Cementing Success in Rainbows

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Key Points

- Thomson River avulsed into Rainbow Creek in 1952
- In 1979 over 300 concrete groyne structures were built along Rainbow Creek.
- In 2023 an assessment was done to determine groyne stability and effectiveness in providing long term stability.
- The structures have been effective in mitigating gross meander migration
- Great example of how large reach scale management intervention, based on pro-active investment can be more effective in managing wholescale system issues over the long-term than small-scale site-based remediation.

Abstract

After the Thomson River avulsed into Rainbow Creek in 1952, cutting farms in half, the new 15km channel continued to undergo channel migration and deepening, further impacting on farming land and release of sediments to the Gippsland Lakes. In 1979 over 300 concrete groyne structures were built along Rainbow Creek to mitigate lateral migration.

In 2023 these groynes were assessed by engineers and geomorphologists to determine their stability and effectiveness in providing ongoing long-term stability to the system.

The structures have been effective in mitigating gross meander migration and the rate of channel adjustment. In many cases the river has completely “healed itself” around them. They remain highly effective 45 years later.

The long-term success of these structures is a great example of how large reach scale management intervention, based on pro-active investment can be more effective in managing wholescale system issues over the long-term than small-scale site-based remediation.

Keywords

Meander migration, reach scale management intervention, engineering, construction, environmental outcomes, groynes

Introduction

In 2023 the WGCMA and Alluvium undertook an assessment of the 340 concrete groyne structures installed along Rainbow Creek in 1979-80 and ongoing role they are providing in stabilising Rainbow Creek. The groynes, which have been in place for over 40 years, appear have been effective in mitigating meander migration within Rainbow Creek.

While the groynes have performed their intended functions, some movement of blocks and loss of cables (used to tie them together) has been observed. Additionally, the “new” waterway has continued to adjust within its environment. Therefore, WGCMA initiated a review of these structures to identify where they are continuing to provide critical stabilisation functions, where this function is at risk, and where required, prioritise management actions to maintain their ongoing function.

The subsequent results provided an overview of the groyne condition, the ongoing processes within Rainbow Creek, and recommended management actions to provide ongoing stability to the reach.

Background

Rainbow Creek was formed in 1954 when floodwaters spilling from the Thomson River scoured a new, much straighter, channel along the southern edge of the Thomson River alluvial fan. Rainbow Creek runs for approximately 15 km along the southern edge of the floodplain before re-joining the original course of Thomson River near Heyfield. The sudden abandonment of the original course of the Thomson River in favour of Rainbow Creek is termed an avulsion and is the culmination of a natural process caused by the gradual decrease in the capacity of the Thomson River over time.

