Faculty of Science and Engineering

MACQUARIE University

River Styles

River Styles Framework

FACT SHEETS

Applications to river management

River Styles Impact & Engagement

The River Styles Framework is helping decision makers around the world to implement strategic, science-based management of river systems.

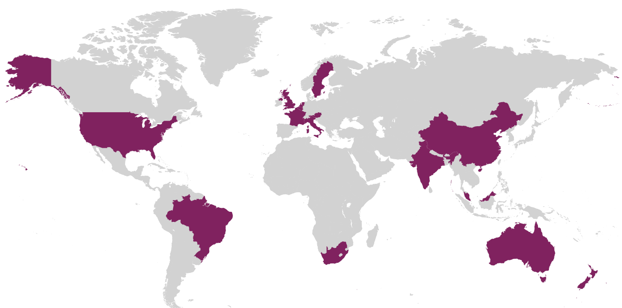
more than **500** professionals now trained in River Styles worldwide

20 years of research

60+ peer-reviewed articles

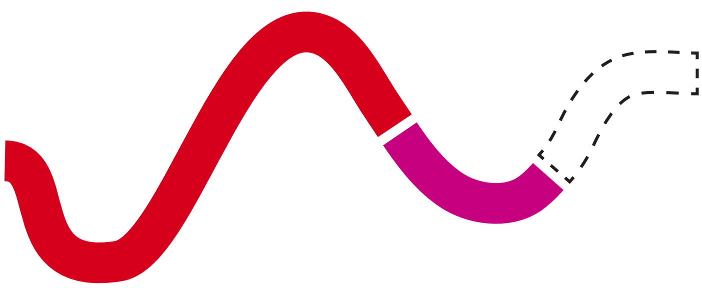
6,500+ book sales worldwide

20+ short courses delivered worldwide



▲ The River Styles Framework has been applied on six continents and continues to be adopted by new countries, supported by a portfolio of professional training courses.

an **open-ended scaffolded place-based** *approach to understanding and managing rivers*



▲ More than 253,000 km of river length has been mapped using River Styles in Australia and overseas. This number continues to grow as more countries embrace the value of geomorphology in integrated river management.

River Styles

MACQUARIE University

What is the River Styles Framework?

The River Styles Framework is an approach for the geomorphic analysis of rivers. It is used around the world to implement proactive and strategic, nature-based management of rivers and catchments. The River Styles Framework has 4 stages.

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4. **River management applications**
   Focuses on transparent decision making and vision setting.

3. **River recovery potential**
   Analyses what the river could be like, which sets realistic expectations and helps to determine what is achievable, and over what time frame.

2. **Geomorphic river condition**
   Situated in the context of what the river is, relative to what is expected.

1. **River character and behaviour**
   Focuses on the character and behaviour as it is, not how it was.

Supported by the

What can the River Styles Framework and databases be used for?

Scale	Uses
At the **site** and **reach** scales	• Know what type of river you are working with, and how that river behaves • Rapidly integrate geomorphology into property management plans • Understand relationships between river structure, habitat types and ecological populations • Relate geomorphic understandings to local values
At the **sub-catchment** and **catchment** scales	• Treat threatening processes before they become a problem • Manage responses to disturbance events in ways to minimise onsite and offsite impacts • Identify underlying causes of environmental problems, rather than just treating the symptoms • Transfer understanding from one place to another in meaningful ways
At the **regional** and **state/territory** scale scales	• Integrate and align environmental decision making across agencies and disciplines • Develop management guidelines that are relevant for the types of river • Transfer understanding from one place to another • Prioritise activities for strategic and efficient use of resources and best return on investment
At the **national** scale	• Enact adaptive management • Coordinate whole-of-government and non-government programs using consistent information • Undertake state of environment audits and reporting • Situate local, catchment and state conservation and rehabilitation goals in context of national priorities
At the **intercontinental** scale	• Make intercontinental comparisons of river type, condition and recovery • Situate local, catchment, state and national conservation and rehabilitation goals in context of international priorities • Fulfil international reporting, monitoring and evaluation to meet statutory obligations on the state of rivers and water resources (e.g. via UN Sustainability Goals, RAMSAR Wetlands Convention).

