All the best intentions (and information): Using multiple and sequential data sources to inform the large-scale rehabilitation of the Cann River, East Gippsland, Victoria

Sean Phillipson[1] and Alex Sims[2]

1 East Gippsland Catchment Management Authority, Bairnsdale, Victoria, 3875. Email: sphillipson@egcma.com.au

2 Alluvium Consulting, Melbourne, Victoria, 3002. Email: alex.soms@alluvium.com.au

Key points

- More frequent and higher-resolution LiDAR, aerial imagery and flow data are shifting river monitoring from site observations to repeat, spatially continuous assessment of channel change.
- The Cann River is a strong case study because it is a classic example of river metamorphosis following European settlement, with a well-documented history of management intervention and geomorphic response recorded through remotely sensed data and field observations.
- Grade-control works have slowed incision and created local hard points, but they have not halted the broader downstream-progressing sediment deficit that continues to control channel trajectory.
- The Cann River provides a case study for moving from monitoring change to collecting the data needed to parameterise numerical models that can test conceptual models, asset performance and future management scenarios.

Abstract

The Cann River provides a case study for how increasingly detailed river monitoring datasets can be used to move from documenting change to testing management options. The river has undergone substantial geomorphic adjustment since European settlement, including incision, widening, sediment redistribution and repeated management intervention. More recent LiDAR, aerial imagery, field observations and flow records show that the system remains a net exporter of sediment, with grade-control works slowing but not halting a downstream-progressing phase of incision.

This paper uses the Cann River to show how long-term historical records and repeat remotely sensed datasets can be combined to understand geomorphic trajectory, assess intervention performance and define future monitoring needs. The key management question is not simply whether the river is changing, but what type and scale of intervention could alter that trajectory, and whether such intervention is feasible under current sediment supply constraints.

We argue that monitoring programs should increasingly be designed around model development and testing. These models may range from simple hypothesis-testing frameworks to numerical hydraulic, sediment transport or morphodynamic models. In all cases, the aim is to use monitoring data to test conceptual models, compare future management scenarios, identify uncertainty and improve decisions over time. This provides a practical pathway for waterway managers to better use the increasingly frequent and detailed datasets now available for many Australian rivers.

Keywords

Cann River, sand bed stream, incision, reach scale river rehabilitation, LiDAR, data sources

Introduction

Across Victoria, river systems are transitioning rapidly towards a to data-rich environment. The increasing availability of high-resolution LiDAR, improved aerial imagery, long-term monitoring datasets and better hydrological records has significantly enhanced our ability to describe channel form, quantify change and interpret geomorphic processes through time.

These advances have greatly improved retrospective understanding of river behaviour, allowing clearer identification of erosion patterns, sediment movement and channel adjustment. However, this improved understanding has not always translated into improved decision-making. In many instances, there remains a disconnect between technical interpretation and on-ground management actions.

Decisions are still frequently influenced by immediate pressures such as visible erosion or instability, the availability of post-flood recovery funding, and community expectations to stabilise or “fix” localised issues. While these drivers are valid and unavoidable, they do not always align with the broader geomorphic trajectory of a system. As a result, intervention can be reactive rather than strategic, with limited influence on longer-term system behaviour.

The Cann River provides a strong case study to explore this challenge. It is one of the most extensively studied river systems in East Gippsland, with more than 30 years of work documenting channel adjustment, sediment dynamics and management response. Because of this, it represents a relatively uncommon example where the geomorphic trajectory of the system is well understood and supported by a substantial body of data.

Previous work has effectively established the geomorphic trajectory of the Cann River. The focus of this paper is not to revisit that evidence, but to consider how that knowledge, supported by an increasingly rich dataset, can be used to inform future management.

This paper aims to describe moving beyond describing past change, focusing instead on how a rich river dataset can be used to guide practical management decisions.