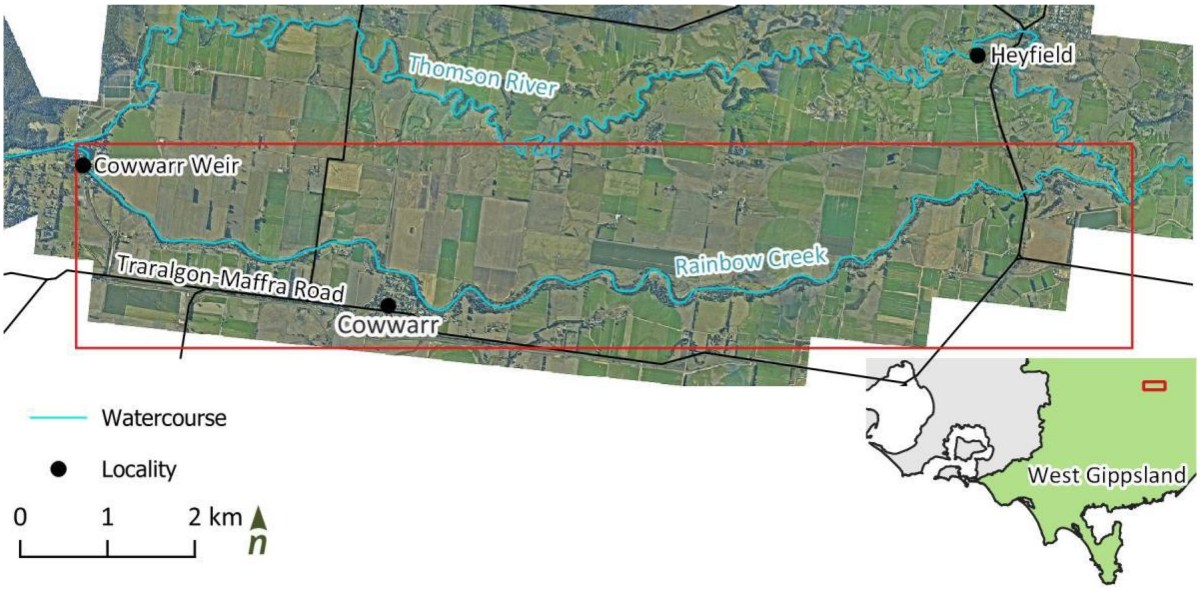

Figure 1. Locality map of Thomson River and Rainbow Creek study area. River flows left to right of map

The rapid deepening and widening of Rainbow Creek, post-avulsion, led to a significant loss of agricultural land and liberated large volumes of sediment that were delivered to the Thomson River and the downstream receiving waters of the Ramsar-listed Gippsland Lakes. Construction of Cowwarr Weir in 1959 at the point where Rainbow Creek diverged from the Thomson, effectively ‘paused’ the avulsion process, preventing the Thomson River from being completely abandoned and partitioning flows between the original Thomson River channel and Rainbow Creek. The weir also provides an irrigation offtake for the Macalister Irrigation District. Without active management of flow at Cowwarr Weir, the Rainbow Creek channel would be the preferred flow path of the Thomson River.

Since 1954, Rainbow Creek experienced ongoing channel adjustment within the floodplain. The impact of these changes on the community were so great, and the governments financial response so little, that a group of locals attempted to secede from the Commonwealth and declare “war” on the State of Victoria. Consequently, in-channel works were funded and undertaken to mitigate impacts of channel changes on adjacent landholders and reduce rates of erosion and sediment transportation into the Gippsland lakes. In 1979-80, a $1 Million investment ($6 Million equivalence in 2024) was made to mitigate ongoing lateral river bank retreat, resulting in the installation of 340 concrete groynes (in approximately 35 group locations) along Rainbow Creek (Figure 2 and 3). The groynes were constructed from stacked concrete blocks and secured with stainless-steel cables.

Figure 2. Early 1980's as-constructed aerial imagery of Group E groynes (left), current condition of groyne (2023) (right)

Figure 3. Early 1980's as-constructed aerial imagery of Group V groynes (left), current condition of groyne site (2018) (right)

Conceptualising the system

The Rainbow Creek conceptual model provides a summary of chronological river phases and the corresponding river responses. It provides an overview of historical channel change in Rainbow Creek, from its formation (in 1954) to now (2023) and outlines the expected future system trajectory. The conceptual model (Figure 4) was used to predict how physical and ecological processes, and their interaction, respond to intervention and how that response can steer the reach or site towards the desired outcomes.

PROCESS	THREAT	IMPACTS ON VALUES
Avulsion – formation of Rainbow Creek	Avulsion of Thomson River – floodwaters scoured a new channel which formed Rainbow Creek	Environmental: Decreased floodplain connectivity, decreased longitudinal connectivity, loss of instream habitat. Economic: Loss of production land and waterway infrastructure
Deepening and widening	Increased total flow energy: increase in stream power potentially triggering further channel incision Vegetation loss: decreased bed and bank roughness	Environmental: Decreased floodplain connectivity, increased sediment delivery to waterway. Economic: Loss of production land and waterway infrastructure
Bank adjustment / lateral retreat	Increased bed grade and stream power: accelerated rate of meander migration Vegetation loss: decreased bed and bank roughness	Environmental: Decreased longitudinal connectivity, increased sediment delivery to waterway. Economic: Loss of production land

ACTION	RESPONSE	IMPACTS ON VALUES
Management actions	Grade control structures, groyne bank stabilisation, stock exclusion fencing, and riparian revegetation implemented to control above processes	Environmental: Improved longitudinal riparian vegetation connectivity, improved instream habitat and water quality. Economic: Protection of production land and waterway infrastructure
System response	Ongoing system response to works which reduced stream power and shear stress within the system: infilling of banks, establishment of riparian vegetation	Environmental: Improved longitudinal riparian vegetation connectivity, improved instream habitat and water quality. Economic: Protection of production land and waterway infrastructure
Hypothesis of future channel change	Waterway condition should continue to gradually improve, assisted by program of ongoing revegetation and willow removal works, and monitoring and maintenance of existing stabilisation works.	Environmental: Improved longitudinal riparian vegetation connectivity, improved instream habitat and water quality. Economic: Protection of production land and waterway infrastructure

Figure 4. Conceptual model of channel change: Rainbow Creek

Assessing the role in ongoing stability

Digital Elevation Model of Difference (DoD)

2008 and 2018 LiDAR data of the study reach were compared, and the resulting Digital Elevation Model of Difference (DoD) was used to assess the changes in sediment storage in the study reach between 2008 and 2018.

