## Lower Gordon River erosion – history and lessons learned

*Aerial view of part of the deeply incised lower Gordon River, between Ghost Creek and Limekiln Reach.*

DESCRIPTION AND GEOCONSERVATION VALUES

The lower Gordon River is a narrow estuary within the Tasmanian Wilderness World Heritage Area. Its geomorphology is in itself of World Heritage significance. The suite of landforms documents the progressive sedimentary filling of the steep sided river valley after it was drowned by rising sea level following the last ice age. Several evolutionary stages in the development of the estuary are displayed as one travels upstream past low muddy banks then higher silty banks and finally yet higher sandy levee banks. The last two bank types are of particular significance as they enclosed several small, formerly meromictic (permanently stratified) lakes that were very rare in a global sense.

HISTORY

The lower Gordon River has been a tourism venue for well over a century. In the early 1980s the Tasmanian government started work on the Gordon below Franklin dam. The ensuing blockade by conservationists and the Federal High Court decision to stop construction considerably raised the public profile of the area. With more visitors small and slow cruise boats were replaced by larger and faster vessels and the amount of traffic increased. By 1985 the local Parks and Wildlife Service (PWS) rangers had noticed that the river banks were starting to collapse.

It was apparent to PWS staff that the wake from the new cruise boats was responsible for erosion and that speed limits were required. However at that time organisational constraints meant that these could only be imposed by a separate agency responsible for maritime matters. They agreed to speed limits on short reaches where erosion was most obvious but were reluctant to become involved in this controversial area and demanded solid proof that cruise boats were responsible for erosion before taking further action.

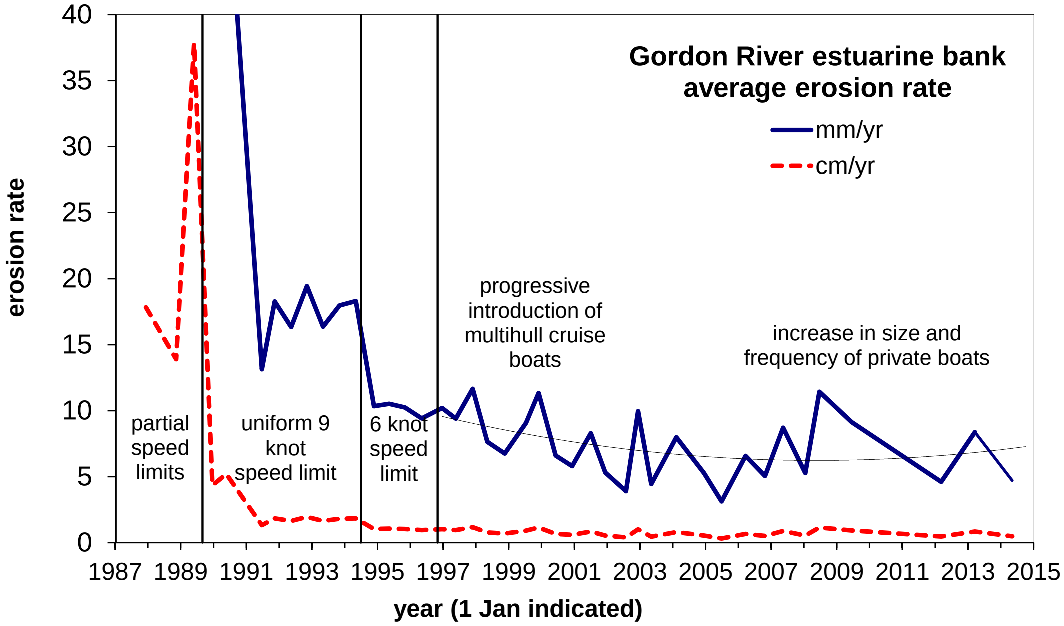
In 1986 consultant geomorphologists were called in, studies initiated and the monitoring programme started by the rangers was greatly expanded. The principal monitoring techniques used were erosion pins and repeated bank profile surveys, with a record of landslips also kept. Erosion pins are lengths of thin rod inserted perpendicular to the bank face. Change in the exposed length of pins between measurements indicates the net amount of erosion that occurred between measurements. Recorded rates of erosion exceeded 1 m per year in places. In 1987 experiments on a sandy levee bank showed that the rate of erosion increased sharply at cruise boat speeds above 9 knots (published later as Nanson *et al*. 1994). That was enough to satisfy the Marine Board and a 9 knot speed limit for vessels greater than 8 m in length was applied to some three quarters of the length of the estuary.

*Even at their minimum possible speed these boats continued to cause erosion because the wake waves were larger than those of the natural wave climate.*

By 1988 monitoring had shown that while the rate of bank retreat had slowed in those areas where speed limits had been introduced erosion was still occurring. Further management action was required however the cruise operators were strongly objecting to the existing speed limits. The main destination, some 35 km upstream, was a waterfall on a tributary where passengers could take a short walk. The speed limit increased the travel time and effectively prohibited more than one trip by each boat per day.

