Geomorphically adaptive management of an evolving anabranch network of the Murray River

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Key points

- Flow regulation in the Hume to Yarrawonga reach has inverted seasonal flows and accelerated anabranch engagement.
- Multiple lines of evidence show several anabranches have captured flow while corresponding Murray sections are infilling.
- A five-stage anabranch classification (Stable, Emerging, Constrained, Developed, Captured) translates complex morphodynamics into decision-relevant categories.
- Managing this corridor requires treating the "main channel" as dynamic, defined by hydraulic and geomorphic dominance, with interventions matched to developmental stage.

Abstract

We present a geomorphic reassessment of the Hume to Yarrawonga (H2Y) reach of the River Murray, a highly regulated corridor downstream of Hume Dam where flows are operated primarily for irrigation. Long-term regulation, combined with legacy desnagging, stock access and boating pressure, has altered the timing, duration and variability of flows, creating a mismatch between river behaviour and a management focus that defined success as maintaining the historically mapped Murray main stem as the primary flow path under the 2022 strategic management plan.

We used multiple lines of evidence to diagnose change and reframe management intent, including long-term flow split monitoring, interpretation of LiDAR, top-of-bank mapping, DEM of Difference analysis, relative depth mapping, and targeted field observations. Findings highlight regulation-driven shifts in bank erosion mechanisms and the sustained engagement of anabranches, with implications for sediment transport, riparian recovery and system reconfiguration.

A key output is a simplified five-stage anabranch development classification (Stable, Emerging, Constrained, Developed, Captured) that converts complex behaviour into decision-relevant categories. We demonstrate how this framework supports geomorphically adaptive management by treating the "main channel" as a moving target, considering conveyance across the full corridor, and aligning interventions to developmental stage, while prioritising vegetation/roughness and "softer" approaches where appropriate, and planning for inevitable transitions in dominant pathways.

This is an example of geomorphically adaptive, process-driven management, which is becoming recognised as increasingly important across Australian fluvial systems. In this case, where regulation, land-use change and climate variability are accelerating channel adjustment and making corridor-scale, trajectory-led decisions essential for sustaining river values and managing risk.

Keywords

anabranching rivers; geomorphically adaptive management; River Murray; flow regulation; channel capture; process-based restoration; corridor management

Introduction

River regulation reshapes flow timing, magnitude and variability, altering sediment transport capacity and triggering channel adjustment (Erskine et al., 1990; Maheshwari et al., 1995; Kondolf, 1997; Erskine et al., 1999). In many regulated rivers, management has historically emphasised controlling visible erosion or defending fixed alignments. These approaches can drift into “set and forget” and reduce overall system resilience. Adaptive management offers an alternative: treat interventions as hypotheses, monitor outcomes, and adjust decisions as understanding improves (Webb et al., 2018). Yet in practice, “adaptive management” often remains procedural rather than geomorphic (Russell et al., 2023). Programs monitor symptoms (e.g., erosion rates) without explicitly tracking how interventions interact with river evolution and dominance shifts. Process-based decision-support frameworks are effective because they identify not only where to intervene, but the level and type of intervention required and, importantly, where intervention is not needed (Fryirs et al., 2018).

This paper argues that geomorphically adaptive management requires a different starting point: a coherent geomorphic understanding of what the system is, how it is adjusting, and where it is likely to go next (Schumm, 1973; Brierley & Fryirs, 2005; Fryirs & Brierley, 2016). We develop this argument using the Hume to Yarrawonga (H2Y) reach of the River Murray based on the assessment undertaken by Geomorphe (2025). The assessment underpinning this paper identifies a necessary paradigm shift: the “main channel” should be understood as a dynamic channel defined by hydraulic and geomorphic dominance, not a fixed mapped line. In multiple locations along this reach, adjacent anabranches have captured flow, and the historically mapped Murray River channel is infilling and transitioning to a secondary channel (Figure 1), making attempts to manage the reach based on historic alignments unsustainable.

Figure 1 Photograph illustrating flow capture by Hans Creek (left) and infilling of the Murray River channel (right), demonstrating the need to define the “main channel” by hydraulic/geomorphic dominance rather than mapped labels

We focus on two key shifts in management of the H2Y reach:

1. An anabranch development stage classification that is simple enough for decision processes but grounded in evolutionary geomorphology.