Open source reference: Fryirs, K.A., Hancock, F., Healey, M., Mould, S., Raine, A., Riches, M., Brierley, G. 2021. Things we can do now that we could not do before: Developing and using a cross-scalar, state-wide database to support geomorphologically-informed river management. *PloSONE* 16(1): e0244719.

River Styles Fact Sheets

FACT SHEET

Respecting river diversity

Understanding river diversity is critical for developing river management approaches that work with nature and are tailored to the river type.

What do we mean by 'river diversity'?

When we talk about 'river diversity,' we are referring to the wide range of different 'types' of rivers that exist in the environment. Stage 1 of the River Styles Framework identifies and interprets rivers based on their geomorphology; their **character** (the physical landforms) and **behaviour** (geomorphic processes that create and shape landforms at different flow stages).

Stage 1 of the Framework gives managers the tools to recognise diversity of river character and behaviour, and to develop management strategies that will work with the expected character and behaviour of each river type. The Framework does not classify rivers, it characterises them. This avoids 'pigeon-holing' and ensures that rivers are managed to meet individual need.

River character

River character is comprised of five key components: **valley setting**, degree of **lateral confinement**, river **planform**, **geomorphic units** (landforms) and **bed material texture**. The procedures used to identify a River Style are also used to assign a name using a consistent convention (Figure 1).

Geomorphic analysis of river character can help to identify distributions of various types of physical habitat and to interpret processes driving river adjustment over time.

River behaviour

River behaviour is interpreted at three flow stages: **low flow**, **bankfull** and **overbank**, recognising that different channel-bed, within-channel and floodplain-formation and -reworking processes are occurring at these flow stages.

Interpretation of form-process associations of geomorphic units, and assemblages of geomorphic units, is used to analyse river behaviour. By identifying the correct forms (geomorphic units) an interpretation of the range of erosion and deposition processes can be made.

Managing for river diversity

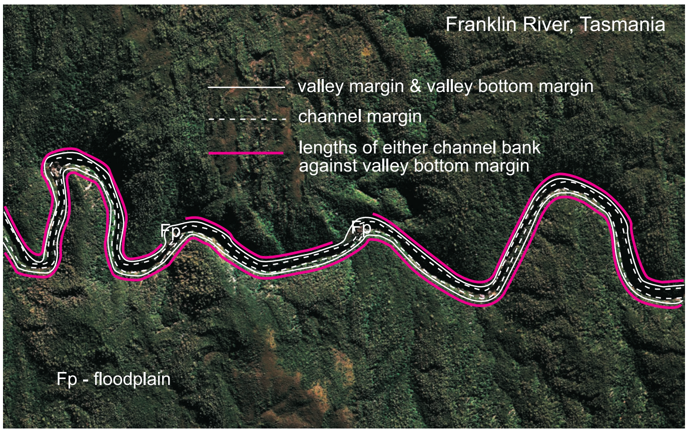
Understanding geomorphic river diversity through analysis of river character and behaviour is fundamental for developing river management systems and strategies that are appropriate for the river type and therefore more likely to be successful in the long term.

Managing for river diversity means:

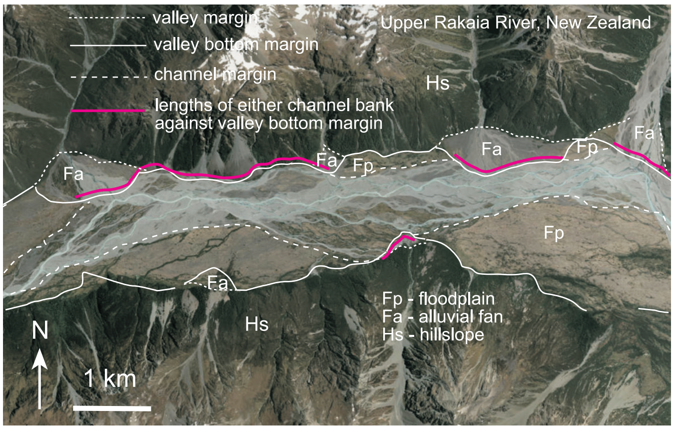
- ☑ Knowing what kind of river you are working with
- ☑ Understanding rivers on their own terms, characterising rather than classifying
- ☑ Using place-based approaches to manage rivers, avoiding 'one-size-fits-all' approaches

