# Living with change: Working with geomorphic-groundwater processes to inform river rehabilitation in Seqwater's Source Protection Program, North Pine River, QLD

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**Key points**

- Active geomorphic adjustment driven by flood disturbance, historical channel modification, and local base-level change is a common scenario in QLD, and how to effectively manage it is evidenced by this project on the North Pine River.
- Groundwater water supply reliability for the town of Dayboro is linked to riverbed elevation and channel position, with incision and migration reducing hydraulic connectivity to Seqwater's production wells.
- Traditional hard engineering, localised erosion control is often poorly suited to a highly dynamic wandering gravel-bed river system.
- A geomorphology-led assessment integrating historical analysis, LiDAR change detection, hydraulic interpretation, and groundwater understanding informed a structured options analysis and rehabilitation strategy.
- The preferred management pathway adopted a staged, adaptive approach focused on guiding recovery processes through revegetation, selective infrastructure protection, and targeted future grade-control opportunities.

## Abstract

Rivers across South East Queensland (SEQ) are undergoing increasing geomorphic adjustment driven by climate variability, extreme flood events, historical disturbance, and population growth. At the Dayboro Reach of the North Pine River, these changes have altered channel form, groundwater connectivity, and sediment dynamics, creating challenges for Seqwater's groundwater supply infrastructure within the North Pine catchment. This project, delivered as part of Seqwater's Source Protection Program, explored an alternative approach to erosion management by focusing on understanding and working with river processes rather than attempting to control them. The Dayboro wells rely on hydraulic connectivity between the river and adjacent alluvial aquifers. However, recent channel incision, widening, and migration have lowered river levels and reduced groundwater recharge while increasing sediment delivery to North Pine Dam. The North Pine Dam is an important component of SEQ's water supply system, as a regional source within the interconnected Seqwater grid, providing drinking water to north Brisbane.

A geomorphology-led assessment was undertaken to understand the evolutionary trajectory of the reach and the interaction between river processes and groundwater behaviour. The study integrated historical aerial analysis, lidar-based change detection, field investigation, hydraulic modelling, and groundwater interpretation. These insights informed a structured options analysis and multi-criteria assessment to evaluate rehabilitation strategies. Rather than relying solely on conventional erosion control, the project considered lower-intervention pathways including revegetation, infrastructure protection, and targeted grade control to guide river self-adjustment and support long-term recovery. The findings highlight how rehabilitation can be informed by linked geomorphic and groundwater processes to support both water supply reliability and river resilience. This approach reflects an emerging practice in SEQ: shifting from stabilisation toward guiding recovery processes to achieve sustainable outcomes for water security and river health.

## Keywords

Geomorphology, River Rehabilitation, River Management, River Recovery, Groundwater

## Introduction

River systems across SEQ are changing, driven by highly variable hydrology, major flood events, historical disturbance, and changing catchment pressures. While many SEQ rivers are naturally dynamic, historical impacts such as vegetation clearing, gravel extraction, infrastructure development, and altered downstream boundary conditions have amplified rates of channel instability in many systems. The Dayboro Reach of the North Pine River, upstream of North Pine Dam, represents one such system. The reach has experienced substantial geomorphic adjustment over recent decades including incision, widening, lateral migration, and localised avulsion processes. These changes directly affect Seqwater's groundwater extraction infrastructure adjacent to the river corridor.

The Dayboro groundwater wells rely on hydraulic connectivity between the river and surrounding alluvial aquifers. However, progressive channel incision and migration have lowered river levels relative to the floodplain aquifer and shifted the active channel away from key production wells. This has reduced recharge efficiency while simultaneously increasing sediment delivery to North Pine Dam. Historically, many erosion-management approaches within SEQ have focused on localised bank stabilisation and hard engineering solutions. However, within highly dynamic wandering gravel-bed rivers, these approaches often fail to address the broader geomorphic drivers of change and may redistribute erosive energy elsewhere in the system.

This paper presents the outcomes of the Erosion Control at Dayboro Project, delivered as part of Seqwater's Source Protection Program. The project explored how geomorphic and groundwater process understanding can inform rehabilitation strategies that work with river adjustment processes rather than attempting to prevent change entirely.

The project objectives were to:

1. Support and sustain groundwater supply to the Dayboro wells;
2. Improve long-term geomorphic resilience of the North Pine River; and
3. Reduce sediment delivery to North Pine Dam.

