250	~1.6	~135	~80
Evans Road check weir to Thompsons Drain confluence	~210	~230	~1.9	~220	~115
Check weir downstream of Corcoran Road to Evans Road check weir	~200	~230	~2.0	~260	~130
13 Mile Road check weir to check weir downstream of Corcoran Road	~180	~200	~1.8	~210	~115
Check weir upstream of Gunn Road to 13 Mile Road check weir	~150	~180	~1.8	~130	~70
11 Mile Road check weir to check weir upstream of Gunn Road	~125	~180	~1.8	~120	~65
Cora Lynn to 11 Mile Road check weir	~115	~150	~1.8	~110	~65

Table 2. Risk assessment factors for determining priorities for bank erosion management. Actions may involve relocation of assets and/or structural stabilisation works. NB. The criteria in this table have been developed specifically for conditions in the Bunyip River, and should not be applied elsewhere without prior verification. Risk criteria can be expected to vary significantly amongst rivers and streams depending on factors such as stream size, hydrologic regime, sediment load, and bank sediment materials.

Item	Factor	Criteria	Risk Category
1	<i>Proximity of assets</i> Effective slope between riverside crest edge of road or levee and toe of main channel bank (H:V)	>=2:1 <2:1, >= 3:1 <3:1, >6:1 <=6:1	Very High High Moderate Low
2	<i>Meander extension rate</i> Susceptibility to future bank erosion associated with meander extension, estimated as possible average meander amplitude increase in metres/decade	Active (>5 m) Moderate (2-5 m) Low (<2) Negligible (~0)	Very High High Moderate Low
3	<i>Meander translation rate</i> Susceptibility to future bank erosion associated with meander translation, estimated as possible average movement downstream in metres/decade	Active (>10 m) Moderate (4-10 m) Low (<4) Negligible (~0)	Very High High Moderate Low
4	<i>Structural strength of banks</i> Susceptibility to future bank erosion or slumping because of soil type and/or groundwater conditions	Geotechnical advice needed	Very High High Moderate Low

Where there is a high risk of damage to adjacent roads or levee banks, a need for management intervention is indicated. Relocation is generally the preferred option as it provides the additional benefit of allowing the floodway to be widened, therefore enabling flood protection to be increased without increasing hydraulic loadings. Structural bank protection works to enable retention of the road or levee in their present position are recommended in situations where relocation is not feasible, such as where the location of roads or levees are constrained by nearby houses. Costings for these various activities are discussed by Brizga and Craigie (1998).

Works to increase hydraulic capacity can be detrimental to channel stability if they increase stream power by increasing flow confinement (eg., by deepening the drain or raising levee bank levels). However, additional hydraulic capacity can be gained without increasing hydraulic loadings, by widening the drain and increasing the distance between the levees.

7. CONCLUSIONS

This paper has illustrated the use of fluvial geomorphological analysis in determining management options and setting priorities in a particularly difficult case of bank erosion. Appropriately tailored hydraulic studies are an integral input, and provide a sound basis for the assessment of geomorphological implications of potential management scenarios.

8. REFERENCES

- Bird, J.F. 1980. Some geomorphological implications of flood control measures on the Lang Lang River, Victoria. *Australian Geographical Studies* 18, 169-83.
- Brizga, S.O. and Craigie, N.M. 1998. *Fluvial Geomorphology of the Bunyip River: Princes Highway to Cora Lynn*. Report prepared for Melbourne Water, Waterways and Drainage Group.
- East, L.R. 1935. Swamp reclamation in Victoria. *Transactions of the Institute of Engineers Australia* 7. 77-91.
- Roberts, D. 1985. *From Swampland to Farmland: A History of the Koo-wee-rup Flood Protection District*. Rural Water Commission, Armadale, Victoria.