Characterising river diversity

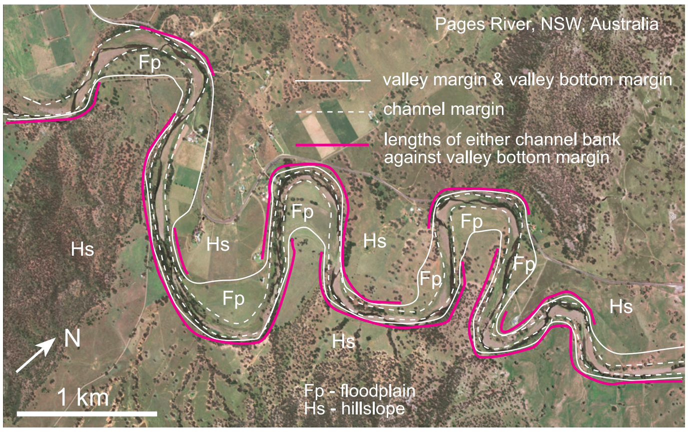
River Style name = valley setting + degree of lateral confinement + river planform + geomorphic units + bed material texture



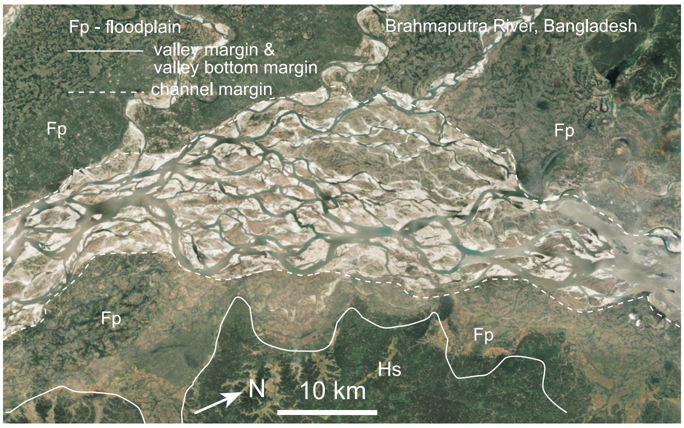
Confined, bedrock margin controlled, occasional floodplain pockets, boulder bed River Style



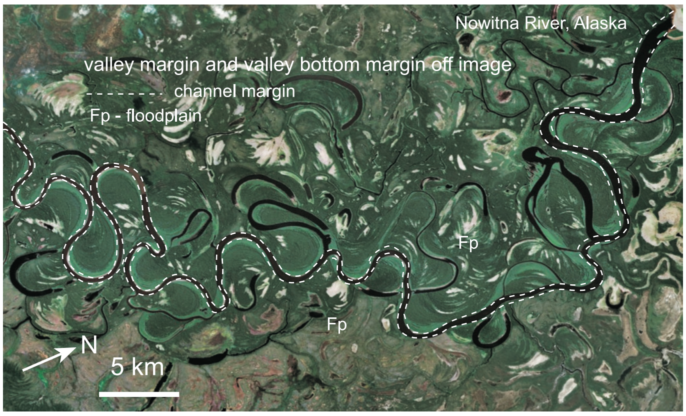
Partly confined, planform controlled, braided, fan constrained, discontinuous floodplain, gravel bed River Style



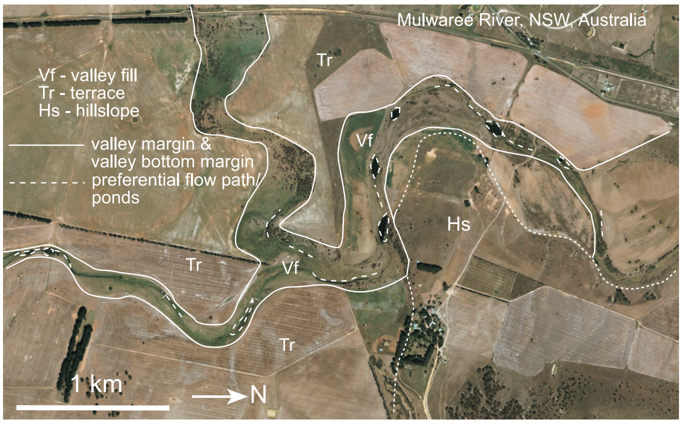
Partly confined, bedrock margin controlled, discontinuous floodplain, gravel bed River Style



