Integrating River Styles Framework and *Room for the River* for urban catchment management

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Key points

- Floodplain development is a key driver of urban geomorphic change, progressively reducing *Room for the River* and increasing vulnerability to erosion and flood impacts.
- The River Styles framework proved effective for reach-scale prioritisation for cost effective management and supporting identification of locations where *Room for the River* can be protected or enhanced.
- *Room for the River* principles were vital for developing effective management measures that reduce hydraulic stresses and improve geomorphic resilience.
- Integration of River Styles framework and *Room for the River* approach provides a proactive, catchment-scale approach to urban catchment management by linking geomorphic recovery potential with spatial freedom for river adjustment.

Abstract

The Kedron Brook catchment in Brisbane suffered significant geomorphic damage from recent floods, resulting in severe bank erosion and infrastructure damage. In response, a comprehensive geomorphic assessment was conducted to inform the Kedron Brook Flood Recovery Project and future catchment management strategies.

The River Styles Framework was applied to assess the catchment's condition and identify priority areas for management. This involved mapping the River Styles of major waterways and evaluating their geomorphic condition, resilience, and recovery potential. Historical aerial imagery analysis and field-supported geomorphic characterisation revealed extensive floodplain encroachment, channelisation, and anthropogenic confinement, resulting in a significant loss of lateral mobility, floodplain connectivity, and *Room for the River*. River Styles mapping revealed increasing downstream potential for channel adjustment that has been progressively overridden by urban development and anthropogenic modifications. Conservation reaches with near-intact geomorphic condition were prioritised for protection, while strategically important reaches were targeted for intervention to address threatening processes and geomorphic risks.

Integrating the River Styles framework with *Room for the River* principles provides a proactive, catchment-scale approach to urban catchment management by linking geomorphic recovery potential with spatial freedom for river adjustment. River Styles identifies how valley setting, channel form, and catchment processes control river behaviour and recovery potential at the reach scale, while *Room for the River* translates this understanding into actionable management that protects or reinstates space for lateral movement, floodplain connectivity, and energy dissipation. The findings and approaches applied in this study are transferable to other urban catchments, providing a robust, geomorphically informed framework for mitigating the impacts of urbanisation and improving long-term river resilience.

Keywords

Geomorphology, Room for the River, River Styles, urban catchment, nature based solutions

Introduction

Project background

Record-breaking floods in late 2021 and early 2022 caused extensive damage across eastern Australia, resulting in an estimated $5.45 billion in losses (ICA, 2022) and the inundation of over 15,000 homes in Southeast Queensland alone (Ludlow, 2022). The Kedron Brook catchment was significantly impacted, experiencing severe bank erosion, floodplain scour, sediment deposition, and infrastructure damage. In response, the Kedron Brook Flood Recovery Project was initiated to address streambank erosion, restore riparian vegetation, and enhance biodiversity, ultimately improving waterway health and flood resilience (Queensland Reconstruction Authority (QRA), 2022). In alignment with the aforementioned project, a geomorphic assessment was conducted using River Styles Framework and Room for the River principles to assess the existing condition of the catchment, identify priority reaches for restoration and develop management strategies.

Kedron Brook catchment

Kedron Brook is located immediately north of Brisbane's Central Business District (CBD), draining a catchment area of 104 km^2. While discharging directly into Moreton Bay, Kedron Brook catchment is reported by Department of Environment, Tourism, Science and Innovation (DETSI) as a northern associated sub-catchment of the Lower Brisbane Catchment (DETSI, 2021). The catchment makes up ~8% of Brisbane's total local government area spanning 36 suburbs (AECOM, 2013). It flows through a mixture of residential, commercial, industrial and community areas, including over 30 parks and reserves adjacent to the creek and its tributaries, with uses ranging from conservation, open space, sports fields and golf courses. There are an estimated 5,258 buildings located within the probable maximum flood (PMF) extent of the floodplain (AECOM, 2013). The catchment is connected through a network of local and regional roads, bikeways, public transport networks (buses and trains), including the Brisbane Airport, forming a regional transport hub for Brisbane.

