

An Investigation of Bed Scour in the Lower Mitchell River

Anthony Ladson*, Rex Candy**, Geoff Claffey**, and John Tilleard**

ABSTRACT: *Following the major floods in April 1990 there were reports of severe scouring in the bed of the Mitchell River. Our investigation of the scour included a hydraulic analysis and review of historical and field data. The investigation showed that a scour of 9m below the average unscoured bed elevation could be attributed to the combined effects of: local scour around bridge piers; scour resulting from the constriction of flood flows by bridge abutments; scour associated with bends; and scour associated with the passage of bed forms.*

1. INTRODUCTION

The April 1990 flood in the Mitchell River caused a major erosion scour up, to 6 m deep, in the bed of the river near the Princess Highway and railway bridges in Bairnsdale, Victoria. This scour could threaten the stability of the bridges and a Telecom cable laid in the bed of the river downstream of the railway bridge.

1.1 Background

The Mitchell river has a catchment of 4778 km² and flows from the junction of the Wonnangatta and Dargo Rivers through Bairnsdale to Lake King, a distance of approximately 120 km. In April 1990 a major flood occurred that caused extensive damage to the bed and banks of the river. In Bairnsdale, flood waters overtopped the Princess Highway and a Telecom cable in the bed of the river was washed out.

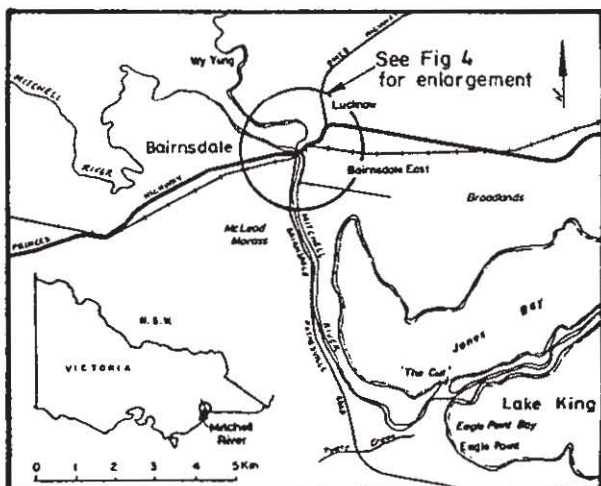


Figure 1: Locality Plan

* Centre for Environmental Applied Hydrology, University of Melbourne, Parkville Vic 3052, Tel: (03) 9344 6646 Fax: (03) 9344 6215 Email: a.ladson@engineering.unimelb.edu.au

**I. D. & A. Pty. Ltd., P.O. Box 1372, Sale Vic 3850, Tel (051) 431 822

An investigation of scour in the vicinity of the bridges was proposed by the Mitchell River Management Board and funding was contributed by the Board, Public Transport Corporation and Telecom Australia.

The location of the study area is shown in figure 1.

2. FIELD SURVEY

As part of this investigation, the bed of the river was surveyed from approximately 400m upstream of the highway bridge to 2km downstream. Eight cross sections were surveyed and selected results are reproduced herein. The bed of the river, in the area of interest, was surveyed using a boat mounted depth sounder. The boat was continuously located using a shore based tracking theodolite. Position information was telemetered to a data logger mounted on the boat that simultaneously recorded bed elevation (figure 2).

As part of a separate investigation, Vic Roads obtained bore logs from the bed of the Mitchell River. Three borings were done immediately downstream of the Princes Highway bridge, one upstream of the bridge and 2 between the railway bridge and the telephone cable.

3. HISTORICAL INVESTIGATION

A review was made of historical cross sections and longitudinal sections near the bridges, geotechnical data, and information on works at the telephone cable.

3.1 Cross Sections at the Rail Bridge

Historical evidence suggests that scour in this area has existed for a considerable period. Cross sections have been provided at the railway bridge for the years: 1907, 1914, 1915, 1916, and 1937. The Cross section was re-surveyed in 1990 following the flood. These cross sections are presented in figure 3.

The cross sections show that a major scour occurred between December 1915 and 1916 probably in association with the flood of September 1916. This flood is one of the largest on record with instantaneous maximum flows reaching 101,000 ML/d at Bairnsdale.