## Study area and geomorphic context

The North Pine River drains a predominantly forested upper catchment within the D'Aguilar Range before transitioning through the semi-confined Dayboro Valley upstream of North Pine Dam (Figure 1). The river displays many characteristics typical of South East Queensland gravel-bed rivers, including a high energy morphology, inset floodplains, a wandering planform, and high geomorphic sensitivity to flood disturbance.

The contemporary condition of the Dayboro Reach reflects a sequence of historical disturbances and subsequent channel responses. Widespread gravel extraction during the 1970s and 1980s widened and simplified sections of the river corridor, while historical vegetation clearing reduced bank resistance and floodplain stability. Riparian revegetation and natural recovery from the 1990s onwards promoted stabilisation of inset benches and floodplain surfaces, resulting in a period of relative channel stability under lower-flow conditions.

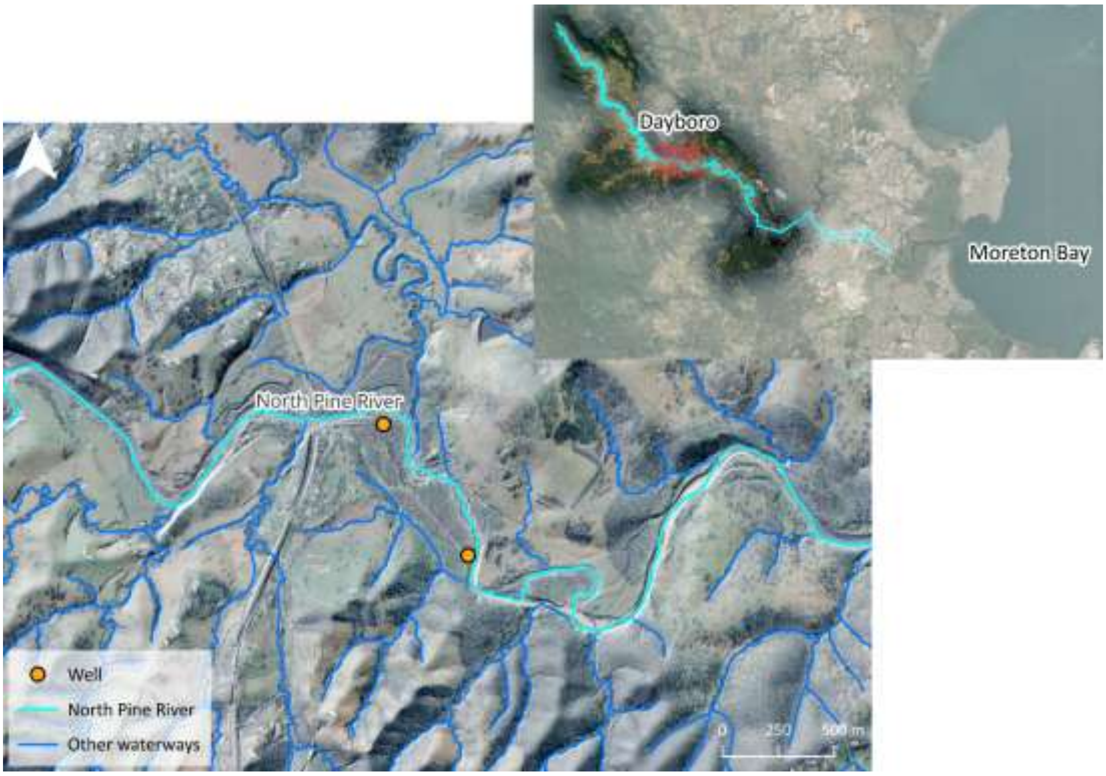
Over the past two decades, this relative stability has been disrupted by a combination of changing boundary conditions and major flood events. Progressive lowering of water levels within North Pine Dam due to changes in downstream security, together with a downstream meander cut-off that reduced local base level, increased the potential for upstream channel incision. These changes coincided with major flood events in 2011, 2013 and, most significantly, 2022, which exceeded the capacity of the recovering riparian corridor to resist erosion and accelerated channel adjustment through incision, bank widening, floodplain stripping and channel migration.

The geomorphic interpretation is not a simple case of channel incision. The observed channel evolution is controlled by the interaction of two primary geomorphic processes (Figure 2):

1. Wandering gravel-bed river dynamics involving lateral migration, bar reworking and avulsion; and
2. Local base-level adjustment associated with downstream meander cut-offs and lower operating water levels in North Pine Dam.

Together, these processes from a series of events (Figure 3) have initiated a wave of channel incision and widening that continues to propagate upstream through the reach.