2. Management implications of embedding geomorphic state (stage of anabranch development) and process logic into objectives and prioritisation, shifting from site-by-site containment to corridor-scale, adaptive investment.

Study system and geomorphic context

The H2Y reach extends approximately 200 km downstream of Hume Dam and functions as a critical water delivery corridor while supporting ecological, cultural and economic values. Flow regulation via Hume Dam and Yarrawonga Weir has inverted the seasonal flow regime and reduced flow variability (Figure 2), reducing overbank floods and prolonging summer near-bankfull flows. This has substantially increased the duration of engagement for some anabranches that historically flowed primarily during high-water events (Erskine et al., 1990). These shifts alter sediment transport and accelerate development of existing anabranches, including through incision, widening and channel reconfiguration.

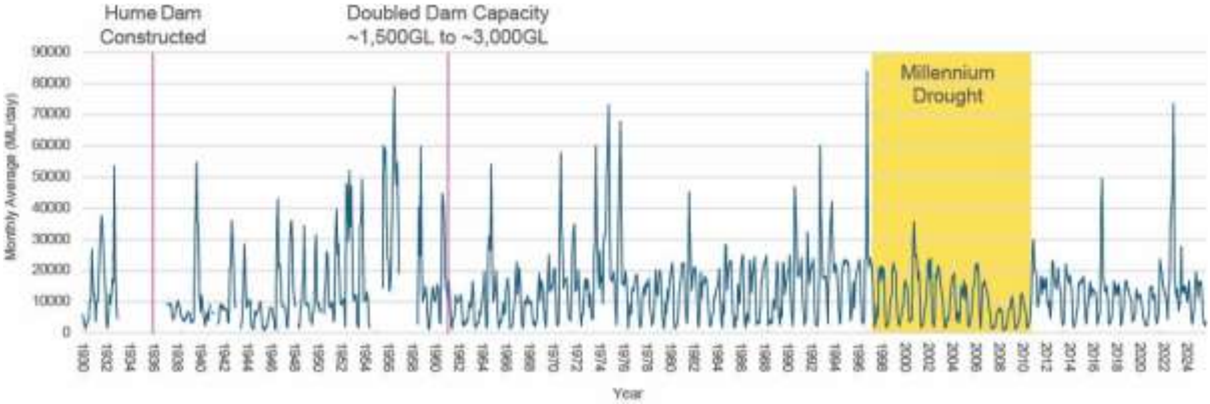

Figure 2 Average monthly discharge since 1930 showing reduction in flood frequency following the 1961 increase in dam capacity (Data Source: Murray–Darling Basin Authority, 2025)

Consistent with Nanson & Knighton's (1996) classification, the reach is recognised as a Type 3: laterally active anabranching river. This alone highlights issues with management objectives that implicitly assume a stable main channel.

A core reframing is that the "main channel" should be identified by capacity, conveyance efficiency, sediment transport competence and continuity, rather than administrative mapping. In many parts of this system, anabranches have captured flow and now exhibit greater geomorphic activity and/or convey the majority of flow, while the mapped "Murray River" channel is locally infilling. From a management standpoint, attempts to force return to historic alignments are not sustainable; instead, management should work with the evolving geomorphic reality.

This argument aligns with process-based river restoration principles where effective interventions progressively address causes rather than repeatedly treating symptoms at isolated sites (Brierley & Fryirs, 2005; Kondolf et al., 2006; Fryirs & Brierley, 2016; Beechie et al., 2010; Russell et al., 2023).

Data and methods

The geomorphic assessment underpinning this paper combined field observations with spatial analyses, including high-resolution LiDAR and top-of-bank (ToB) mapping to quantify patterns of channel change through time. LiDAR from 2001 and 2024 (with additional datasets noted in the assessment) was used for ToB change analysis and DEM of Difference (DoD) methods, supplemented by time-series aerial imagery. Limitations included absence of bathymetric data. As such, relative depth mapping using high-resolution aerial imagery was employed to infer reach-scale relative depth patterns whereby depth was related to the clarity of bed form observations through the water column. The absence of bathymetric data also prevented any assessment of channel cross-section changes.

Hydrologic context was characterised using gauge records (e.g., Doctors Point), including long-term shifts in flood frequency and recent multi-year discharge patterns. Flow split monitoring records (Soil Conservation Service, 2024) were also assessed to compare the relative discharge between the "Main Channel" and major anabranch offtakes.