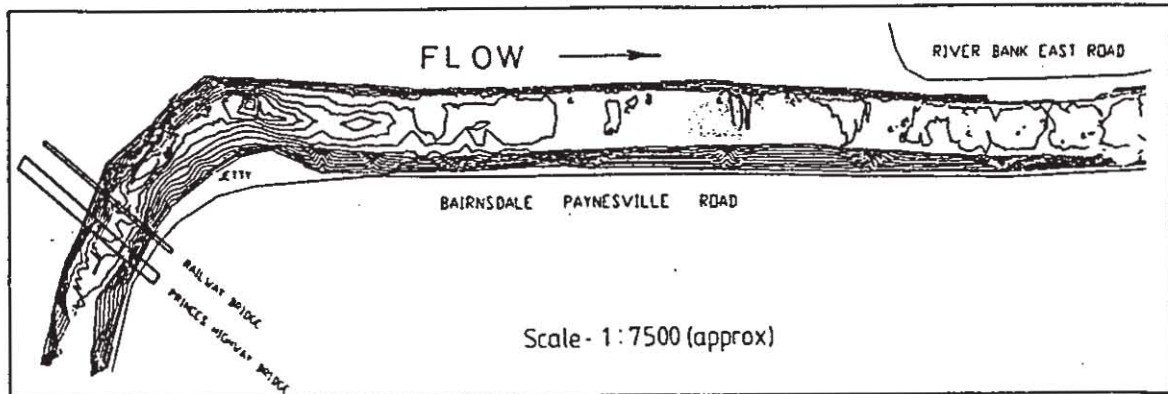


Figure 2: Survey of the bed of the Mitchell River

There is evidence of considerable scour between 1916 and 1937. In early surveys, a retaining wall is shown on the west bank. This wall was removed or destroyed between 1916 and 1937 and approximately 5 m of the bank was eroded. There have been only minor changes in the western part of the channel between 1937 and 1990 but the eastern part of the channel has deepened by about 3 m.

The cross sections show a total of about 5m of scour since 1907. The bed has deepened from -3m AHD to about -8m AHD.

3.2 1937 Mitchell River Survey

In 1937 the State Rivers and Water Supply Commission conducted a survey of the Mitchell River including occasional bed levels and cross sections (SRWSC plan 30056). The lowest level recorded immediately downstream of the bridge has an RL of -10.5 m AHD. This level is about 5 m lower than bed levels upstream of the bridges and is approximately the same as more recent survey information.

3.3 Geotechnical Investigation at Princess Highway Bridge

A report by Vic Roads (Brown 1990) suggests that scour at the Highway bridge has been aggravated since bridge construction in the 1950s. A survey of bed levels and borings of bed material was carried out to determine the extent of the changes and the threat to the bridge.

The survey shows a decrease in bed level of about 2.5m between 1955 and 1990 in the western part of the channel. The eastern part is unchanged. The maximum depth is approximately -10m AHD.

The borings show clay, sand and gravels overlaying limestone. Scourable material was found at depths down to about -15m AHD.

3.4 Destruction of Telephone Cable

The most important piece of evidence suggesting major bed movement in the recent flood was the destruction of a telephone cable placed in the bed of the river. Local reports were that bed levels dropped by up to 5 m since the installation of the cable in 1977. Further investigation showed that the cable was laid 2.5 m below bed level when installed. The cable was washed out during the 1981 floods and was re-installed 2.5 m below bed level after the flood. This was taken as evidence of 5m of scour.

This need not be the case. Investigations as part of the Vic Roads report show unconsolidated silts and sands in the bed. This material is likely to have been mobile during the passage of the flood, and re-deposited as the flood peak passed. It is likely that the cable was actually installed to similar levels before and after the 1981 floods, and that temporary scour of at least 2.5m occurred during the flood event. No survey information of the cable was taken at the time of installation.

3.5 Historical Surveys

Cross section comparisons were possible upstream of the bridge site. Three cross sections 200, 300, and 400m upstream of the Princess Highway Bridge were surveyed, in 1990, before the April 1990 flood, by the Australian Surveying and Land Information Group Victoria. These cross sections were re-surveyed during this investigation.