The issue eventually reached the highest level. The state and federal environment ministers finally agreed that cruise vessels would be subject to a nine knot speed limit upstream from the mouth and that two thirds of the river would be closed to commercial traffic. The most sensitive and significant banks were now protected and a new landing and walkway was required. Construction of Heritage Landing, 13.5 km from the mouth, was completed in 1989. The rate of erosion slowed dramatically, however by now some 80% of banks had been affected and seriously destabilised so the problem was far from completely solved. Around this time PWS took over and further expanded the consultants' monitoring programme.

After a period of adjustment to the 1989 restrictions the rate of erosion had slowed to 1 – 2 cm per year. In 1992 and after much consultation a voluntary users code was produced to guide private visitors to the river in how to reduce damage caused by their vessels. However, people were beginning to question why PWS still regarded the erosion as a matter of concern and there were even pushes from some quarters to increase speed limits or re-open closed reaches. A series of radiocarbon dates obtained on bank sediments settled the matter in 1993. These proved that most banks had been stable for thousands of years, while those nearer the mouth had been very strongly depositional (Bradbury *et al*. 1995). On those banks it wasn't the absolute rate of erosion that mattered as much as the reversal of geomorphic process from deposition to erosion. Together with the data from ongoing monitoring, this supported implementation in 1994 of a further reduction in commercial vessel speed to six knots, as had been foreshadowed in 1989.




*Change in the measured rate of muddy estuarine bank erosion in response to management controls introduced to limit erosion. The curve shows the best fit trend of the data since the first introduction of multihulled cruise vessels.*

With the progressive introduction of these and numerous other changes management of the lower Gordon River had become complex and discriminatory against certain operators. An overhaul was required and in 1994 former deputy premier Sir Max Bingham QC was commissioned to head an *Inquiry into Gordon River Tourist Operations* (Bingham 1994). The principal outcomes were a new licensing regime which gave priority to environmental protection and a management plan for the lower Gordon that recognised the three major aims of World Heritage Area management: protection, presentation and rehabilitation (the latest version is Tasmania 1998). Replacement of the existing cruise fleet with vessels designed for low wake characteristics was encouraged.

As part of the Bingham Inquiry the wave characteristics of all commercial vessels were measured by the Australian Maritime College (AMC). The tests were repeated and expanded upon in 1995 and again in 1997 when a new, twin hull cruise vessel was proposed. Wake measurements allowed ranking of the vessels according to wave characteristics and the proposed vessel was licensed on the basis that it had the lowest maximum wave height.

Other studies were conducted by AMC, the University of Tasmania and James Cook University over the years. However, by 1997 we had achieved as much as we could by drawing upon the existing scientific and erosion management literature, which was often incomplete and sometimes contradictory. Part of the problem was that similar erosion elsewhere was normally controlled by bank protection works, however this is considered inappropriate for the Gordon where bank geomorphology contributes to World Heritage values. Further understanding of erosion processes was going to take some fundamental research.

An experimental approach was decided upon – driving a boat repeatedly past selected banks, measuring the waves using techniques borrowed from the AMC and observing their effects. However measurement of the small amount of erosion caused by each boat pass proved frustrating. Suitable instruments were either unaffordable or didn't deliver their lab specified resolution in the field. Eventually it was found that using a small array of turbidity sensors to track the plume of muddy water generated by wave activity, as it moved from the bank into deeper water, could indicate when erosion was occurring, even if the amount of erosion could not be quantified.

This work allowed estimation of true thresholds of erosion, rather than the point at which erosion became more pronounced, as was measured in the 1987 experiments. From early results a maximum permissible wave height of 75 mm, as measured in deep water 50 m from the vessel track, was established and incorporated into commercial licence conditions. It was now possible to set speed limits for individual cruise vessels based on their wake characteristics. New cruise boats are now assessed by scaling existing data from the extensive AMC wave wake database to fit the proposed vessel. This allows a speed limit to be set, a licence issued and the operator to gain finance before construction of the vessel commences.

Continued experimental work later showed that maximum wave height is not the best predictor of erosion. As increasing numbers of vessels were tested maximum wave energy and power (both functions of wave height *and* period) were found to be more reliable indicators. The inadequacy of the 75 mm wave height criterion has been demonstrated by instrumental monitoring of near shore turbidity at 15 second intervals. The magnitude, frequency and timing of turbidity events in both daily and seasonal terms indicates that commercial cruise vessels continue to have the greatest collective impact while the effect of private visitors is variable and in some cases disproportionately large (Bradbury 2005a). The 75 mm wave height limit has now been replaced by a wash rule that considers both maximum wave height and its associated period (Bradbury 2005b).

Around 2009 a major study was conducted to further characterize the susceptibility of the levee bank reaches to vessel wave wake. That was commissioned with a view to potentially reopening that zone to cruise operations. Significant recovery of both landforms and vegetation had occurred since closure in 1989. However it was found that the present level of traffic within the zone approximately matched its sustainable carrying capacity. Therefore no further commercial operations on the leveed reaches could be recommended.