River Styles Framework

River Styles provides a geomorphic framework used to understand and manage river systems (Brierley & Fryirs, 2013). The framework is based on the concept of River Styles, which are discrete river types defined by a characteristic combination of valley setting, channel planform, bed material, and assemblage of geomorphic units within a specific river reach. River Styles mapping helps to characterise the geomorphic diversity of a river system and understand its distribution throughout a catchment. As such, the River Styles Framework is particularly useful for catchment-scale management, enabling systematic analysis of river systems from source to sink.

By using the River Styles Framework, catchment managers can shift from reactive to proactive management strategies. Reactive management often involves responding to symptoms of problems, such as erosion or flooding, after they have occurred. In contrast, proactive management involves anticipating and mitigating potential issues before they become major problems. The River Styles Framework facilitates proactive management in several ways:

- Identifying areas of high conservation value: The framework helps to identify reaches with high geomorphic conservation value, allowing for targeted protection and preservation efforts.
- Predicting future changes: By understanding the geomorphic processes and evolutionary trajectory, managers can anticipate potential future changes, such as channel adjustments or sediment supply changes.
- Developing targeted management interventions: By understanding the specific geomorphic processes operating within each River Style and identifying threatening processes, managers can design targeted interventions to mitigate potential problems or restore degraded reaches.
- Evaluating the effectiveness of management actions: The framework provides a basis for monitoring and evaluating the effectiveness of management interventions, allowing for adaptive management and continuous improvement.

By adopting a proactive approach to catchment management using the River Styles Framework, managers can reduce the likelihood of costly and ineffective reactive management responses, ultimately leading to more sustainable and effective management of river systems. Its use within this project is further characterised in the Approach section.

Room for the River

The Room for the River (RftR) concept is a holistic, integrated approach that aims to achieve flood safety while improving landscape, environmental, and cultural values (Zevenbergen et al., 2015). It involves giving rivers more space to flow and meander, rather than trying to control them through traditional engineering methods. The RftR concept encompasses a range of strategies to manage flood risk and improve river function, including increasing channel conveyance by deepening channels and removing obstacles, managing peak flows through water storage, widening floodplains via levee relocation or floodplain lowering, improving land-use planning to reduce flood exposure, and enhancing river systems through vegetation and other nature-based solutions.

Incorporating geomorphology into the RftR approach leads to a better understanding of river characteristics and processes, enabling more effective management of rivers (Pearson & Wheeler, 2024). By allowing channel migration and morphological shifts, RftR promotes geomorphic resilience and habitat diversity (McCabe et al., 2025). The River Styles framework, which is based on river character and behaviour, provides a structured basis for identifying where and how RftR principles can be applied across a catchment to enhance geomorphic resilience (Brierley & Fryirs, 2013).

The Kedron Brook catchment has undergone substantial modification as a result of urbanisation, with significant impacts on both the river channel and its floodplain. Recent catchment-scale analysis by Pearson (2023) illustrates the extent of floodplain change over time. Comparison of floodplain extents from 1925 and 2022, alongside the contemporary urban footprint, indicates that the floodplain has been progressively and extensively encroached upon over the past century. The 1925 floodplain, approximated using 20 m contour data, demonstrates that floodplain confinement has occurred as housing and other urban land uses have expanded into areas that were historically floodplain and remain flood-prone today. This analysis highlights clear opportunities for implementing a geomorphologically informed RftR approach within the Kedron Brook catchment.

Approach

Historical geomorphic analysis

Publicly available historical aerial imagery was analysed alongside recent images to examine geomorphic changes within the Kedron Brook catchment. The analysis focused on identifying anthropogenic influences, including land-use change and channel modification, as well as geomorphic responses such as channel migration. These observations were used to assess how historical change has shaped current river condition and the availability of *RftR* across the catchment.

Characterisation of waterways

Geomorphic characterisation of the Kedron Brook reaches was undertaken using the River Styles framework (Brierley & Fryirs, 2013). The assessment comprised a desktop analysis supported by targeted field investigations. Field assessment included a one-day catchment appreciation tour conducted on 20th August 2024, involving cycling along the Kedron Brook trunk stream, followed by site visits to major tributaries. The assessment included:

- Identification and mapping of River Styles, including valley confinement, channel planform, in-channel features, and bed material.
- Evaluation of geomorphic condition following River Styles Stage 2 guidelines.
- Assessment of river recovery potential.