A DoD identifies changes in ground surface elevation from two LiDAR datasets captured at various temporal scales. From the DoD areas of bank and channel scour can be identified. LiDAR cannot penetrate the water surface, as such where there is water in the channel an accurate estimation of bed level, and therefore change in bed level, cannot be determined.

The DoD analysis shows that there was limited lateral bank erosion (meander migration) between 2008 and 2018 (3). However, there are isolated areas in the upper reach where meander migration has occurred including downstream of groyne group A (Figure 5 - Inset A) and within the groyne group E (Figure 5 - Inset B).

Overall, based on the LiDAR data, there has not been gross channel adjustment within Rainbow Creek between 2008 and 2018, indicating that the groyne program continues be largely successful at slowing bank retreat.

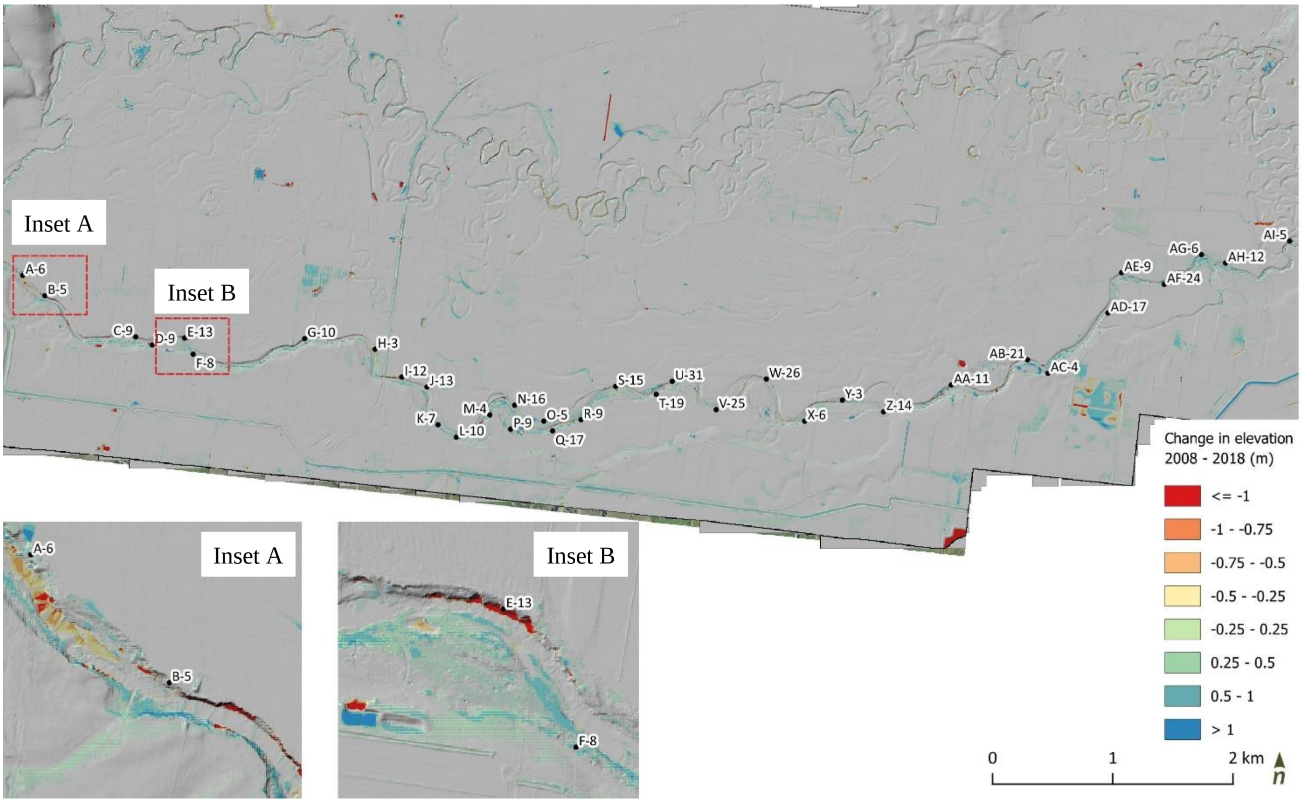

Figure 5. Change in elevation between 2008 and 2018 at the study site. Yellow and orange displays a drop in elevation