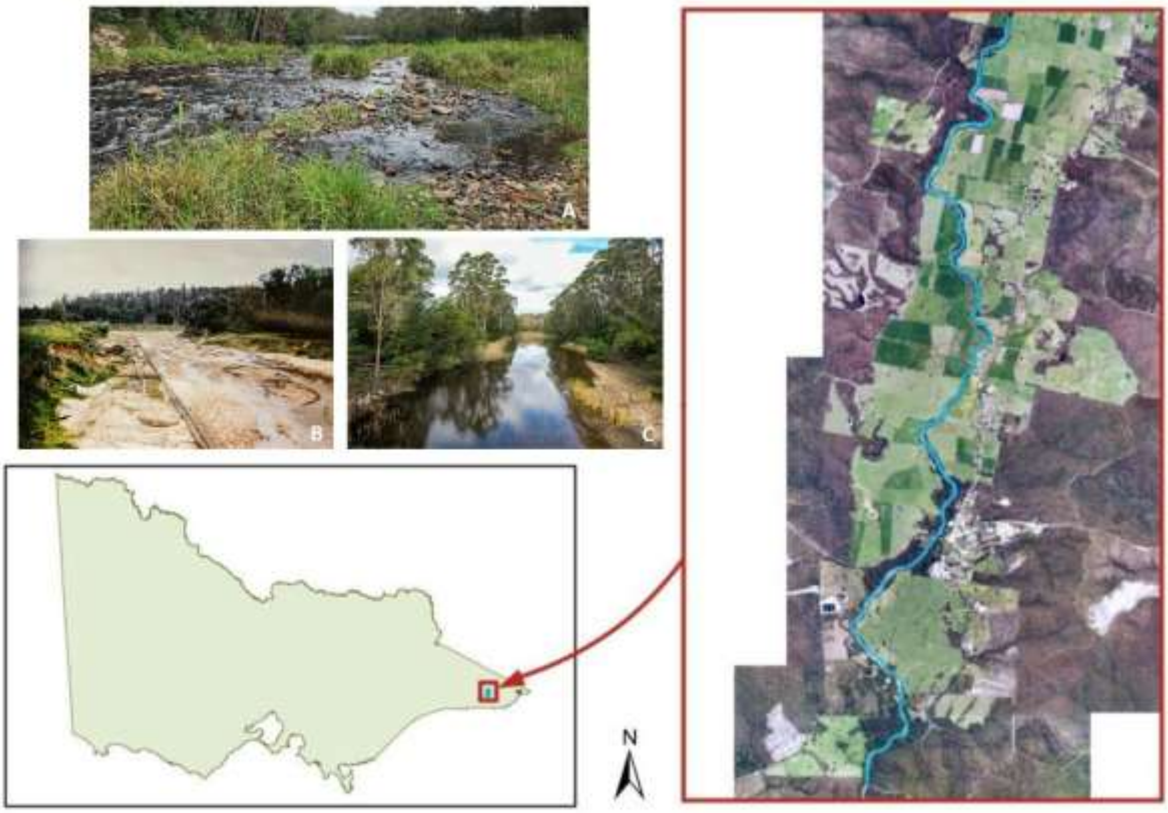

Figure 1 Location map. Inset images A) Rock chute downstream stream of the West Cann Bridge B) and C) Observed channel change since 1969 (left), 2018 (right) (adapted from Alluvium, 2022)

Background

The floodplain reach of the Cann River is an actively incising stream located in far East Gippsland. This incised reach of the river traverses a cleared floodplain in the vicinity of the township of Cann River and is bound upstream by a bedrock-confined reach within Coopracambra National Park, and downstream by a bedrock-confined reach within Croajingalong National Park. The river mouth is located at Tamboon Inlet on the East Gippsland coast

The Cann River has undergone a sequence of adjustments that have substantially changed channel form and behaviour. The first major phase followed European settlement, when land clearing, riparian vegetation loss and removal of large woody debris reduced channel resistance. This triggered a river metamorphosis: a shift from a narrow, sinuous, highly vegetated channel to a deeper and wider incised channel. This type of change cannot be reversed within normal management timeframes; recovery occurs within the altered channel form rather than through a return to pre-disturbance conditions.

Incision progressed downstream through the floodplain reach, releasing large volumes of sand as the channel bed lowered and the banks expanded. By the 1940s, this phase of incision and widening was widespread through the study reach. Early management responses focused on limiting further erosion and included groynes, wire mesh structures and local realignment works.

The 1998 flood triggered a further phase of rapid incision and widening, driven by high stream powers and large sediment transport capacity. This led to further geomorphic investigations and implementation of a reach-scale grade control program. The program was designed to halt further incision, maintain bed levels and allow vegetation to establish on the channel bed and margins. Over time, that vegetation was expected to increase roughness and resistance, reducing rates of channel change and supporting a more stable adjusted form.

