

The Contribution of Stream Bank Erosion to Sediment Loads in Gowrie Creek, Toowoomba

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Abstract

Gowrie Creek is located in the headwaters of the Murray Darling Basin and is the main drainage system for the city of Toowoomba. To quantify the contribution of the creek banks to sediment loads, two actively eroding sections of the banks in the upper and lower catchments were selected for erosion pin analysis and stream flow sediment sampling. A stream flow simulator was also used for the assessment of bank erodibility. During periods of low stream flow, the exposed near vertical creek banks were observed to lose substantial quantities of soil through fracturing and slumping. The high shrink-swell potential of the soils were also found to produce a friable surface scree layer on other erosion faces which contributed substantially to sediment loads. The creek banks were found to contribute 42% of the sediment load in the upper catchment and in excess of 70% in the lower catchment.

Keywords: Erosion, sediment, stream flow, stream bank.

Introduction

Gowrie Creek is a perennial waterway located in the headwaters of the Murray Darling Basin. The 147 km² creek catchment includes cultivated agriculture and the city of Toowoomba (population~82000) with its associated stormwater drainage network and wastewater treatment plant (WWTP). Since settlement, the role of Gowrie Creek has changed from draining a large swamp area with slow flows, to removing the high velocity flows associated with the urban runoff. The annual creek flow has also increased by up to 330% due to output from the WWTP (WBM Oceanics Australia, 1997).

Like many other Australian waterways, Gowrie Creek suffers from a range of environmental problems due to both urban and rural development. One of the major concerns is the sediment load carried by the creek and its subsequent effect on water quality and downstream river ecology. Whilst there are a number of sources of sediment within the catchment, the local community reference group has suggested that creek bank erosion could be the dominant contributor to stream sediment loads. This is in conflict with anecdotal evidence which suggests that erosion from both the urban and agricultural land within the catchment are the major contributors of the stream sediment loads. The aim of this study was to quantify the contribution of creek bank erosion to the sedimentation load of Gowrie Creek.

Materials and Methods

A 12 km section of Gowrie Creek which encompassed parts of both the upper and lower catchments was selected for study. An initial survey of the creek within the study area was undertaken using both aerial photography and field observations. Two of the sites which were incised by more than 10 m (Table 1) were subsequently selected for erosion pin analysis. The sites were selected because they were representative of the dominant soils in the area with one located in the upper catchment and the other in the lower catchment. Twenty erosion pins consisting of 750 mm lengths of 12 mm diameter reinforcing rod were embedded into the erosion sites until flush with the soil surface. The pins were located in representative sections of the exposed surfaces and the exposure surface surveyed to enable calculations of volume changes. The exposed length of the pins were measured after various periods of the study and the volume of eroded soil material calculated. A portable stream flow simulator (Howard 1997) was also used to investigate the mechanism of soil detachment from the creek banks under different velocities of stream flow.

Only one substantial rainfall event (26 mm) occurred in the catchment during the study period (May-October 1997). During this event, water sampling of stream sediment was undertaken immediately above and below the erosion pin sites during peak flow using a 20 L bucket. The samples were analysed for aggregate size distribution using a combination of sieving and sedimentation techniques and the bulk sediment load determined by oven drying. The measurements of soil loss from the erosion pin sites during the event and the sediment loads at peak flow were used to determine the proportion of sediment load attributable to creek bank erosion.

Table 1. Erosion along a 12 km length of Gowrie Creek, Toowoomba.

	Upper catchment	Lower catchment
Number of erosion sites incised >10 m	1	8
Number of erosion sites incised 5-10 m	4	19
Number of erosion sites incised <5 m	2	39
Length of creek bank in study area (m)	340	11660

Results and Discussion

Approximately 45% (5.4 km) of the creek bank within the study area was found to have bare soil exposures and evidence of active erosion. The erosion pin analysis for the two monitored sites showed substantial amounts of stream sediment are originating from the creek banks (Table 2). The upper catchment erosion site lost a total of 70 m³ of soil from the 300 m² exposure during the study period, while the lower catchment site lost a total of 5 m³ from the exposure surface of 72 m² during the same period. The differences in total sediment loss at the sites appear to be due to differences in stream velocity and soil properties. However, erosion from the exposed surfaces did not only occur during rainfall events. While 39 m³ (or 0.131 m³/m² of exposed surface) of soil material was lost from the upper catchment erosion pin study site during the single observed rainfall event, 25 m³ was lost from the same site during a 122 day period without substantial rainfall (Table 2). Similarly for the lower catchment erosion site, 40% of the total eroded material was lost during the non-rainfall period.

Table 2. Erosion from both upper and lower catchment sites in Gowrie Creek, Toowoomba

Period	Rainfall	Volume of Eroded Material (m ³)	
		Upper catchment site	Lower catchment site
16 May - 17 Sept	no	24.96	1.08
17 Sept - 31 Sept	yes	39.33	2.79
31 Sept - 6 Oct	no	5.51	1.08

The substantial erosion of material during the non-rainfall period (Table 2) at both sites was attributed to undercutting of stream embankments by stream flows originating from the WWTP and the high shrink-swell potential of the soils along the creek length. During dry periods, soil exposed as vertical surfaces was observed to crack and fracture resulting in failure and slumping of material directly into the stream. This mechanism is similar to that reported by Fisher (1993) for erosion in creeks with high shrink-swell soils. However, evidence of erosion on straight sections of the creek line lacking deep incisions was also observed. Soil drying on the exposed creek banks was found to produce a 3 to 4 cm layer of loose friable scree material. This scree material was formed regardless of whether the exposed soil was on the bends or straight lengths of creek bank. However, stream flow simulations conducted on straight sections of the creek demonstrated that the exposed scree material slaked readily on wetting and was easily entrained even at low flow velocities (<1 m/s). Hence, periodic fluctuations in flow depth due to either the WWTP discharge or natural occurrences could be expected to accelerate creek bank erosion due to this mechanism.

Stream sediment loads of up to 0.72 g/L were measured immediately below the upper catchment erosion pin site and 1.96 g/L below the lower catchment site. Assuming that sediment load is constant throughout the event, approximately 130 m³ of sediment passed the upper catchment monitoring site and approximately 450 m³ passed the lower catchment site. Hence, as 39 m³ of soil was removed during the event from the upper catchment erosion pin site and using an estimate of 16 m³ for the amount of scree material removed from other exposed areas up stream of the site, approximately 42% of the sediment load at this site originated from the creek banks. Similarly, by using the soil losses measured at the lower catchment erosion pin site, an estimate of the amount of scree material removed by

stream action from exposed creek banks upstream of the monitoring site, and assuming no deposition of sediment, the creek banks were found to contribute up to 78% of the total sediment load in the lower catchment. This work suggests that creek bank erosion may be the major source of sediment load within the Gowrie Creek system. However, this erosion occurs from both deeply incised creek bends and due to scree material along exposed creek banks. Hence, future work to reduce stream sediment loads should focus on the stabilisation of the actively eroding incisions and the reduction in scree material formation on exposed creek banks.

Conclusions

This work has found that the creek banks may contribute up to 78% of the sediment loads during rainfall events within Gowrie Creek. However, creek bank erosion in this area also actively occurs during non-rainfall periods due to the shrinking and swelling properties of the soil. Hence, strategies to reduce creek bank erosion and reduce sediment loads should investigate control practices under both low and high stream flow conditions.

References

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