Results synthesised for management

Anabranch development classification

To support analysis and management, anabranches were classified into five geomorphic categories: Captured, Developed, Constrained, Emerging, Stable. The classification is designed as a simplified yet functional framework describing stage of evolution and role in the broader network, driven by interactions between flow variability, sediment dynamics, vegetation and anthropogenic influences.

The geomorphic anabranch development classification categories include:

- **Captured anabranches** convey the majority of flow, and functionally replace the previously dominant channel.
- **Developed anabranches** frequently convey flow with sustained geomorphic activity and may be on a trajectory toward capture.
- **Constrained anabranches** show development but are limited by competing anabranches or controls (e.g., weirs).
- **Emerging anabranches** frequently convey flow with early-stage adjustment.
- **Stable anabranches** show minimal contemporary flow or geomorphic activity.

Evidence of dominance shifts and corridor reconfiguration

Top of bank mapping comparisons between 2001 and 2024 LiDAR data sets enabled an assessment of some aspects of geomorphic activity between anabranches and with their corresponding section of the "main channel". Channel width changes and dominant lateral movement were plotted along with historic bank stabilisation works to assess geomorphic activity and response. A comparison between a captured anabranch (Dights Creek) (average width change = 1.56 m) and its corresponding section of the Murray River (average width change = -0.05 m) is shown in Figure 3.