The adjustment also had a strong upstream–downstream sequence. As incision migrated downstream, it released large volumes of sand that were transported through the system. This produced a complex response, with local aggradation occurring alongside continued incision and widening. Much of the incision associated with the 1998 flood appears to have cut into sand deposits that had accumulated during the earlier post-European phase of adjustment. The current supply of sand-sized sediment from the catchment is much lower than the volume now being transported by flows through the Cann River, leaving the system increasingly sediment-limited.

The focus of this paper is the response of the channel to the post-1998 grade control program, including the initial works completed after the 1998 flood and the second phase of works following the 2011 floods. This assessment draws on geomorphic investigations and monitoring data to describe how the channel has adjusted since those interventions.

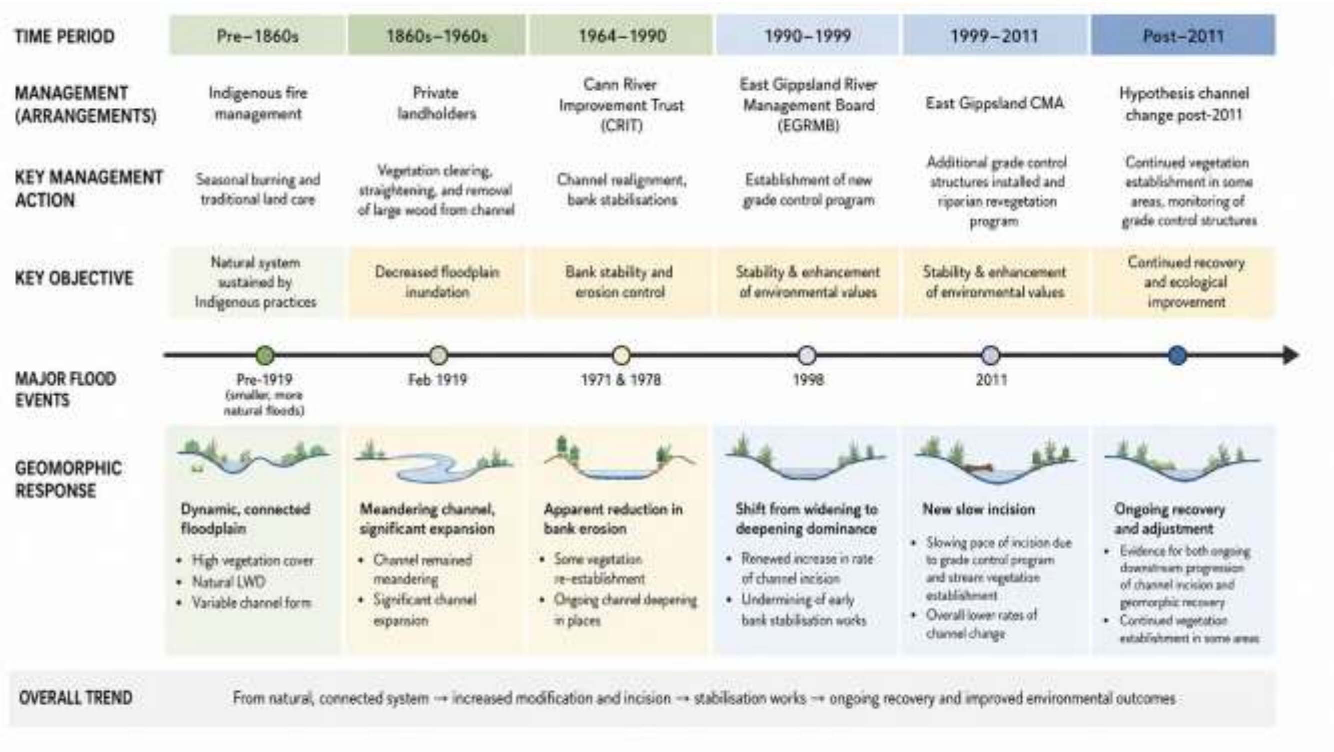

Figure 2 Conceptual model of channel change: Cann River (Alluvium, 2022)

Cann River monitoring data

A range of monitoring datasets are now available for the Cann River, including repeat LiDAR surveys, aerial imagery, streamflow gauge data, historical cross-sections, field observations, site photographs, post-flood assessments, and hydraulic and geomorphic modelling. The main remotely sensed datasets used in this assessment are LiDAR captures from 2010, 2018, 2020, 2023 and 2025, with stated vertical accuracies of approximately 0.1 m. Point density has increased over time, from approximately 8 points/m^2 in earlier captures to more than 60 points/m^2 in the most recent 2025 dataset. These data are used to generate 1 m resolution digital elevation models, with the higher-density recent datasets also supporting finer-resolution elevation models, such as 0.5 m grids, while maintaining comparable vertical accuracy. The corresponding aerial imagery ranges from approximately 0.5 m to 0.25 m resolution. Together, these datasets show that monitoring is becoming both more frequent and higher density, allowing progressively finer assessment of channel change.