Ongoing monitoring (Bradbury 2013) has shown that erosion continues and most can be attributed to wave wake, although sea level rise is perhaps becoming an increasingly significant factor. Despite that, some depositional recovery is also apparent. Deposition appears primarily associated with flood events having a return interval of 20 years or more; therefore recovery is expected to be a very long process. As progressively tighter restrictions have been placed on the commercial tourism fleet in order to limit erosion the erosive contribution of private vessels has become relatively more important. To counter that, stakeholders agreed in 2011 to a speed limit of 5 knots for all vessels longer than 4.2 m.

## LESSONS LEARNED

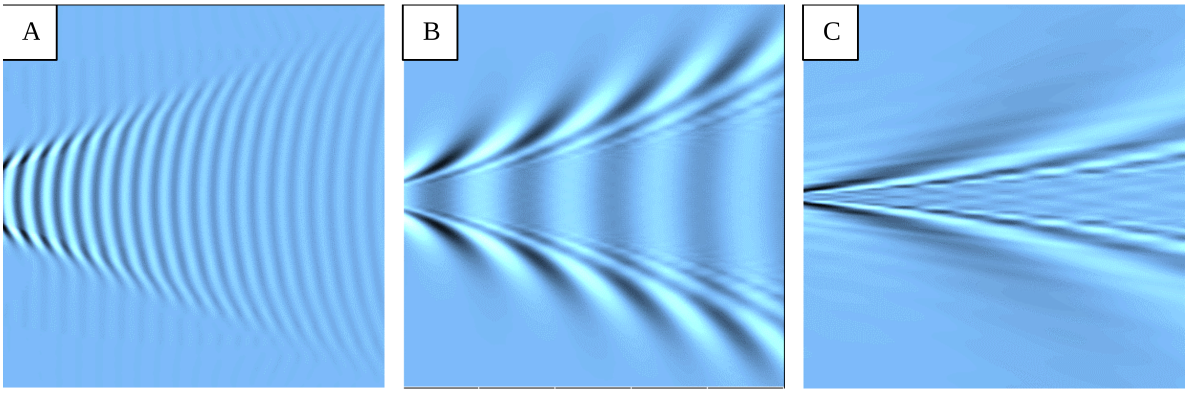
The most general lesson is that it is may be much easier to place environmental controls on a new activity at the outset rather than to try to change established practices after a problem becomes apparent. If it had been normal practice in the early 1980s to apply the precautionary principle then serious degradation of the lower Gordon River may have been avoided.

More specifically, it is clear that vessel wake may be a significant and undesirable driver of geomorphic process in otherwise sheltered waterways. The natural wave climate provides the key to what level of wake activity a shoreline can withstand. Ironically, on the Gordon the wave climate is suggested by cruise brochures that show the rainforest reflected in perfectly still water, although wind will whip up a chop at times. Our findings suggest that boats may cause wake erosion in any waterbody less than about a kilometer wide (or more if fast shipping is involved) and especially where vessels travel within 100 m of shore.

The effect of waves generated by river traffic is different to that of naturally occurring wind driven waves, which travel along the relatively straight reaches with greatest fetch. Whilst large waves may develop towards the center of the channel they only travel into nearshore waters at the ends of reaches. Relatively few stretches of bank are therefore subject to direct attack from wind driven waves. Wake waves however may directly approach all banks, including areas not normally affected by wind waves. Concentration of erosion on the inside banks of bends in the river channel, normally depositional areas, is considered diagnostic of wave wake being the cause of erosion.

As the erosion caused by commercial traffic was progressively reduced the impact of private vessels became relatively more significant. Speed limits were originally only applied to vessels greater than 8 m in length because it was believed than the lower waves from small, planing boats were less erosive. Experimental work, together with some recent more theoretical developments, has shown that this was incorrect.

The pattern of waves generated by a moving vessel is controlled by its speed in relation to its length. At low speed (displacement mode) the wake waves are relatively small and most follow the vessel’s track (wake pattern A). If the vessel is travelling along a reach these mimic the natural waves, only impacting at the end of the reach.  At higher speed (transition mode) the waves are much larger and more waves travel out from the vessel track (B) to impact upon otherwise sheltered sections of bank.  At yet higher speed (planing mode) the waves are once again relatively small but all of the waves travel out from the vessel track, almost directly towards the bank (C).  These waves have greater energy, travel faster and may cause disturbance at greater depth or at a greater distance than those generated in other modes.  We now strongly discourage small boat travel in transition or planing mode and to help boaters minimise the impact of their activities a guide to low wake boating has recently been prepared.




*Numerical simulations of wake wave patterns (verified by field studies) according to mode of vessel operation a) displacement b) transition c) planing.  Modeled using the computer program Michlet developed by Leo Lazauskas of the University of Adelaide.*

If managed properly water-borne tourism may allow large numbers of people to visit an area with less impact than other means of access.  Erosion can be entirely avoided if the maximum wave does not exceed the threshold values for height and period.  Speed limits are the best management tool available to limit wake erosion whilst maintaining access.  Counter-intuitively, but because of the relative speed effect on wake patterns, larger vessels may be able to travel slightly faster than smaller ones for the same level of impact.

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