A comparison of the survey shows that there was little change at any of the cross sections before and after the 1990 flood.

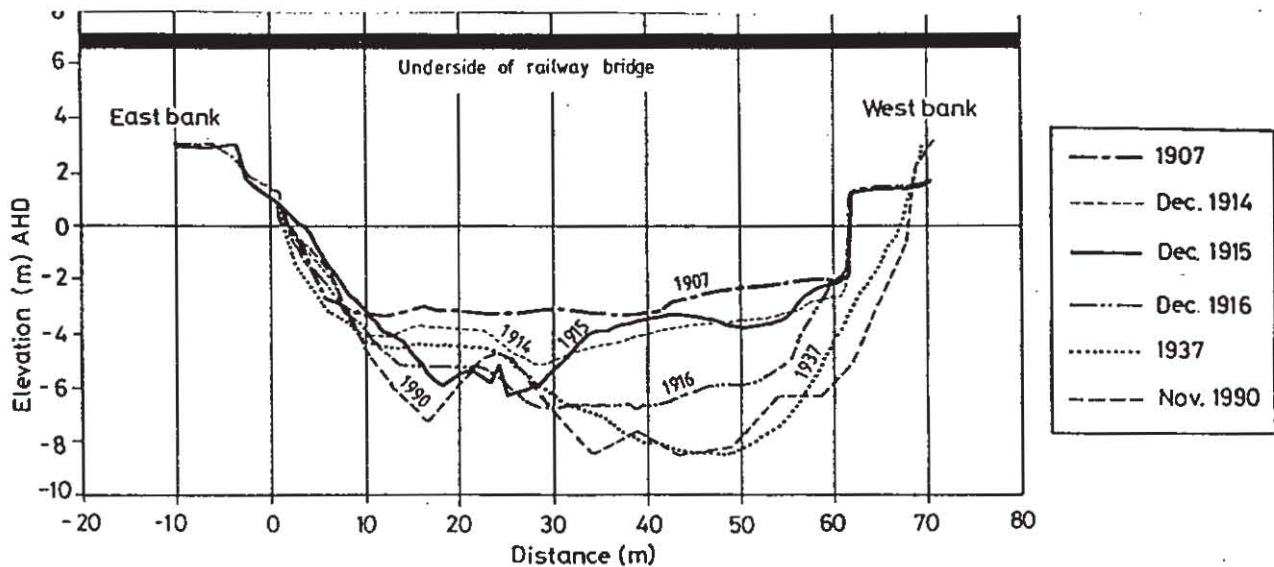


Figure 3: Comparison of cross sections at rail bridge

4. SCOUR MECHANISMS

Scour of a river bed can occur as a general process throughout the whole river system or in localised areas where there is disturbance of flow. There are four mechanisms that may cause local scour at the Mitchell river bridge. These are related to:

- disturbance of flow at bridge piers;
- contraction of flow by a narrowing of the floodplain and bridge abutments;
- secondary currents at a bend;
- migration of bed forms along the river bed.

Likely scour depths associated with each of these mechanisms can be estimated.

Calculations have been carried out to quantify the effect of these different scour processes. Scour depths are calculated for a flow of 150 000 ML/d, which was approximately the peak discharge in the 1990 flood.

4.1 Scour at Bridge Piers

Bridge piers cause high local velocities and shedding of vortices which create local scour. On the rising limb of a flood hydrograph the scour increases and reaches a maximum at the flood peak. After the peak has passed the scour hole refills as sediment drops out of lower flows. The critical time for hydraulic structures occurs at the flood peak and the depth of scour, at this time, cannot be estimated from surveys of the bed done after the flood has passed.

The component of scour attributable to bridge piers was calculated using a number of methods. Values are summarised in table 1. Scour depths show considerable variation. The average predicted scour depth is 5.2 m and the maximum is 6.2 m.