These datasets were collected for a range of purposes, rather than as a single monitoring program. This is common across many Australian rivers, where LiDAR and aerial imagery are routinely captured through statewide programs such as the Index of Stream Condition, targeted post-flood recovery programs, and investigations that support the design and evaluation of river management works. Post-flood geomorphic assessments are also a common mechanism for funding new data capture, as they provide both the evidence base for recovery works and the context for assessing subsequent channel response.

The Cann River also has a continuous streamflow record from gauges that have operated at various locations since the late 1990s. These flow data are often paired with targeted post-flood assessments, including field observations, site photographs and hydraulic modelling to estimate flow forces through the channel. Together, these datasets provide the basis for linking observed channel change to flood history, sediment transport conditions, vegetation establishment and management interventions.

Earlier records of channel change relied on historical photographs, anecdotal observations and repeat cross-sections. Cross-sections provided useful evidence of local adjustment, but their capture was more labour-intensive and generally limited to selected representative reaches. The shift toward repeat LiDAR and aerial imagery allows channel change to be compared more consistently through time across the floodplain reach. Together, the historical records and remotely sensed datasets provide a longer-term history of change and a stronger basis for assessing whether recent patterns are localised responses or part of a broader channel trajectory.

The availability of repeat LiDAR and aerial imagery has shifted the assessment from testing change at selected cross-sections or individual sites (often selected as 'representative of broader reaches of river) to measuring patterns of erosion, deposition and vegetation change across much larger areas. This allows rates and patterns of channel adjustment to be assessed at higher spatial resolution and over a broader extent than was previously possible. It also allows flood impacts to be bracketed by pre- and post-event datasets, making it easier to separate event-driven change from longer-term recovery or adjustment trends.

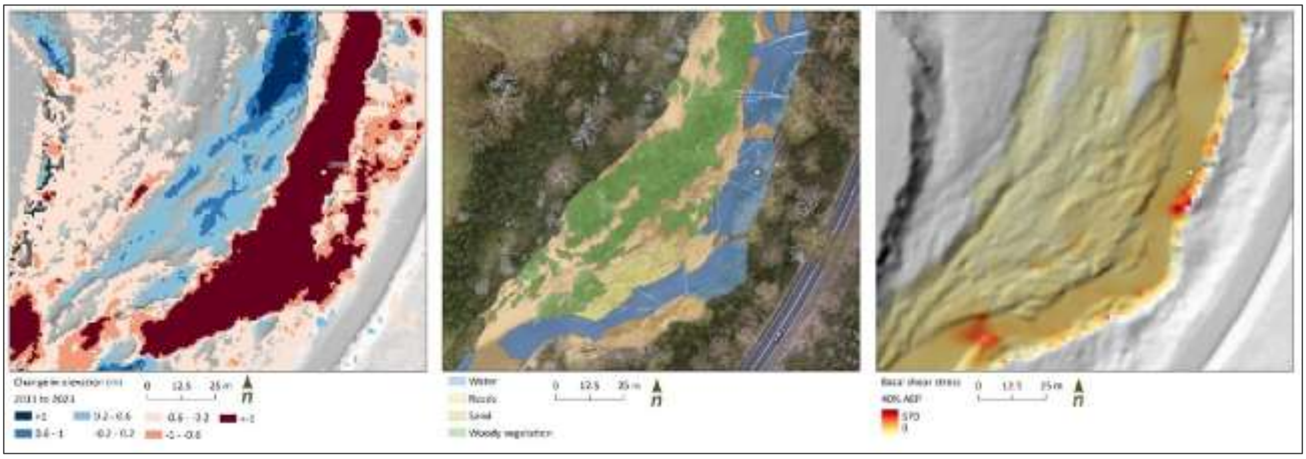

Figure 3 Monitoring datasets used in the Cann River (left) DEMs of difference, (middle) mapping of vegetation change, (right) modelled shear stress (40 % AEP) (Alluvium, 2024)