A River Styles tree was developed for the catchment, and River Styles were spatially mapped to support an understanding of downstream patterns and inform reach prioritisation for geomorphic recovery.

Results and discussion

Loss of Room for the River

Historical image analysis revealed the Kedron Brook catchment has undergone significant modifications over the recent years. Urbanisation has led to substantial increases in impervious areas in the catchment. The Kedron Brook and its tributaries have been channelised or converted to stormwater drains. For example, the tributary draining through Grinstead Park (Tributary 2) has been converted from a historically meandering channel within a broad floodplain to a straight concrete canal with a constrained floodplain (Figure 1). Commercial development has encroached the floodplain, substantially limiting the available *RftR*. Similar patterns of floodplain encroachment and constraint were observed throughout the catchment, including a development within the Brisbane City Council's (BCC's) designated waterway corridor and flood overlay previously identified by Pearson & Wheeler (2024).

Figure 1 Channelisation and floodplain encroachment by commercial development near Grinstead Park. Historically meandering channel within a broad floodplain in 1936 (left image). Straight concrete channel with a constrained floodplain in 2023 (right image).

In addition to floodplain development, in-channel anthropogenic modifications have further constrained *RftR*. This is particularly evident near the Stafford City Shopping Centre (Figure 2). The 1936 imagery shows a larger channel bend aligned toward the left-bank valley margin. By 1991, the channel had been realigned toward the right bank, introducing a sharp bend immediately downstream of the confined section. During the 2022 flood, the channel migrated back toward the left bank, demonstrating ongoing channel activity and the need for lateral adjustment space at this location. By 2024, flood restoration works had realigned the channel back to its 1991 configuration. Given the channel's demonstrated geomorphic behaviour, it is likely that future floods will again drive lateral migration toward the historical 1936 alignment. While recent bank stabilisation works may delay this process, they are unlikely to fully suppress the channel's natural tendency to adjust.

The Stafford City Access bridge at this site further illustrates the tension between fixed infrastructure and dynamic river processes. The bridge is constructed spanning the low-flow channel, which is repeatedly mobilised and reshaped during floods. Such designs implicitly assume channel stability and limited movement, an assumption that is inconsistent with the observed behaviour of Kedron Brook at this location. Constraining channel migration in this manner reduces *RftR*, increases geomorphic stress on engineered banks, and heightens the risk of damage during subsequent flood events. Over time, this approach is likely to necessitate repeated and costly intervention as the channel continues to seek adjustment space, resulting in a cycle of reactive engineering rather than a sustainable, process-based river management outcome.

Figure 2 Anthropogenic controls restricting the *Room for the River* near Stafford City Shopping Centre

River Styles of Kedron Brook

The River Styles tree for Kedron Brook catchment is shown in Figure 3, with the spatial distribution of River Styles mapped in Figure 4. Eight contemporary River Styles were identified across the catchment, highlighting its geomorphic diversity and spatial variation in river character.

The most upstream waterways (Upstream Reach 1 and 2) are set within a confined valley with limited capacity for lateral movement. In these reaches, *RftR* is inherently constrained by the underlying bedrock. Moving downstream into the mid-catchment (Reach 1 to 5), valley confinement decreases and waterways transition into partly confined valley settings. These reaches comprise channels with lateral and point bars and are associated with discontinuous floodplains. The lateral movement was restricted to the valley floor and was controlled by the valley margin and exposed bedrock in some locations. Floodplain development in this section has reduced floodplain width, limiting *RftR* during high-flow events. In addition, strong anthropogenic controls were observed in tributaries, most notably Tributaries 1 and 2, which have been completely transformed into concrete-lined canals with fixed banks and beds.

In the lower catchment, waterways are located within laterally unconfined valley settings, where, under natural conditions, River Styles would be expected to exhibit greater planform complexity, higher sinuosity, and extensive floodplain interaction. Although these valley settings provide space for lateral movement, this capacity has been heavily compromised by anthropogenic controls. Embankments, rock revetments, and other engineered structures confine channels laterally, suppressing natural adjustment processes and resulting in low-sinuosity planforms that are atypical for their geomorphic setting.