Modelling analysis

A 2D hydraulic flood model was completed as part of a Thomson River-Rainbow Creek Waterway Management Plan and was used to inform this study. Modelling outputs (50%, 5% and 1% AEP) were examined. The 5% AEP event was identified as the most appropriate to inform the groyne stability risk assessment, as bank stabilisation works are often designed to withstand up to the 5% AEP event.

The maximum velocity results for the 5% AEP event are shown in Figure 6. The velocity results were used to inform the groyne stability risk assessment. Threshold velocity is the flow velocity of water at which mobilisation of the channel boundary layer occurs (boundary layers include sediment, cobbles, grasses etc).

The study area has been divided into three zones based on modelled 5% AEP velocities (Figure 6):

- In Zone A, immediately downstream of the Cowwarr weir (and adjacent to groynes groups A and B) there some high energy zones characterise by velocities up to approximately 4 m/s. These velocities exceed the upper velocity threshold for structurally diverse vegetation (i.e. mature trees, shrubs and grasses).
- In Zone B there are isolated high energy zones with velocities up to 3.1 m/s, which is the upper velocity threshold for structurally diverse vegetation. However, the 5% AEP event velocity was generally below 2.3 m/s, which is the upper velocity threshold of 150 mm cobbles.
- In Zone C the 5% AEP event velocity was generally below 1.8 m/s, which is the upper velocity threshold of long native grasses.   There are isolated high energy zones with velocities up to 2.3 m/s mid-channel which corresponds to greater water depth.

The 5% AEP velocities within the study area are generally below upper velocity threshold for structurally diverse vegetation, with the exception of the high energy zone immediately downstream of the weir; the in-channel velocities generally decrease in a downstream direction. Overall, modelling indicates that velocities are within acceptable limits for channel boundary layer thresholds within the system. Therefore, the velocity is generally below the threshold velocity at which mobilisation of boundary layers (e.g. grasses and diverse riparian vegetation) would occur.