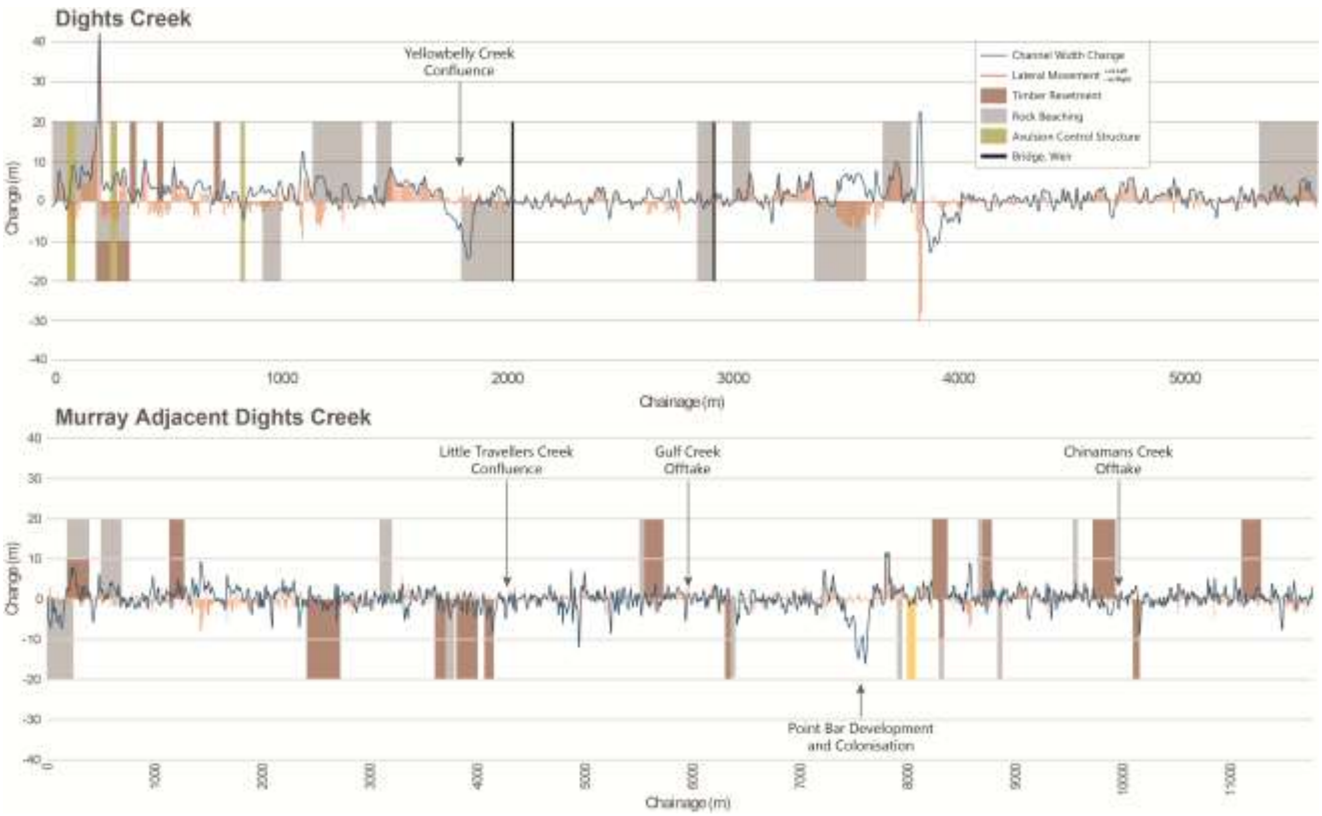

Figure 3 A comparison between a captured anabranch (Dights Creek) and its corresponding section of the Murray River

Flow split monitoring undertaken by the NSW Soil Conservation Service indicates significant flows down various anabranches when compared to the Murray Main Channel when assessed for individual monitoring periods. Differing flow rates and methods between monitoring years limit the ability to assess trends in flow splits across monitoring periods.

Relative depth mapping indicates that Murray River reaches short-circuited by major anabranches are diminishing in depth, suggesting transition toward secondary-channel status. Sediment accumulation in the corresponding section of the Murray River to Murphys Creek was observed in the field and through relative depth mapping (Figure 4). For Hans Creek, the corresponding Murray River reach no longer flows at low flow (Figure 5).

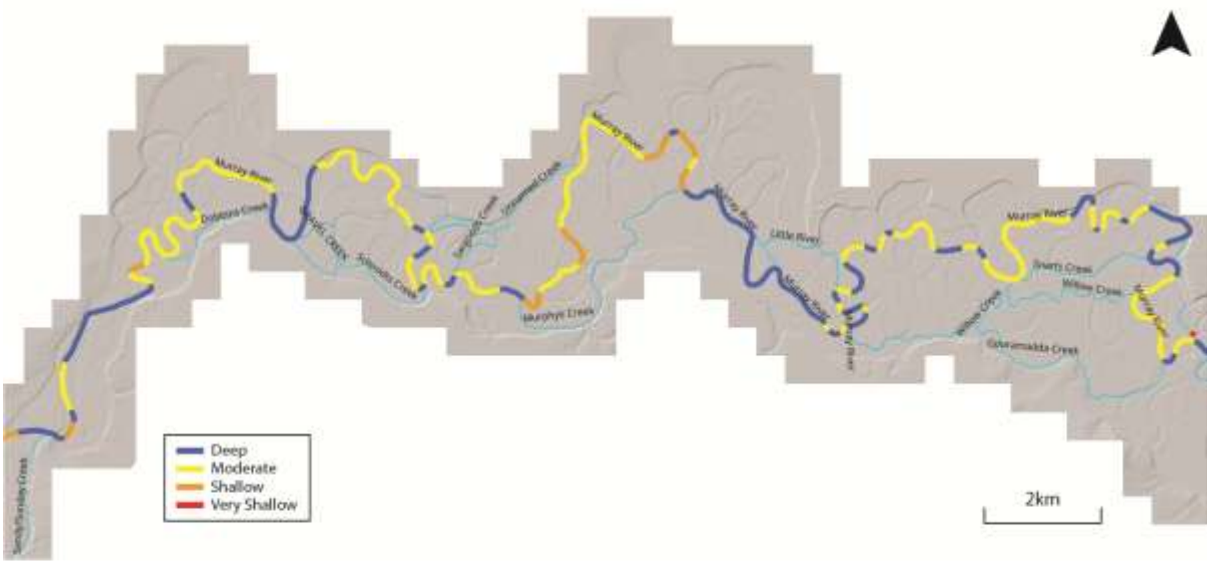

Figure 4 Relative depth categories mapped using high-resolution aerial imagery, illustrating shallowing in section of the Murray River adjacent to major anabranch offtakes (Including Murphys Creek) and supporting inference of transition toward secondary-channel function