Overall, the River Styles analysis demonstrates that while mid- and downstream reaches (Reach 1 to 10) of the Kedron Brook catchment naturally offer increasing potential for *RftR*, this potential has been progressively overridden by anthropogenic constraints. The mismatch between geomorphic setting and contemporary channel form highlights the extent to which anthropogenic constraints have limited river adjustment processes and reduced system resilience to high-flow and flood events.

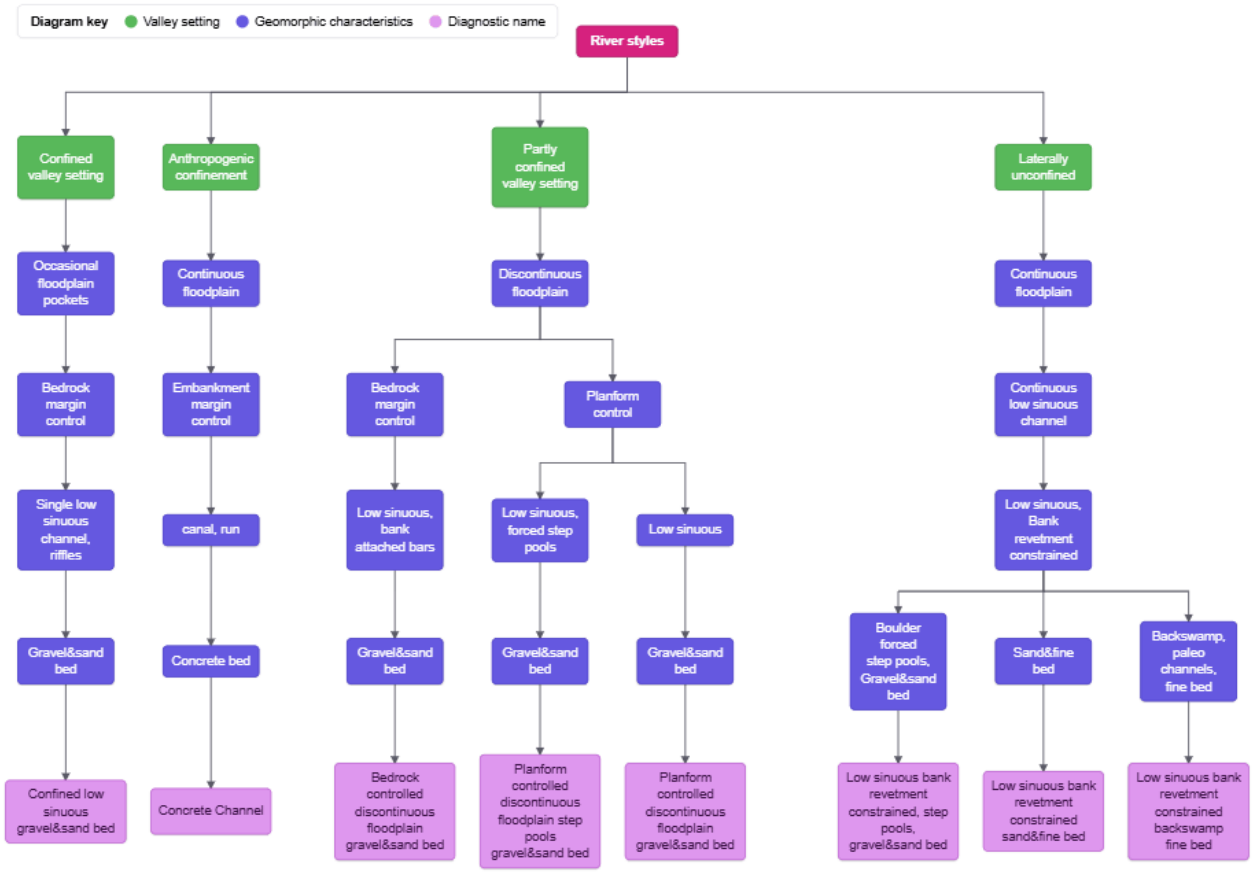

Figure 3 River Styles tree for Kedron Brook catchment

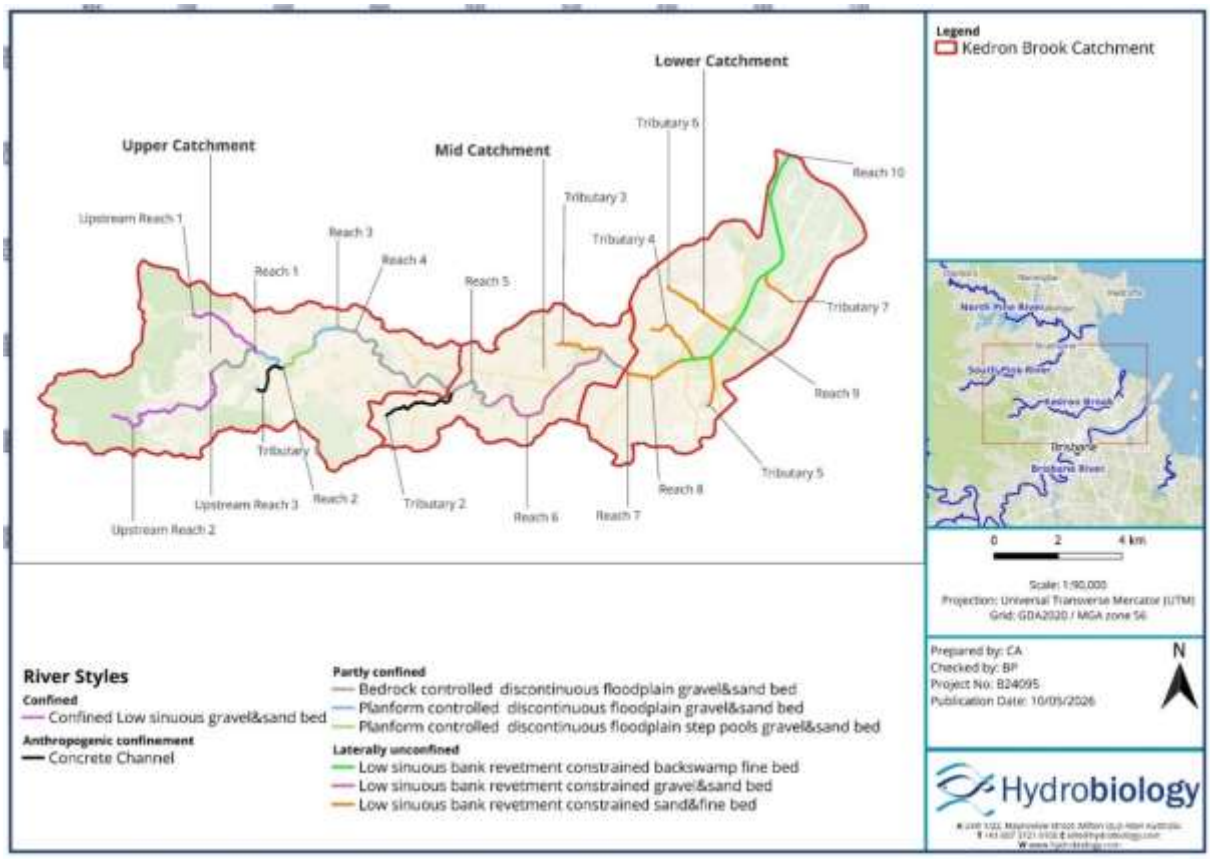

Figure 4 Contemporary River Styles of Kedron Brook catchment

Prioritisation and management

Reach-specific management strategies are summarised in Table 1. To support geomorphic recovery and enhance long-term river resilience, the following management priorities have been identified.

- **Conservation reaches (Upstream Reach 1, Upstream Reach 2, and Reach 1):** These reaches exhibit near-intact geomorphic conditions and should be managed primarily for conservation. The key objective is to preserve existing channel form and processes by minimising disturbance.
- **Strategic reaches:** In these reaches, threatening processes have been identified that may drive catchment-scale degradation if left unmanaged. Targeted interventions are required to address specific geomorphic risks:
    - Reach 2: Prevent land use encroachment and reduce the hydraulic forces.
    - Reach 5: Stabilise the channel bed, reduce sediment load, and mitigate hydraulic forces.