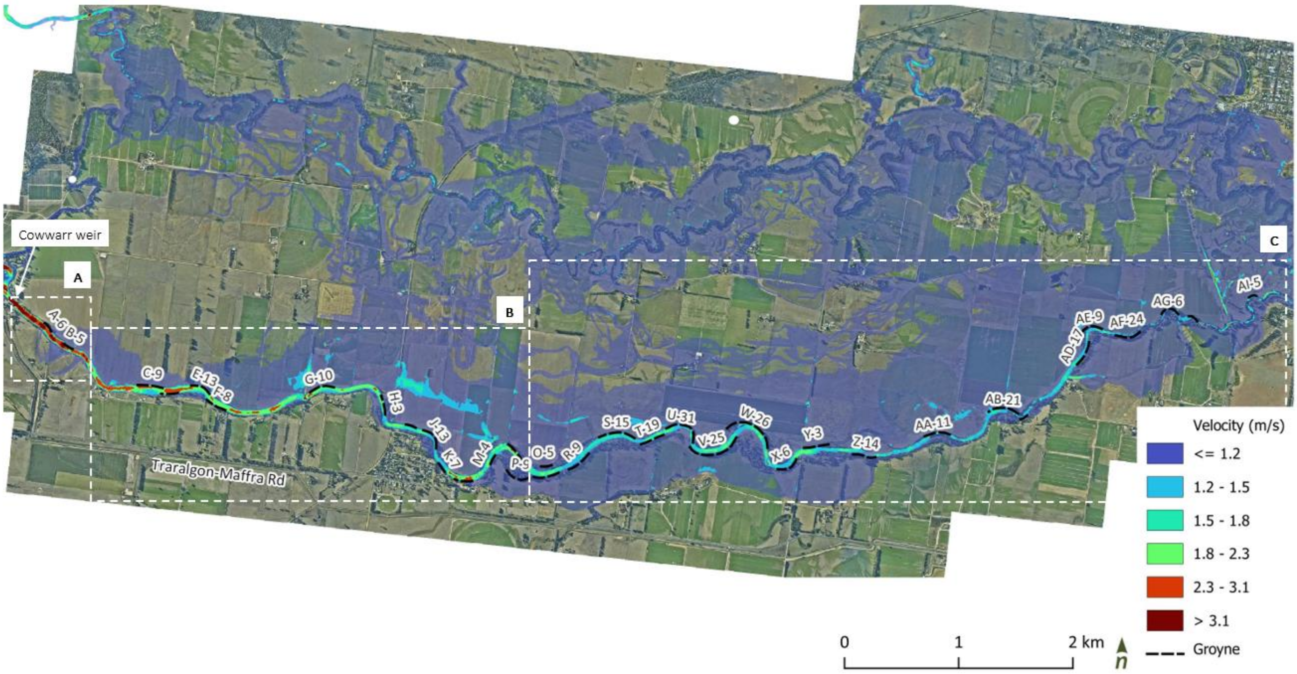

Figure 6. Maximum velocity (m/s) results for the 5% AEP event. With groyne group locations shown (Modelling results from Water Technology, 2020).

Groyne management recommendations

As part of the assessment the vulnerability of each groyne was determined based on three metrics (structural condition, vegetation cover, and erosion). Asset vulnerability was defined as:

- Low – Stable groyne/bank (Good structural condition, Low erosion) – no works required
- Moderate – Moderate risk of groyne/bank failure (Moderate structural condition, Moderate erosion) - monitor
- High – High risk of groyne/bank failure – prioritise works (Poor structural condition, High erosion) (e.g. repair, revegetate, and monitor as required)

The final step in the risk assessment was to use the ratings assigned to each groyne to determine the vulnerability of each site. The risk matrix used to relate likelihood and consequence scores to a risk rating is provided in Table 1.

Table 1. Vulnerability risk matrix.

		EROSION		
		Low	Moderate	High
STRUCTURAL CONDITIONS	Good	Low	Low	Moderate
	Moderate	Low	Moderate	High
	Poor	Moderate	High	High

A summary table, of asset vulnerability and recommended works, is provided in Table 2. The results showed that the majority of the sites (groyne groups) were rated as low risk, with no works required. Nine sites were rated moderate risk – with monitoring recommended and one site was rated as high risk and is considered a priority works site.

Table 2. Asset vulnerability summary

Groyne group (Group ID – number of groynes)		
Low vulnerability	**Moderate vulnerability**	**High vulnerability**
A - 6 C - 9 F – 8 H – 3 J - 13 K - 7 L - 10 M - 4 N - 16 O - 5 P – 9 R - 9 S - 15 T - 19 U – 31 Y - 3 Z - 14 AA - 11 AB - 21 AC - 4	B - 5 E – 13 G – 10 I – 12 Q – 17 V – 25 X - 6	W - 26

Management actions are informed by the risk rating of each asset (Table 1).

Table 3. Recommended management actions based on risk rating.

Risk rating	**Management action**
Low	No works required (monitoring only post flood event > 5% AEP)
Moderate	Infill planting Monitoring and maintenance program (annual)
High	Groyne repair, replacement and vegetation works etc..

Current system trajectory

Following its formation as the preferred pathway for the Thomson River, Rainbow Creek continued to develop, deepening and lengthening (through lateral migration) as the channel adjusted to its geomorphic setting. This process has been interrupted by the establishment of Cowwarr Weir, flow management down the two courses, and groyne and grade control management intervention. The structural stability of the groynes and their effectiveness in resisting channel migration and in some cases assisting in channel rehabilitation, means they remain highly effective 45 years later. Combined with the grade control, fencing, and riparian revegetation programs, they have been effective in mitigating gross meander migration within Rainbow Creek and have effectively reduced the rate of channel adjustment.

Conclusion

The long-term success of these structures is a great example of how large reach scale management intervention, based on pro-active investment can be effective in managing wholescale system issues over the long-term. Although the engineering solutions today may differ from that implemented in 1979, the benefit of intentional system scale intervention is clearly demonstrated at this site.

In the last 40 years, the groynes structures (combined with the grade control, fencing, and riparian revegetation programs) have been effective in mitigating gross meander migration within Rainbow Creek and have effectively reduced the rate of channel adjustment.

The condition assessment of the concrete groynes showed that the majority of the sites (groyne groups) were rated as low risk, with no works required. Nine sites were rated as moderate risk (with monitoring recommended), and one site as high risk – which is considered a priority works site.

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