Geomorphic trajectory of the Cann River

Sediment export and downstream incision

The Cann River is operating as a net exporter of sediment. Repeat LiDAR analysis, DEMs of difference and comparison of LiDAR-derived longitudinal profiles with earlier surveyed profiles show continued incision and net sediment loss between 2011 and 2023. The 2025 LiDAR dataset has not yet been analysed. Local deposition still occurs, particularly near grade control structures and within vegetated areas, but these gains are outweighed by broader erosion through the floodplain reach.

This sediment loss has a clear longitudinal pattern (Figure 4). Net export is greatest in the upstream reaches and progressively decreases downstream, although the full assessed length remains in sediment deficit. This is consistent with a downstream-progressing wave of incision, where the transport capacity of the Cann River during higher flows is much greater than the current sediment supplied from upstream.

The current bed material includes sand stored during earlier phases of post-European channel adjustment. Much of the incision triggered by the 1998 flood and later high-flow events appears to have cut into these stored sand deposits, rather than into sediment supplied by the contemporary catchment. As this stored sand is removed, the bed lowers and the channel is coarser. Upstream reaches that have incised further now expose coarser gravel substrates, while downstream the channel remains dominated by medium to coarse sand. This downstream sand-filled section likely represents the next stage in the adjustment sequence if incision continues.

Figure 4 Net change in sediment storage (2011- 2023) along the Cann River (Alluvium, 2024)

Performance of management works

The original works undertaken by the Catchment Improvement Trusts in the 1960s were intended to limit bank erosion where it threatened agricultural land on the floodplain. This was a common motivation for river works across Australian rivers at the time, and remains a common driver of intervention in some systems today. These works included structures installed near bed level to control widening and protect banks.

Field observations now show that many of these structures have been undercut and stranded above the present channel bed. They were well intended, but they treated the visible symptom of widening without addressing the controlling process of bed incision. As the bed lowered, the structures became disconnected from the active channel and lost much of their function.

The more recent grade control program, including rock chutes and intermediate rock pile structures, was designed to slow incision, maintain bed levels and support vegetation establishment. The intermediate structures were also cheaper to construct and intended to deform gradually as the bed adjusted, allowing them to continue providing some grade control rather than failing as fixed structures.

These works appear to have partially achieved that purpose. The stepped longitudinal profile shows that the structures remain hard points in the channel bed and continue to limit the rate of incision. However, their crest elevations have lowered and the channel grade has continued to decline. This indicates that the structures have slowed the downstream progression of incision but have not halted it. The scale of the sediment deficit remains the dominant control on channel behaviour.

Vegetation, flow sequence and current conceptual model

Vegetation establishment has been an important part of the recovery response, but it has not overridden the sediment deficit. *Phragmites* and other vegetation established on sand deposits upstream of some intermediate structures after the 1998 works and during the low-flow conditions of the Millennium Drought. Some of this vegetation was later removed by large floods, and continued sediment export has removed or undermined the sand surfaces needed for re-establishment in what are now deeper sections of the channel (Figure 5).