Table 1. Predicted Scour at Bridge Piers

Method	Scour Depth (m)
Laursen (1962)	6.2
Richardson et al (1987)	4.8
Shen et al (1981)	4.5

4.2 Scour at Bends

Bends associated with meandering channels cause "secondary" currents which scour sediment from the outside of the bend and deposit it along the inside. The extent of scour depends on the characteristics of the bed as well as the hydraulics of the channel. The bend in the Mitchell river at the bridges has a radius of curvature of about 500 m which could cause approximately 2.3 m of scour, at the bend apex, in flood conditions similar to those in 1990 (Breusers and Raudkivi 1991).

4.3 Contraction of Flood Plain

There is a major contraction of the floodplain in the area of the highway and railway bridges. This occurs as a consequence of the natural land form and because of the construction of bridge abutments and embankments.

Figure 4 shows the high ground on the edge of the Mitchell river floodplain. The construction of the railway embankment restricts flow capacity but three bridges were constructed, the main river crossing (figure 3) and two bridges over the floodplain with spans of 57m and 21m.

The, more recent, construction of the highway embankment further restricted waterway area. The only bridge in this section of road is the main river crossing, there are no floodplain bridges and the highway embankment effectively prevents water

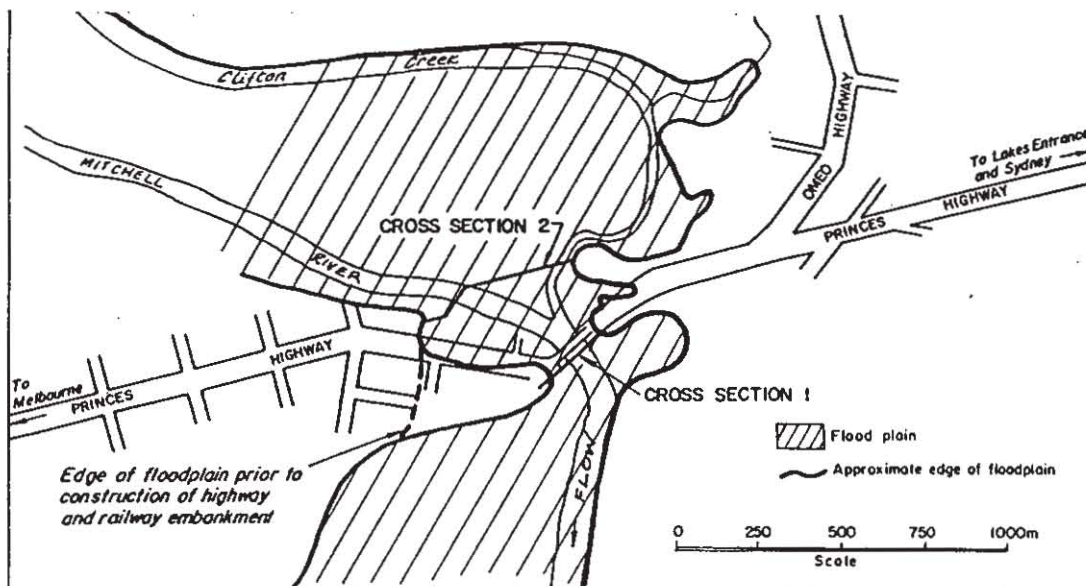


Figure 4: Contraction of the floodplain caused by highway and railway embankment

from flowing through the two floodplain railway bridges. Upgrading and construction of the east bound carriageway means the roadway is rarely overtopped.

Two cross sections were surveyed to assess the effect of the flow constriction. The locations of the cross sections are shown in figure 4. Cross section 1 was taken immediately downstream of the railway bridge and Cross section 2 was taken across the floodplain at a natural constriction upstream of the bridges. The cross sections are illustrated in figure 5 and 6.

In the 1990 flood the floodplain upstream of cross section 2 was covered with water. Under these conditions cross section 2 would be at about right angles to overbank flow. The cross section was deviated to cross the river at right angles as shown in figure 4.

Figure 5 and 6 shows waterway areas and average velocities for the two cross sections for 1990 flood levels. There is a significant reduction in waterway area at the bridge site and a large increase in velocity. More material will be transported through the contracted section and the bed will tend to scour until there is a balance between sediment supply and transport.

Scour depth attributable to the contraction in the floodplain is estimated to be approximately 3m (Farraday and Charlton 1983).