Laterally unconfined, continuous channel, braided, gravel bed River Style



Laterally unconfined, continuous channel, meandering, sand bed River Style



Laterally unconfined, discontinuous channel, chain of ponds, fine grained River Style

Figure 1: Application of the River Styles naming convention, which helps to develop consistent and geomorphically meaningful names for the full diversity of rivers. Modified from Fryirs et al. (2018).

Further reading:

Fryirs, K. A. & Brierley, G. J. 2018. What's in a name? A naming convention for geomorphic river types using the River Styles Framework. PLOS ONE, 13 (9):e0201909. https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0201909.

Fryirs, K. & Brierley, G. J. 2009. Naturalness and place in river rehabilitation. Ecology & Society, 14 (1):1-10. https://www.ecologyandsociety.org/vol14/iss1/art20/.

FACT SHEET

The good, the bad & the ugly: **Assessing geomorphic river condition**

What's 'good' or 'bad' geomorphic condition depends on which characteristics and processes can be expected for a particular river type.

Measuring condition – against what?

Geomorphic river condition is a measure of the capacity of a river to perform functions that are expected for that river, given its setting. The characteristics we expect to see, and the processes that shape this will often differ between river types.

Assessments of river condition must be benchmarked, but identifying appropriate benchmarks is a big challenge. While people often refer to 'historical reference conditions' of a pre-disturbance ideal state, the reality is that very few pristine examples exist for many river types. Instead, we can benchmark condition assessment against what can be expected for the given river type, given the contemporary catchment conditions. This relies on interpretation of a river's geomorphic character, behaviour and evolutionary history in order to identify useful measures and benchmarks.

Reference conditions

Good **Moderate** **Poor**

Figure 1: Which of these examples is in good, moderate and poor condition? Partly confined, planform controlled, meandering, discontinuous floodplain pocket, sand bed River Style, Wollombi Brook, NSW, Australia.

What to measure?

Stage 2 of the River Styles Framework is used to assess the geomorphic condition of rivers. It involves measuring a range of geoindicators for each river type that provide a signal of good, moderate or poor condition. The geoindicators used are tailored to the River Style to measure the right things in the right place at the right time.

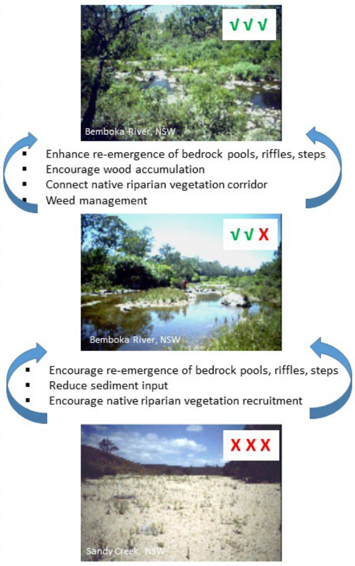
A good signal – or 'geoindicator' – of geomorphic river condition is one that gives an early warning sign and direct insight into how a particular river adjusts (or is adjusting) to disturbance. See Figure 2 for an example. If the geoindicator is operating as expected, it receives a 'tick' (✓). If it is not, it receives a 'cross' (x).