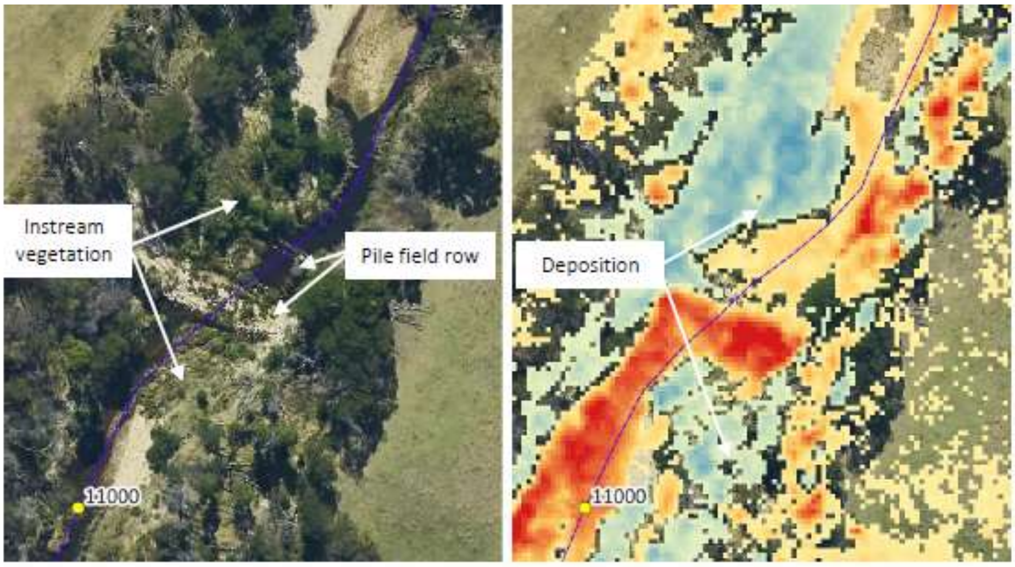

Figure 5 Associations between net erosion and deposition (2011 – 2023) and vegetation establishment immediately upstream and downstream of grade control structures (Alluvium, 2024)

The vegetation response is not uniform. Some stabilising vegetation around sand deposits has been lost, while woody vegetation has established more strongly in upstream reaches with coarser gravel substrates, inset terraces, coarse bars and islands. This means there is not a simple relationship between vegetation extent and sediment export. Vegetation can increase local resistance where stable surfaces exist, but vegetation establishment appears to be superimposing a more subtle impact on sediment storage compared to broader process of downstream progressing channel incision, driven by the mismatch between sediment supply and transport capacity.

The flow sequence has affected how the channel and vegetation have responded. Low flows during the Millennium Drought likely promoted establishment of vegetation on exposed deposits. Subsequent wetter periods, including high-flow years before and after the 2019–20 Black Summer bushfires, increased the frequency of flows capable of mobilising bed material and removing vegetation from unstable sand surfaces.

The current conceptual model is that the Cann River is undergoing a downstream-progressing phase of incision driven by a large imbalance between sediment supply and transport capacity. The channel is still exporting stored sand released during earlier phases of adjustment. Grade control structures have slowed the rate of incision and created local hard points, but they have not stabilised the overall channel grade. The upstream reaches show the likely trajectory for downstream sand-filled reaches if incision continues: lowering of the bed, removal of stored sand, exposure of coarser substrate, and a shift toward a more incised gravel-bed form. Vegetation will continue to establish where stable surfaces are available, particularly on bars, islands and inset benches, but it is unlikely to control the overall adjustment while sediment export remains the dominant process.

Building adaptive river models from existing monitoring datasets

The Cann River is now at the point where the main task is not more description of channel change, but better use of the data already being collected. Extensive data sets can now be brought together into a modelling framework that is updated through time. The value of that framework is not that it predicts the future with certainty. Its value is that it allows future management options to be trialled, compared and improved at relatively low cost before works are implemented.

This is the practical role of a digital twin-type model for rivers. In the river-basin literature, digital twins are described as systems that combine data, physical models, data-driven tools and scenario testing to support forecasting, planning and management decisions (Yang et al., 2024). For the Cann River, the useful step is narrower and more practical: converting the existing conceptual model into a spatial and numerical framework that can test alternative intervention pathways. This is consistent with broader riverscape approaches, where remotely sensed and geospatial data are used to move from isolated site assessment toward spatially continuous interpretation of channel and riparian condition (Carbonneau et al., 2012; Glassic et al., 2024).

These kinds of river digital twins are typically built in stages. For the Cann River, the pathway would be:

- Stage 1: build the baseline. This has largely been done. The available LiDAR, aerial imagery, longitudinal profiles, streamflow records, structure locations, field observations and historical records have been assembled to describe channel trajectory, asset performance and broad sediment behaviour.
- Stage 2: convert the conceptual model into a testable model. This means using the existing data to parameterise hydraulic, sediment transport and, where appropriate, morphodynamic models. The aim is to represent the dominant processes well enough to test management options, not to reproduce every local feature of the channel.
- Stage 3: trial management scenarios. Options such as further grade control, targeted sediment retention, revegetation, assisted establishment on inset surfaces, asset maintenance, or allowing some reaches to continue adjusting can be tested against likely effects on bed level, sediment storage, vegetation surfaces, structure performance and downstream propagation of incision.
- Stage 4: update the model as new data are collected. Future LiDAR, aerial imagery, field surveys and post-flood inspections become a calibration and testing dataset. Where the model performs well, confidence increases. Where it fails, the assumptions and parameters are revised.