(a)




(b)

**Figure 1 (a) Study site extent, Dayboro Reach of the North Pine River, Queensland. (b) Dayboro study reach drone image**

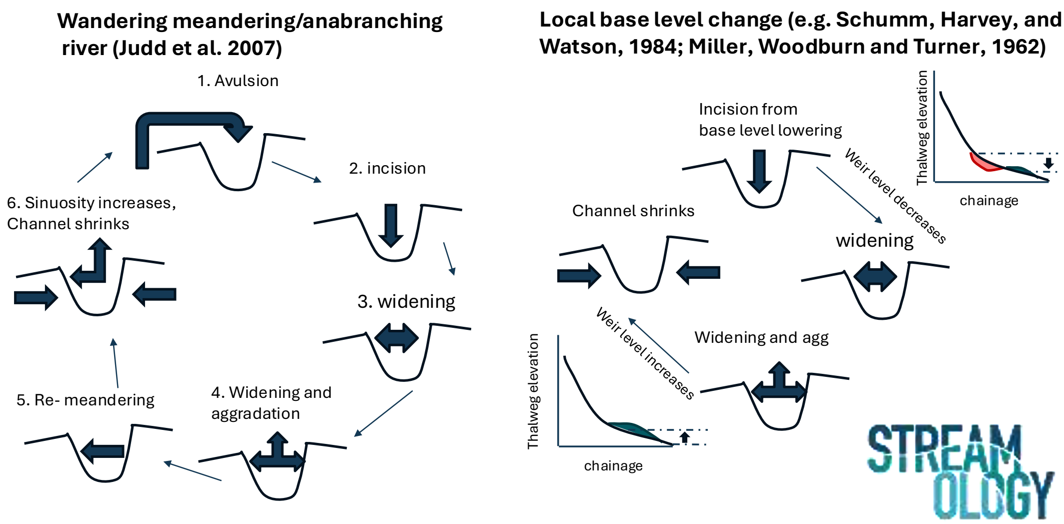



**Figure 2 Two channel evolution models meet at Dayboro**

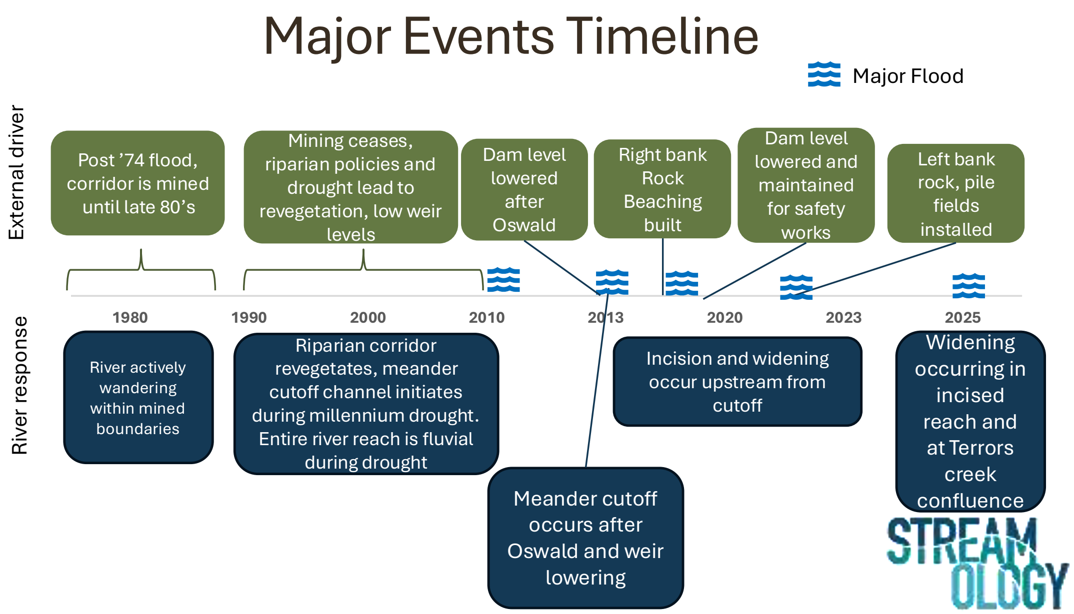



**Figure 3 Summary of major events timeline at Dayboro**

## Method

The project adopted an integrated geomorphology-led assessment framework combining historical analysis, field investigation, hydraulic interpretation, groundwater understanding, and structured options analysis. Historical aerial imagery from 1952 onwards was analysed to assess long-term channel evolution including meander migration, avulsion activity, widening, and incision (Figure 4). Lidar-derived digital elevation models and change-detection analysis were used to quantify recent erosion and deposition patterns throughout the reach.