Find out more: www.riverstyles.com

Geoindicators, 'ticks' and 'crosses'

(A) Confined with occasional floodplain pockets

Geoindicator	Useful to measure
Channel attributes √ **or** X (summary = √ **or** X)	
Size	NO
Shape	YES
Bank morphology	YES
Instream vegetation structure	YES
Wood loading	YES
River planform (summary = √ **or** X)	
Number of channels	NO
Sinuosity	NO
Lateral stability	NO
Geomorphic unit assemblage	YES
Riparian vegetation	YES
Bed character √ **or** X (summary = √ **or** X)	
Grain size and sorting	YES
Bed stability	NO
Hydraulic diversity	YES
Sediment regime	YES



(B) Partly confined urban stream

Geoindicator	Useful to measure
Channel attributes √ **or** X (summary = √ **or** X)	
Size	YES
Shape	YES
Bank morphology	YES
Instream vegetation structure	YES
Wood loading	NO
River planform (summary = √ **or** X)	
Number of channels	NO
Sinuosity	YES
Lateral stability	NO
Geomorphic unit assemblage	YES
Riparian vegetation	YES
Bed character √ **or** X (summary = √ **or** X)	
Grain size and sorting	YES
Bed stability	NO
Hydraulic diversity	YES
Sediment regime	YES

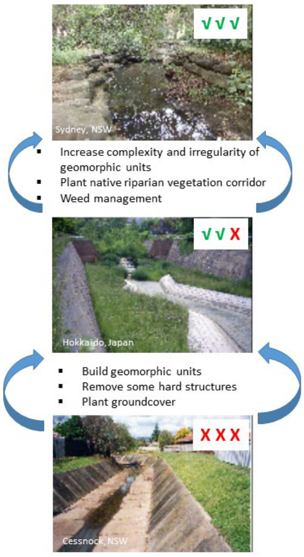


Figure 2: Different measures will be useful for assessing condition for different River Styles.

Managing for geomorphic river condition

Compare like with like
An understanding of each River Style's character and behaviour (Stage 1) is fundamental for condition assessment. This allows meaningful comparisons to be made between river reaches.

Place reaches within their evolutionary context
Present-day geomorphic condition must be placed within an evolutionary context, understanding the history of river dynamics in order to identify drivers of change (rather than symptoms).

Select appropriate reference conditions
Reference conditions must be an appropriate comparison in terms of River Style and setting within the catchment (compare like with like). Reference conditions may be defined for a range of condition states, from 'intact' or 'good' condition variants through to those reaches that have experienced direct human disturbance with irreversible change ('poor' condition).

Measure appropriate geoindicators for each River Style
As different River Styles have varying capacity to adjust, certain parameters will give a reliable and relevant signal about the condition of a reach, whereas others give irrelevant or poor signals. Hence, the range of parameters measured should be River Style-specific.

Define irreversible change
In some cases, following a disturbance, a river reach may be able to return to a condition similar to the pre-disturbance state; however, in other cases the change may be irreversible. If change is irreversible, condition must be assessed according to the new contemporary River Style. There is no point in defining an unachievable goal.

Treat the crosses, not the ticks
In management practice, leave the 'ticks' alone – they do not require treatment. Geoindicators that have 'crosses' are not functioning as expected, signaling that treatment may be needed.

Further reading:

Fryirs, K. A. 2015. Developing and using geomorphic condition assessments for river rehabilitation planning, implementation and monitoring. Wiley Interdisciplinary Reviews: Water, 2(6):649-667. https://doi.org/10.1002/wat2.1100.

FACT SHEET

Working with recovery processes in river rehabilitation

We can be most effective in river rehabilitation when we work with geomorphic recovery processes, rather than fighting the river for control.

What are recovery processes?

Recovery processes are the forms of adjustment by which a river is responding to a disturbance and improving its geomorphic condition. Recovery processes are specific to the type of river and the nature of the disturbance. It is important to note that recovery may not mean a return to a previous state; if a change is irreversible, then recovery may be on a new trajectory toward an improved – but different – condition.

Recognising the signs of geomorphic recovery requires a sound understanding of the river's character and behaviour, its geomorphic condition and its evolutionary history (including causes of disturbance). These insights can be generated through application of Stages 1 and 2 of the River Styles Framework. Stage 3 of the River Styles Framework considers geomorphic recovery potential for prioritisation of river conservation and rehabilitation.

Dimensions of river recovery

Figure 1: A river over-widened and impacted by a sand slug (A) and in recovery (B). Channel contraction has occurred through bench building and vegetation recovery, leading to redefinition of the low-flow channel. Modified from Fryirs et al. (2018).

Will my river recover?