This approach is useful because it makes the management logic explicit. For example, if a proposed intervention is intended to reduce incision, the model can test whether it is likely to influence bed levels beyond the immediate works footprint. If revegetation is proposed, the model can test whether the target surfaces are likely to remain stable long enough for establishment. If no further intervention is proposed, the model can test the likely direction and rate of ongoing change. Comparison between options is the main value.

The broader opportunity is that many Australian rivers now have similar datasets. LiDAR, aerial imagery, post-flood assessments, asset inventories, hydraulic models and local management knowledge are often available, but are used for individual projects rather than maintained as part of a continuing model of river behaviour. The Cann River provides a clear case for shifting from a sequence of one-off assessments to a continuously improving framework. Each new dataset should test a defined hypothesis: whether incision is continuing, whether a structure is still acting as a hard point, whether vegetation is stabilising a surface, whether sediment deficit is moving downstream, and whether intervention is changing the trajectory or only slowing it.

For management, this means monitoring should be designed to collect data that can then be used within the modelling framework to test those hypothesis, rather than just documenting change in detail. The aim is to embed existing technical knowledge, field validation and local experience into a framework where future scenarios can be tested and compared. Over time, that gives managers a better way to compare options, explain trade-offs and refine intervention priorities as new evidence becomes available.

Conclusions

The Cann River shows that many Australian rivers are no longer limited by a lack of data. The greater challenge is how to use this data to understand trajectory, test management assumptions and identify what intervention can realistically change. For the Cann River, the evidence indicates a sediment-deficit system that continues to incise and export stored sand, with grade-control works slowing but not stopping that adjustment.

The next step is to use monitoring as part of a modelling and management framework, not just as a record of past change. This should be used to test the type and scale of management intervention needed, whether it is feasible to change the overall trajectory, and the likely final grade and form of the channel if the current geomorphic trajectory continues. This should include testing whether interventions such as grade control, revegetation, large wood introduction and other roughness elements can meaningfully alter the trajectory to promote recovery, and the scale at which they would need to be implemented. A clearer view of the likely future channel state also allows management of assets, landholder expectations and community understanding to be planned around the trajectory the river is most likely to follow.

The broader point is that monitoring should increasingly be framed around model development and testing. Those models may range from simple hypothesis-testing frameworks through to detailed numerical and morphodynamic simulations, depending on the management question, data availability and level of uncertainty. In all cases, the aim is to use monitoring data to test how the river is behaving, whether management actions are altering that behaviour, and what scale of intervention would be needed to change the trajectory. This is the emerging opportunity for waterway managers in Australian rivers: to make better use of increasingly frequent and detailed datasets by turning monitoring programs into a structured pathway for testing concepts, comparing scenarios and improving management decisions and actions over time.

Acknowledgements

Thanks go to all those involved improving our understanding of the Cann River through their knowledge and experience including Robert Allan, Rex Candy, Ross Hardie, and the late Wayne Erskine. We would also like to acknowledge the Victorian Government for providing funds for much of the investigative and rehabilitation program.

References

Alluvium (2022). Cann River Geomorphic Change Assessment. Report prepared by Alluvium Consulting for East Gippsland Catchment Management Authority, Bairnsdale.

Alluvium (2024). East Gippsland River Phase Check – Cann River. Report prepared by Alluvium Consulting for East Gippsland Catchment Management Authority, Bairnsdale.

Carbonneau, P., Fonstad, M.A., Marcus, W.A. and Dugdale, S.J. 2012, 'Making riverscapes real', Geomorphology, vol. 137, no. 1, pp. 74–86.

Glassic, H.C., McGwire, K.C., Macfarlane, W.W., Rasmussen, C., Bouwes, N., Wheaton, J.M. and Al-Chokhachy, R. 2024, 'From pixels to riverscapes: How remote sensing and geospatial tools can prioritize riverscape restoration at multiple scales', WIREs Water, vol. 11, article e1716

Yang, Y., Xie, C., Fan, Z., Xu, Z., Melville, B.W., Liu, G. and Hong, L. 2024, 'Digital twinning of river basins towards full-scale, sustainable and equitable water management and disaster mitigation', npj Natural Hazards, vol. 1, article 43.