Field investigations undertaken jointly by Streamology and Seqwater assessed channel morphology and stability, sediment dynamics, groundwater well connectivity, riparian condition, previous erosion-control works, and evidence of recent erosion and deposition. Hydraulic interpretation and geomorphic process analysis were used to understand the distribution of erosive energy and likely future adjustment pathways (Figure 5). Groundwater investigations undertaken by CDM Smith (the consultancy undertaking groundwater modelling) examined the relationship between riverbed levels, channel position, and alluvial aquifer connectivity.

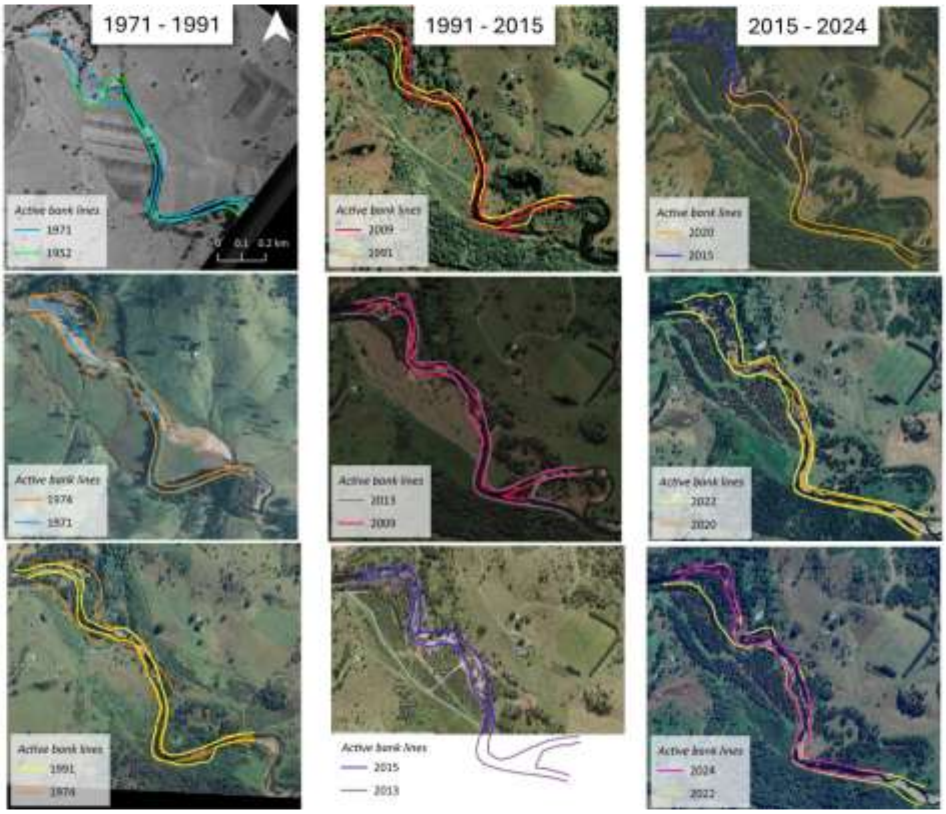



**Figure 4 Aerial imagery showing active bank line changes between 1952 and 2024**

A broad long-list of rehabilitation interventions was progressively refined through fatal-flaw screening and Multi-Criteria Analysis (MCA). Assessment criteria included:

- groundwater protection;
- geomorphic resilience;
- sediment reduction;
- constructability;
- approvals complexity;
- environmental impacts;
- cost; and
- long-term adaptability.

The framework enabled comparison between traditional engineering approaches and lower-intervention recovery-based pathways.