The remaining reaches were prioritised based on their geomorphic recovery potential. Reaches with high recovery potential were prioritised to maximise investment value. Whereas reaches with low recovery potential were deprioritised due to high management costs. This approach of working with recovery potential at catchment or reach scale has been identified as a cost-effective approach compared to ad hoc and reactive management approaches (Agnew et al., 2024).

To support geomorphic recovery, RftR strategies at catchment scale were identified as key enabling measures. These include:

- Creating additional floodplain storage by lowering floodplain surfaces where feasible between Reach 1 and Reach 5, to reduce hydraulic stresses downstream, particularly within Strategic Reaches 2 and 5.
- Expanding waterway corridors through flood-prone property acquisition or buy-back schemes to increase flood conveyance capacity and provide additional RftR during high-flow events.
- Updating waterway corridor overlays to better reflect geomorphic risks and channel adjustment requirements.
- Relocating critical infrastructure (e.g. bikeways and footpaths) away from riverbanks to accommodate channel movement.
- Installing spanning bridge structures that allow for channel widening and lateral adjustment.

Collectively, these management actions are expected to promote geomorphic recovery and improve the overall health and resilience of the waterway. Conservation reaches will act as a seed bank for vegetation reestablishment in downstream reaches, while *RftR* interventions will reduce hydraulic energy and downstream impacts, thereby supporting both current and future rehabilitation efforts.

Table 1 Recommended management strategies for priority reaches

Reach	Prioritisation Type	Recommended Management Strategies
Upstream Reach 1	Conservation	These reaches are in good geomorphic condition and are expected to have critical habitats and unique biodiversity. Hence, they were prioritised for management to maintain current condition, protect the seed bank and support recovery of downstream reaches.
Upstream Reach 2		
Reach 1		
Reach 2	Strategic	Encroachment by surrounding land use and ongoing hydraulic stresses might threaten the stability of this reach, potentially leading to degradation of upstream Conservation reaches. Management should focus on limiting land use encroachment and addressing the hydraulic forces to prevent channel degradation.
Reach 5	Strategic	Excessive sand deposition, high hydraulic forces and channel incision that might lead to headcut initiation. Management should focus on stabilisation of the channel bed, reducing sediment load and addressing the hydraulic

Reach	Prioritisation Type	Recommended Management Strategies
		forces to prevent channel degradation.
Reach 6 Tributary 1 Tributary 2	Low Recovery Potential	Geomorphic recovery of these reaches would require large amounts of intervention involving high cost and may not be successful. Hence reaches were deprioritised due to low-cost effectiveness. However, rehabilitation of these reaches may generate cumulative benefits (e.g.: flood mitigation), which need to be evaluated on a case-by-case basis.
Remaining Reaches	High or Moderate Recovery Potential	Management of these reaches requires limiting further disturbances and some level of intervention depending on the reach specific conditions.

Conclusions

The River Styles framework provided an effective and structured basis for reach-scale prioritisation and catchment-wide river management. Its process-based, catchment-scale perspective enabled a clear understanding of how individual reaches respond to valley setting, geomorphic drivers and human modification. By systematically identifying geomorphic condition and threatening processes, the framework supported the identification of strategic reaches where proactive intervention can most effectively interrupt degradation trajectories. Reaches with relatively intact geomorphic condition and a high likelihood of recovery were prioritised to maximise return on investment, while heavily modified reaches requiring substantial intervention with lower probabilities of success were deprioritised. This approach ensures that management resources are allocated efficiently and contributes to more sustainable, long-term river management outcomes.

Floodplain encroachment and anthropogenic control of channel margins were identified as the dominant geomorphic drivers shaping the contemporary condition of the Kedron Brook catchment. These modifications have progressively reduced channel mobility, floodplain connectivity, and *RftR*, underscoring the need for a management approach that explicitly works with river processes rather than against them. In this context, integrating the River Styles framework with *RftR* principles provides a proactive, catchment-scale approach to urban catchment management by linking geomorphic recovery potential with spatial freedom for river adjustment. River Styles identifies how valley setting, channel form, and catchment processes control river behaviour and recovery potential at the reach scale, while *RftR* translates this understanding into actionable management that protects or reinstates space for lateral movement, floodplain connectivity, and energy dissipation.

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