4.4 Migration of Bed Forms

There is evidence of dune or antidune bed forms in this reach of the Mitchell river. Figure 2 shows regular changes in bed elevation downstream of the bridges. It is likely that these represent bed forms.

Dune or antidune bed forms are known to exist approximately 10km further downstream near "The Bluff".

The migration of bed forms along the river bed causes bed elevations to vary with time. The worst case is where the flood peak occurs at the same time as the trough of a dune is passing through an area of high local scour. Studies have shown that scour depths can be up to 30 percent greater as a consequence of bed form migration (Garde and Ranga Raju 1978).

4.5 Combined Scour

Scour depth caused by piers, bend curvature, contraction of the floodplain and migration of bed forms may have combined to create the scour hole existing downstream of the bridges. The actual depth of scour is a function of discharge with a maximum occurring during flood peaks.

Adding the estimate of scour attributable to contraction of the floodplain and the bridge piers gives a total of 8.2m. Similar scour depths are calculated using the method described by Blench (1969).

A further 2.3m of scour could be attributed to flow disturbance at the bend giving a total of 10.5m. The migration of bed forms could increase this by 30% to 13.7m. The upstream bed elevation is approximately -5.5m AHD so if the processes are considered to be additive an maximum scour depth of -19.2m would be predicted for a flow of 150,000 ML/d.

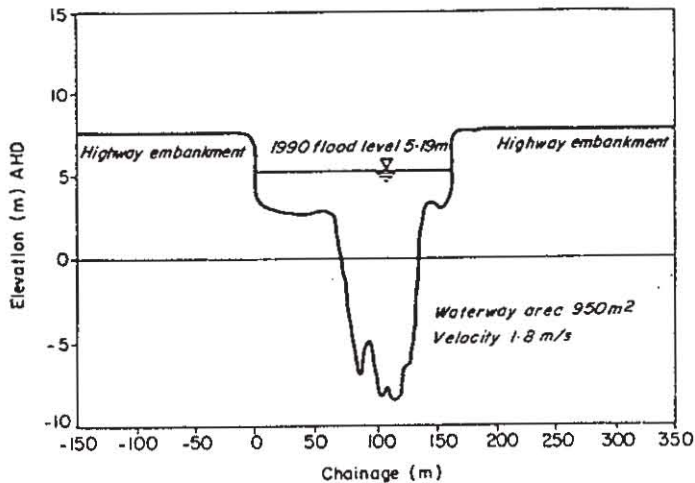


Figure 5: Cross section at bridges. Cross section 1 (looking downstream)

It is acknowledged that scour depths are probably overestimated by adding the results of these equations. The likely extent of scour is discussed below.

5. CONCLUSIONS

In making a judgement on likely future scour during large floods the following factors have been considered.

- The telephone cable was washed out in the 1990 flood indicating temporary scour depths of at least 2.5m.
- Vic Roads bore logs show scourable material, sands, silts, and clays, to depths of -15m AHD at the Princess Highway Bridge and -16m AHD at the telephone cable.
- If scour mechanisms are additive then calculations predict scour depths to -19.2m AHD.
- The longitudinal profile shows an existing hole in the bed of the river down to -10.1m AHD downstream of the bridges (see figure 7).
- Historical cross sections at the rail bridge show 5m of scour since 1907 with depths to -8m AHD.

Considering all these factors, bed elevations of -10m AHD at the Princess Highway Bridge are likely and -15m AHD are possible. -15m AHD is approximately 9m below the unscoured bed elevation as shown in figure 7. A greater depth of scour is expected near the rail bridge as the bridge is closer to the large scour hole at the apex of the bend in the river.

If the telephone cable is to be placed in the bed of the river and made secure against scour in a flood of

similar magnitude to 1990 then it must be installed at or below -16m AHD.

Even on a relatively small river, scour depths during a major event can be limited only by the depth of erodable material. Scour depths during floods could be up to 9m below the general bed elevation in this area. This has profound implications for river stability and for the security of bridge foundations.