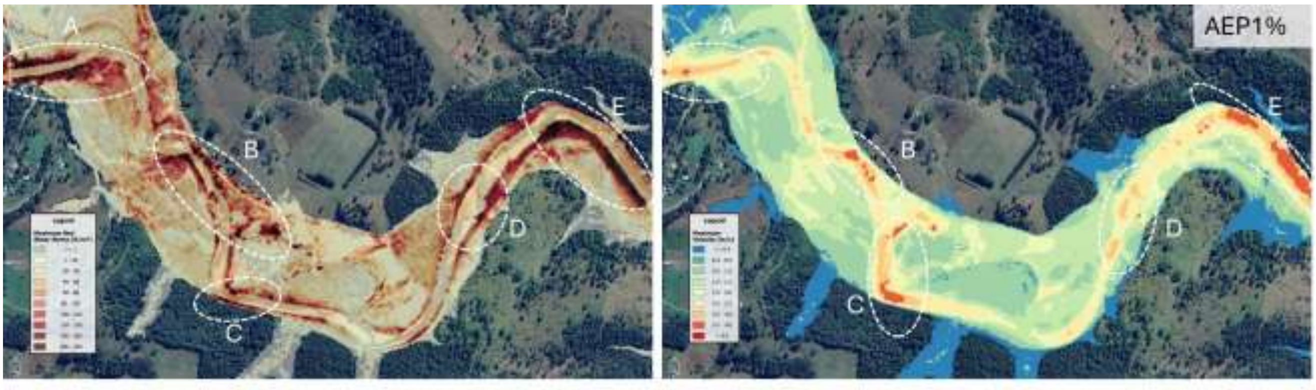



**Figure 5 Hydraulic modelling of existing conditions showing high bed shear stress concentrated on banks driving widening processes, and localised high velocities focused on the bed**

## Results and discussion

### *Geomorphic trajectory and groundwater connectivity*

The study found that erosion at Dayboro is not simply a localised bank stability issue, but rather part of a broader reach-scale geomorphic adjustment process. Historical analysis showed that downstream meander cut-offs combined with lowering of downstream water levels-initiated incision through portions of the reach following the 2011–2013 flood sequence. This incision subsequently propagated upstream, triggering widening and lateral instability.

The system is currently transitioning through a widening and partial re-adjustment phase. Some locations show evidence of recovery through inset bench formation and vegetation establishment, while other areas remain highly unstable and susceptible to continued adjustment from previous base level changes. There is also high potential for future downstream baselevel adjustments that could trigger another phase of incision up through the reach. A key finding was the strong linkage between geomorphic processes and groundwater reliability (Figure 6). At Well 1, channel incision and migration shifted the thalweg away from the extraction well while lowering river water levels relative to the alluvial aquifer. This reduced hydraulic connectivity and recharge potential. The study demonstrated that groundwater performance at Dayboro is directly linked to channel bed elevation and river position. Consequently, interventions focused solely on localised bank protection would not adequately address the underlying risk to water supply infrastructure.

### *Existing intervention performance*

Previous erosion-control works within the reach included rock revetments, pile fields and localised hard-point protection. Field observations and geomorphic interpretation indicated that many of these treatments had limited long-term effectiveness within the highly dynamic wandering gravel-bed system.

Several structures redirected erosive energy toward opposing banks, contributing to localised excessive erosion and channel widening. Other treatments were partially outflanked during major flood events (Figure 7). These findings highlighted that localised hard engineering approaches are often poorly suited to highly mobile gravel-bed systems where adjustment processes operate across the broader channel corridor.

### *Rehabilitation pathways and decision-making*

Recognising that no single intervention could address the interacting processes of channel incision, widening, avulsion risk and groundwater decline, a series of integrated management packages was developed and assessed through a Multi-Criteria Analysis (MCA). The options ranged from passive management (Option 1), through predominantly nature-based rehabilitation (Option 2), to progressively more engineered approaches incorporating fish-friendly grade control structures, avulsion management and targeted bank and groundwater protection (Options 3–6, including refinements 3a and 6a).