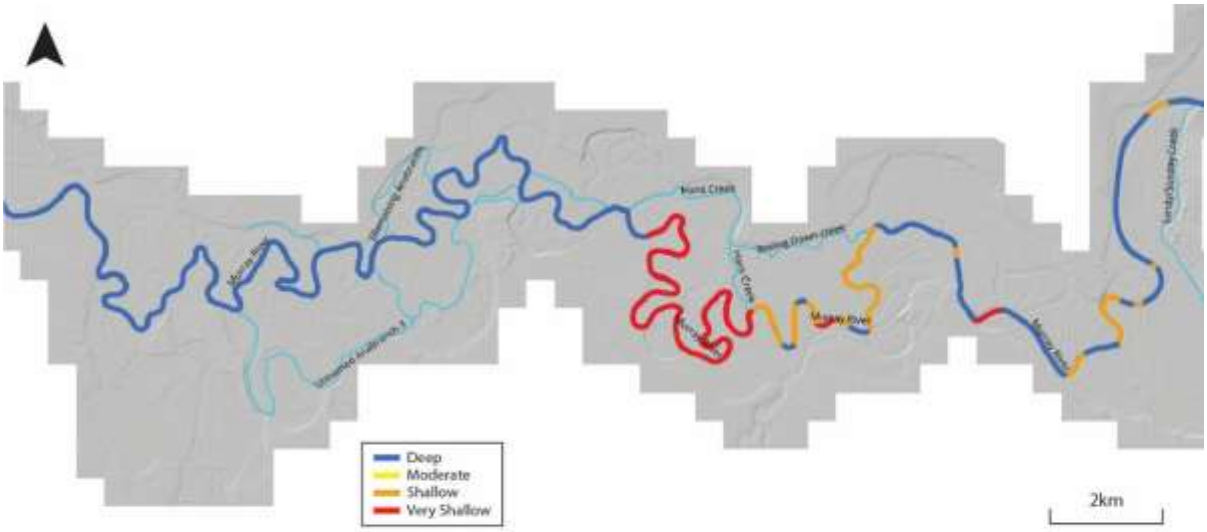

Figure 5 Relative depth categories mapped using high-resolution aerial imagery, illustrating shallowing in sections of the Murray River adjacent to Hans Creek and showing transition toward secondary-channel function. Anabranches are shown in light blue

Bank erosion processes

Monitoring and condition assessment synthesis indicates that notching and block collapse are dominant erosional processes, which is supported by Erskine et al. (1990). Slumping is negligible across the reach, challenging past operational emphasis on rates of water-level reduction alone. Notch cutting is primarily driven by the near static summer and winter flow levels imposed by regulation, enhanced in some areas by boat wash and the presence of exposed dispersive soils. Previous unpublished work undertaken for the reach highlight strong site dependence linked to soil dispersivity, exposure, and shading, with implications for targeted vegetation-based interventions (Gower et al., 2021). Unlimited stock access to the river and its anabranches causes substantial erosion and damage to riparian vegetation.

Geomorphic understanding in adaptive management

Without a geomorphic understanding, adaptive management in fluvial systems risks cycling through interventions that treat symptoms (e.g., visible erosion points) while the river continues to respond to corridor-scale controls. This leads to increased costs, declining effectiveness, and reduced resilience in complex systems. In contrast, process-based restoration emphasises identifying the controlling processes and working with likely trajectories (Fryirs & Brierley, 2016; Brierley & Fryirs, 2005; Russell et al., 2023; Kondolf et al., 2006).

In the H2Y reach, the assessment strongly supports a paradigm shift: manage the river as a dynamic corridor, defined by dominance and process, rather than attempting to preserve a historically defined main channel.

A practical step toward geomorphically adaptive management is to make geomorphic state (stage of anabranch development) the entry point for objectives and actions. Revised objectives for the reach are framed around whole of system and anabranch classification so that intent aligns with the stage of evolution at the time of application, explicitly avoiding bias toward works on the Murray Main Channel.

The existing objectives are listed as:

- Maintaining hydraulic conveyance through the main channel.
- Reducing physical impacts of river regulation.
- Mitigating future risks through vegetation and asset management.

The proposed revised objectives are:

- **Objective 1:** Support a geomorphically dynamic river corridor that sustains water delivery.
- **Objective 2:** Facilitate transition and long-term adjustment of Captured and Developed anabranches via vegetation-based stability, property-scale adaptation and stakeholder education.
- **Objective 3:** Maintain resilience and ecological function across Emerging, Constrained and Stable anabranches via riparian management, monitoring and support for adjustment.