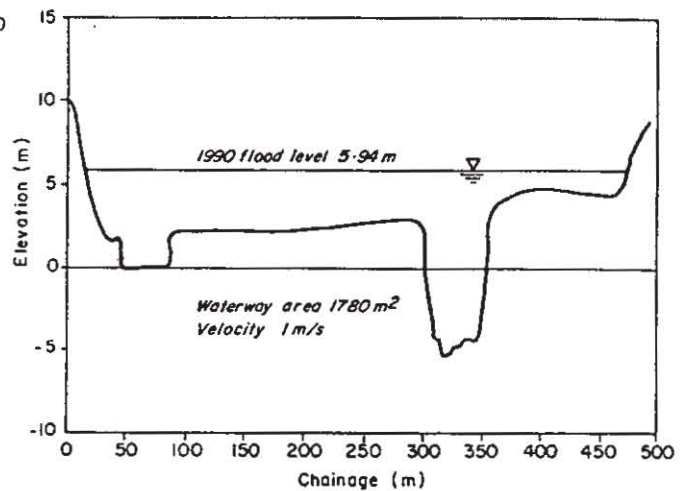


Figure 6: Cross section at restricted section upstream of bridges. Cross section 2 (looking downstream)

6. ACKNOWLEDGMENTS

Review of the history of scour at this location involved inquiry from many agencies. The cooperation of all officers is acknowledged with appreciation. In particular we thank staff of the Public Transport Corporation who provided valuable historical information at the railway bridge site and the Port of Melbourne Authority for their assistance with surveying the bed of the Mitchell river.

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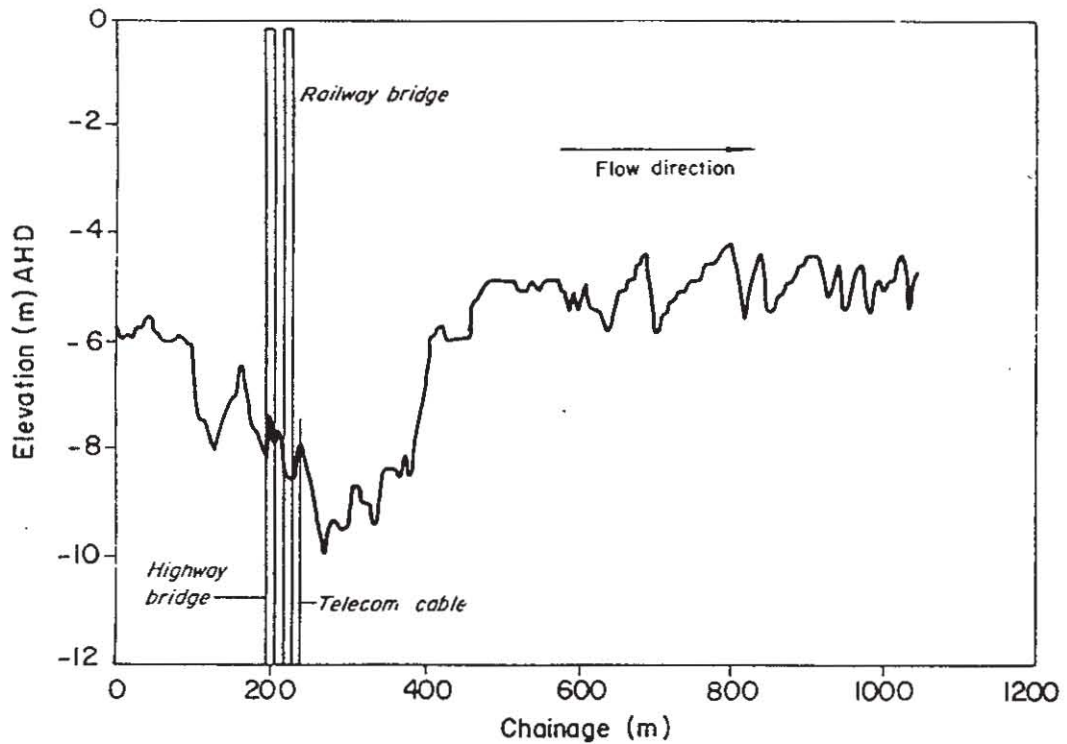


Figure 7. Long section in the vicinity of the highway and railway bridges and telephone cable.

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