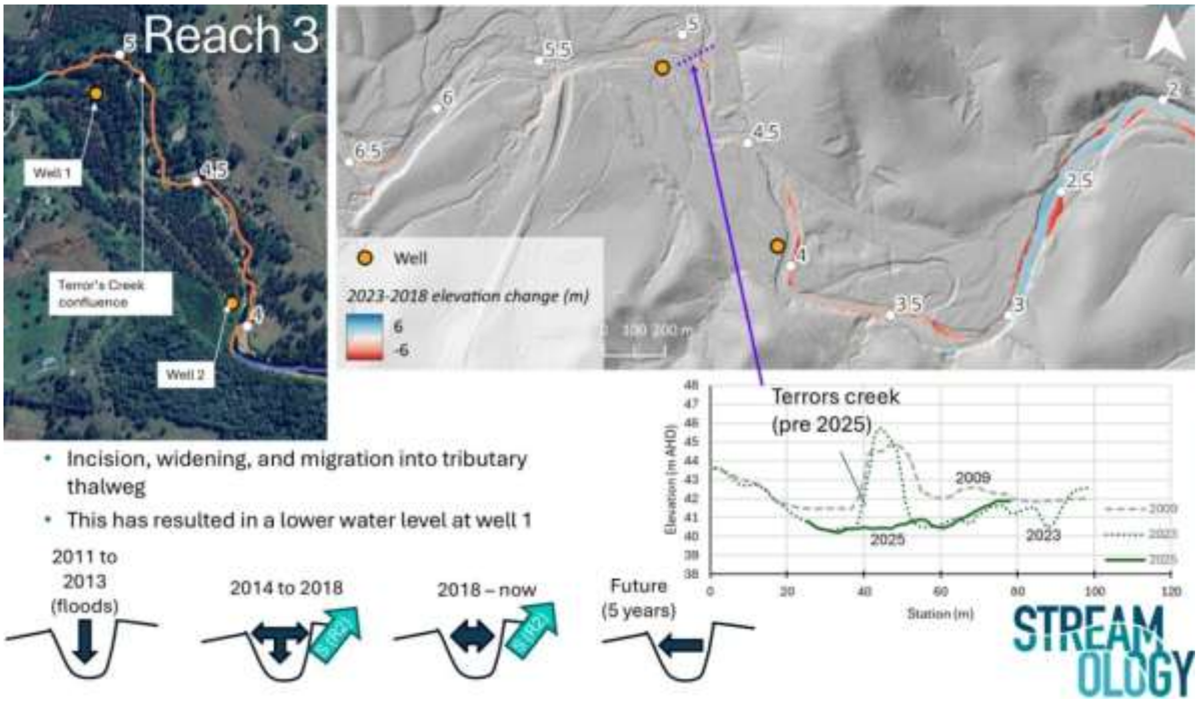
The MCA demonstrated that neither passive management nor highly engineered solutions provided the preferred outcome. Passive management did not adequately address long-term channel adjustment or groundwater security, while the more engineered options improved bed stability but introduced substantially greater cost, approvals complexity, constructability challenges and residual geomorphic uncertainty.

Instead, the preferred pathway combined lower-intervention rehabilitation with targeted structural measures. Nature-based actions, including revegetation, stock exclusion and localised infrastructure protection, provided