These objectives put into operation a core geomorphic principle that, in laterally active anabranching rivers, management cannot and should not uniformly “hold the line.” Instead, it must differentiate between (i) where dominance has already shifted (Captured), (ii) where transition is likely (Developed), and (iii) where episodic or limited evolution is expected (Constrained/Emerging/Stable). This differentiation matches intervention with the reaches likely geomorphic trajectory.

Where anabranches are captured, dominance has already shifted and the main management implication is to accept that shift rather than continue to pursue a return to the historical alignment. In practice, this means reframing “main channel conveyance” as corridor conveyance, and managing the now-dominant pathway for long-term resilience. Interventions should therefore focus on maintaining stability through vegetation corridors and hydraulic roughness, supporting sediment continuity, adapting assets and access arrangements (bridges etc) to the new flow distribution, and monitoring to improve understanding of infilling and future trajectory in bypassed sections of the former main channel.

In developed anabranches, which convey substantial flow and show sustained adjustment towards capture, management should be focused on managing the transition, not preventing change. These settings require preparedness for likely long-term dominance, including building resilience into riparian corridors to support controlled adjustment. Priority should be given to measures that reduce undesirable acceleration. Management, however, must recognise where property and infrastructure limit where the channel has room to move.

For constrained, emerging and stable anabranches, management should focus on monitoring, maintaining resilience and avoiding unnecessary intervention where the setting indicates corridor-scale impacts are limited. The most appropriate focus is on maintaining riparian condition and hydraulic roughness, and on establishing clear monitoring triggers that indicate when a development threshold is nearing, so that intervention occurs strategically and early if needed rather than through reactive engineering.

This approach aligns with recovery-potential thinking, in which interventions recognise that different parts of a river have different capacities and trajectories for adjustment (Fryirs & Brierley, 2016; Brierley & Fryirs, 2005).

Decision-making implications

A revised decision-making framework (DMF) was developed which illustrates how a geomorphic focus changes not only on-ground works, but also the logic of investment. The DMF is process-focused and avoids over-prioritising visually severe but localised sites. Instead, it prioritises actions influencing system behaviour (e.g., channel lengthening/shortening).

Using the anabranch classification as primary entry point ensures prioritisation reflects distinct objectives for each classification rather than applying uniform rules everywhere. These changes create an adaptive pathway whereby decisions can be revisited as anabranches develop, and monitoring is tied to stage transitions and planform dynamics (rather than erosion severity). The process is illustrated at a high level in Figure 6.