strong environmental outcomes and supported long-term channel recovery, while retaining the flexibility to introduce structural works if future monitoring demonstrated they were necessary.

The preferred staged and adaptive approach included (Figure 8):

- immediate implementation of riparian revegetation and localised protection works;
- continued groundwater investigation and monitoring;
- preservation of future grade-control pathways if required; and
- deferral of major structural intervention until supported by monitoring and evidence.

(a)

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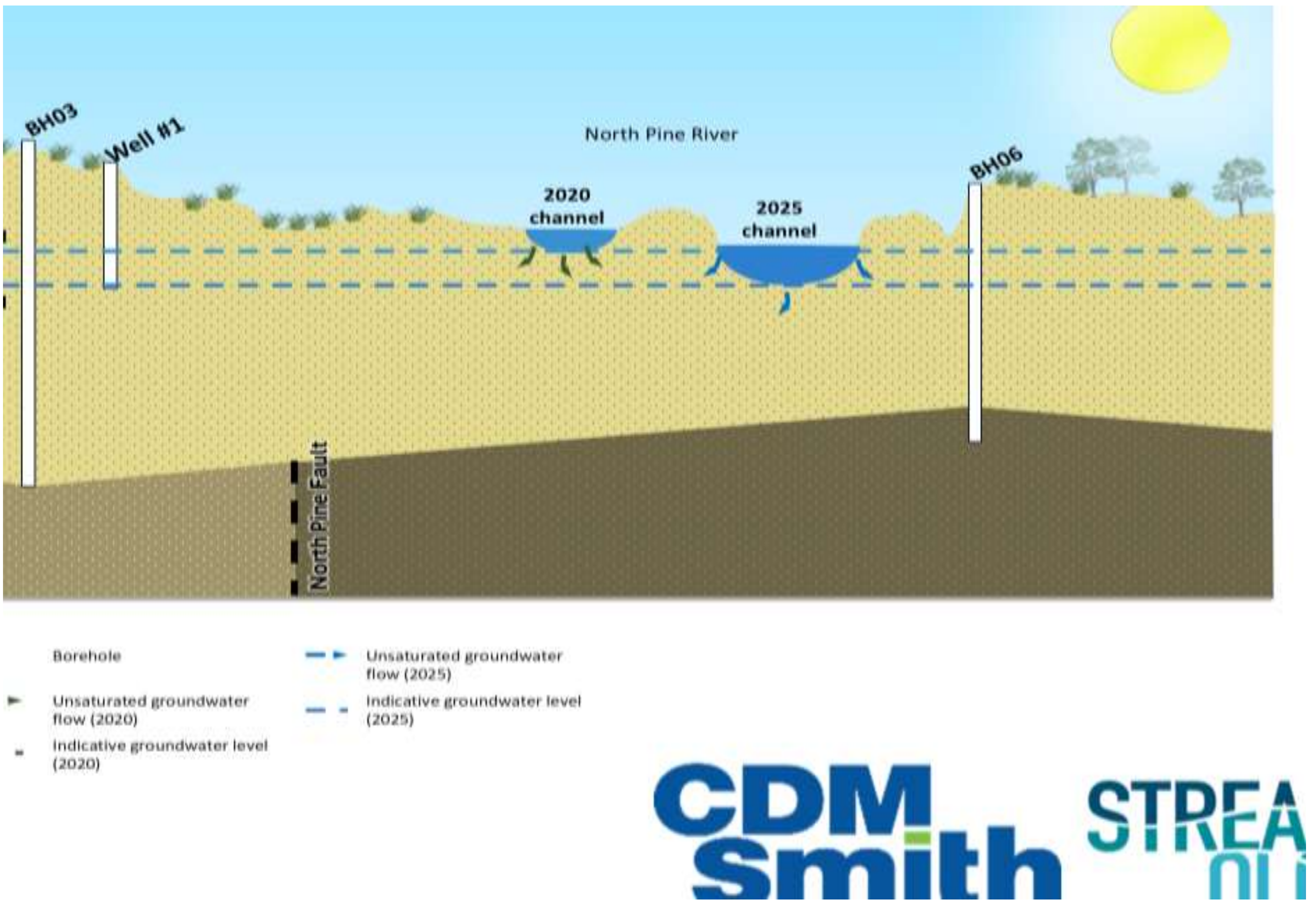