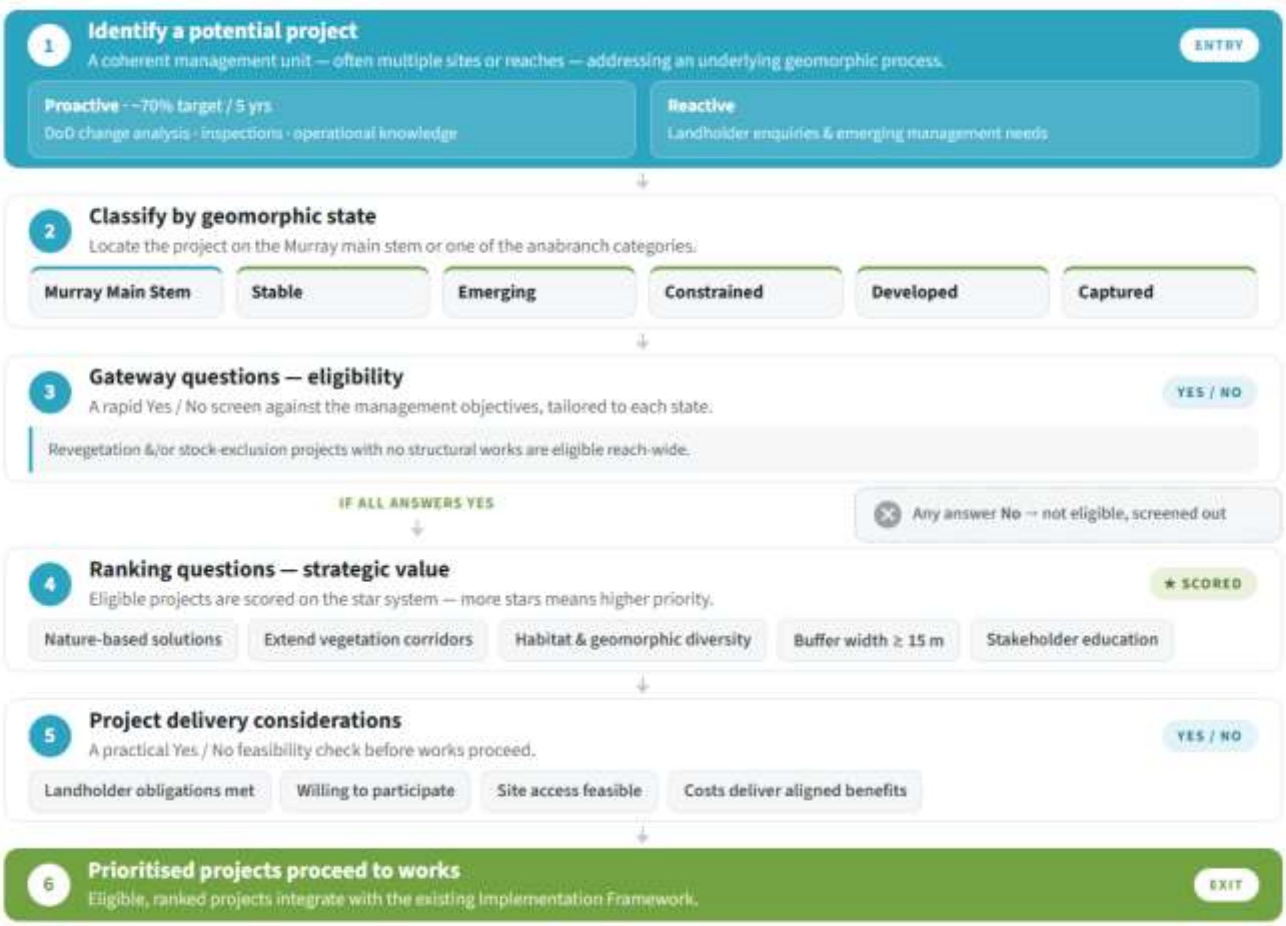

Figure 6 High- level illustration of DMF process

Discussion

In regulated rivers, ecological and geomorphic impacts often arise from altered timing and persistence of flows. In anabranching systems, regulation can also increase engagement of historically episodic pathways, accelerating capture and reorganisation. Where dominance has shifted, defending historical alignments has often remained the management focus, requiring increasing effort as the bypassed channel infills and hydraulic efficiency declines.

A corridor-based framing produces more realistic objectives. Conveyance is maintained across the corridor, and interventions are judged by whether they support corridor function and avoid accelerating undesirable trajectories. This directly responds to the assessment's critique that existing objectives can be constrained by an overly static view of channel structure despite recognition of the system's laterally active anabranching character.

A geomorphically adaptive program should prioritise monitoring that detects:

- Development transitions (Emerging to Developed to Captured).
- Dominance metrics (flow distribution trends, depth/infilling indicators).
- Process indicators (planform change, erosion mechanisms such as notching/block collapse, riparian corridor continuity).

While this case is specific to the River Murray, the logic is transferable. Where regulation alters flow variability and sediment transport, and where anabranching provides multiple competing pathways, management should be explicit about (i) dominance, (ii) geomorphic state and trajectory, and (iii) corridor-scale trade-offs. The approach also aligns with contemporary nature-based river management thinking that seeks to work with geomorphic processes while managing risk and values (Brierley & Fryirs, 2022).

Conclusions

A genuinely geomorphically adaptive approach requires more than iterative planning cycles; it requires decision logic anchored in how the river is reconfiguring. In the Hume–Yarrawonga reach, regulation has shifted flow timing and persistence in ways that substantially increase anabranch engagement and accelerate evolutionary change, including dominance shifts away from the historically mapped Murray River channel. A five-stage anabranch development classification provides a practical entry point for management by converting complex morphodynamics into decision-relevant states linked to different objectives and intervention logics. Embedding development stage and process logic into prioritisation (system-based, process-focused, nature-based stability emphasis) improves investment effectiveness and reduces maladaptive attempts to hold historical alignments.

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