**Figure 6 (a) Summary of geomorphic conditions adjacent to Well 1 and (b) conceptual hydrogeological model relating geomorphic controls to groundwater conditions impacting Well 1**


**Figure 7 Elevation changes by 2014 since 2009 (left) and elevation changes between by 2023 since 2018 (right). Interventions implemented between 2015 and 2017 are mapped in yellow**

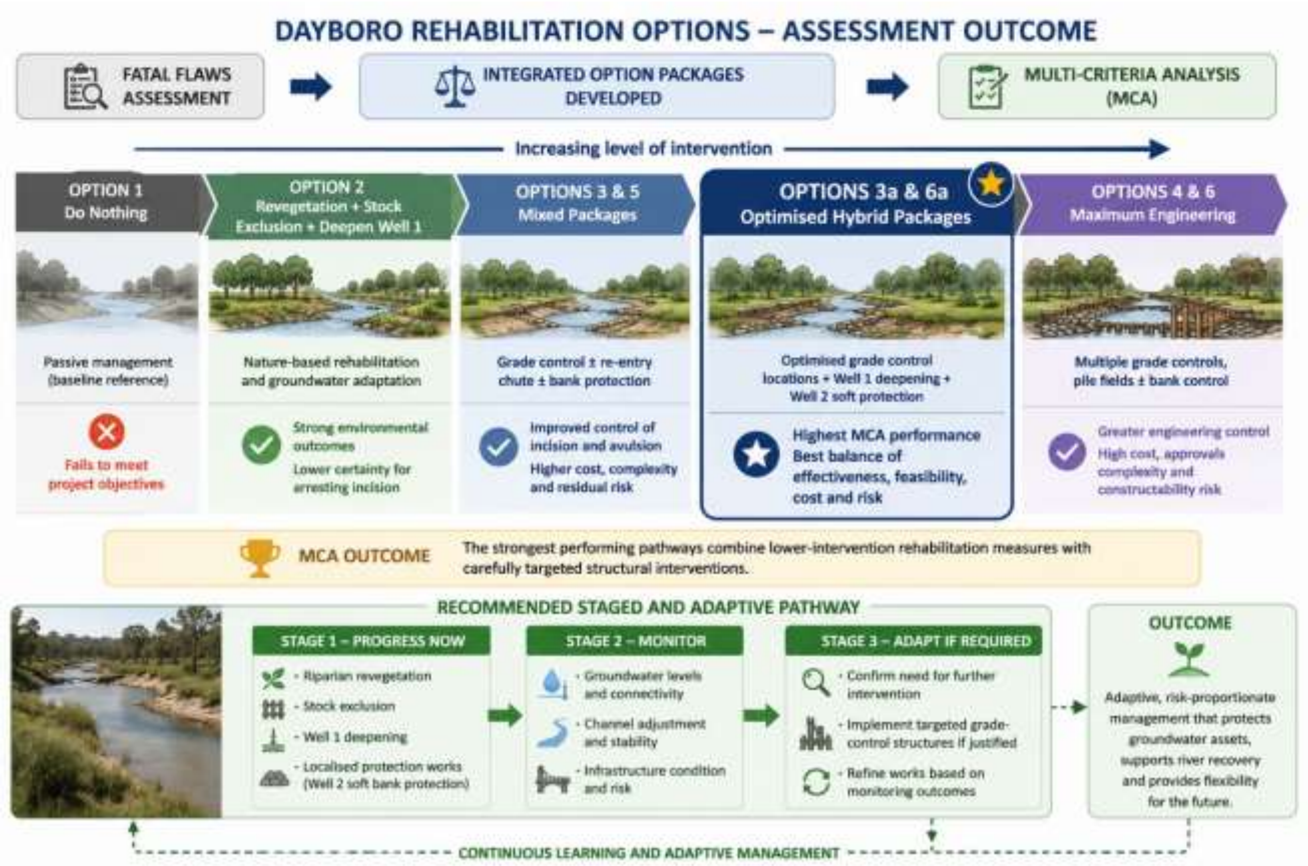


**Figure 8 Design of staged intervention approach**

This approach aligns investment with risk by delivering immediate rehabilitation benefits while maintaining the flexibility to adapt management as channel behaviour and groundwater conditions evolve.

### Implications for river rehabilitation practice

The Dayboro project reflects a broader shift occurring in river management practice across SEQ and beyond. Historically, river rehabilitation has often focused on stabilising channels and preventing movement. However, dynamic gravel-bed rivers are inherently adjusting systems, and attempts to fully "lock" channels in place may simply transfer instability elsewhere or fail under future flood conditions.

At Dayboro, the project demonstrated the importance of:

- understanding geomorphic trajectory rather than only present condition;
- recognising links between groundwater and river processes;
- designing interventions that work with river adjustment;
- adopting staged and adaptive management pathways; and
- integrating geomorphology, engineering, and groundwater science into decision-making.

The project also highlighted the value of geomorphology-led approaches within source protection and water-security planning, within SEQ as well as beneficial across Australia, particularly where river adjustment processes directly influence groundwater infrastructure.

### Conclusions

The Dayboro Reach of the North Pine River is undergoing active geomorphic adjustment driven primarily by lowering of the local base level, with historical channel modification and flood events influencing the rate and expression of change. This adjustment is closely linked to groundwater reliability, meaning conventional bank stabilisation alone cannot address the underlying drivers of channel incision and groundwater disconnection.

By integrating geomorphic, hydraulic and groundwater investigations with structured decision-making, the project identified a staged rehabilitation pathway that supports both river resilience and water security. Rather than attempting to fully stabilise the river, the preferred approach focuses on guiding recovery through revegetation, targeted asset protection, ongoing monitoring and preserving future opportunities for grade-control interventions if warranted. The findings demonstrate the value of process-based rehabilitation in supporting sustainable river management and source-protection outcomes.

### Acknowledgements

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### References

Alluvium. (2013). *Stream restoration plan - North Pine River*. Report P413008_R01 by Alluvium for Seqwater.

Alluvium. (2016). *North Pine River options, July 2016 memorandum*. Prepared for Seqwater Stream-bank Stabilisation Options Analyses and Designs for Priority Catchments project by Alluvium for Seqwater.

Aurecon. (2014). *Pine River Erosion Repair Detailed Design*. Report prepared for Seqwater.

CDM Smith. (2025). *Dayboro Groundwater Assessment 2025 Report.* Report prepared for Streamology.

Daley, J., Croke, J., Thompson, C., Cohen, T., Macklin, M., & Sharma, A. (2017). Late Quaternary channel and floodplain formation in a partly confined subtropical river, eastern Australia. *Journal of Quaternary Science*, 32(6), 729–743. https://doi.org/10.1002/jqs.2930

Ecosure. (2025). *PR9219 Dayboro Reach Ecological Assessment*. Report prepared for Streamology.

Garber, J. L. (2020). *Examining the role that vegetation plays in inducing the deposition of fine sediment*

*in Southeastern Queensland river corridors* [Doctoral dissertation, University of Melbourne].
Hodgkinson J. H., McLoughlin, S., & Cox, M. (2006). The influence of geological fabric and scale on drainage pattern analysis in a catchment of metamorphic terrain: Laceys Creek, southeast Queensland, Australia. *Geomorphology*, 81(3-4), 394-407.
NGH. (2025). *Cultural Heritage Due Diligence Assessment Dayboro Reach*. Report prepared for Streamology.