A river's recovery potential depends on its geomorphic condition, the presence of recovery processes or threatening processes and the contemporary (and projected) catchment conditions that may promote or limit recovery.

Recovery potential is best understood within the context of an evolutionary history and a catchment context, considering pressures and limiting factors operating in a system and the (dis)connection of that system. This often produces multiple possible future trajectories, toward either recovery or degradation. Recovery and degradation trajectories can be mapped on a River Recovery Diagram (Figure 2) to identify potential future pathways and prioritise actions to enhance the likelihood of recovery occurring.

River recovery diagram

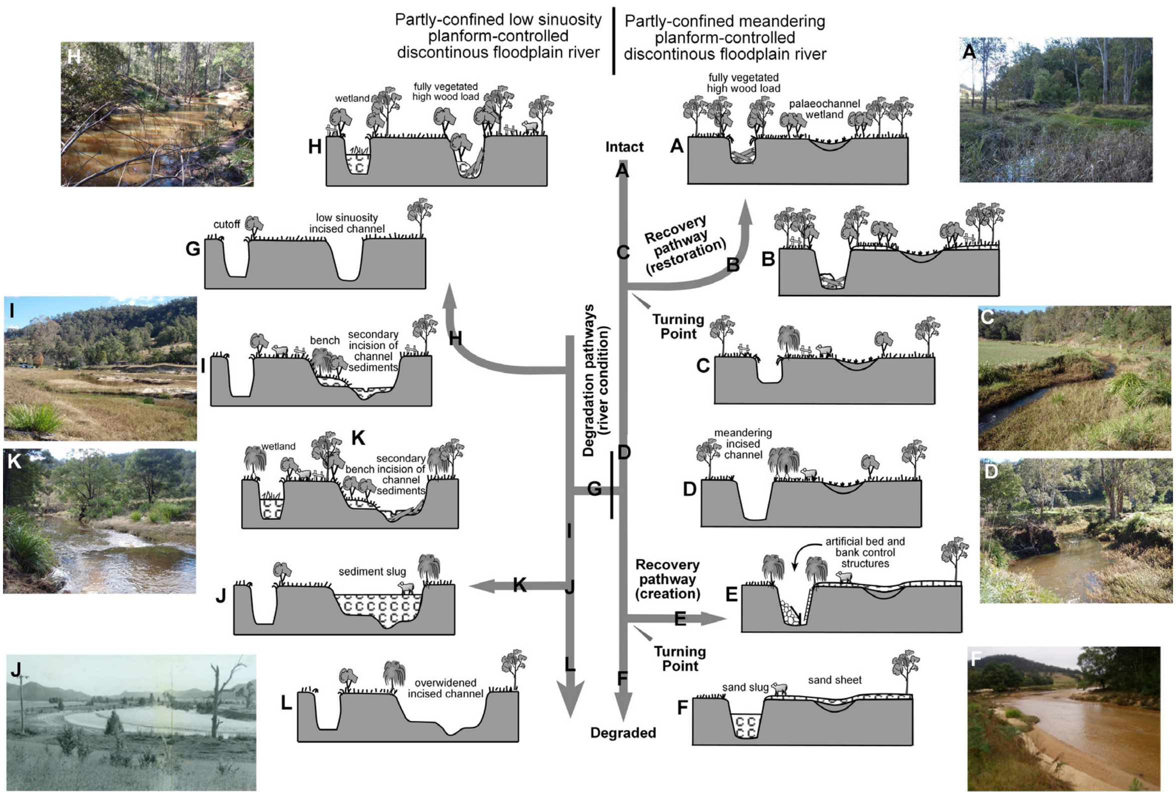


Figure 2: River recovery diagram for Wollombi Brook, NSW. Reaches are placed on a continuum from 'intact' to 'degraded' with recovery trajectories (actual or potential) mapped as side-branches. Modified from Fryirs et al. (2012).

Managing for river recovery

Where geomorphic river recovery is occurring, we can implement recovery-enhancement techniques to support recovery processes. Recovery-enhancement techniques are preferable to more interventionist techniques because they work with river behaviour rather than fighting it, making success more likely. They are also often less expensive to implement and maintain.

For reaches in intact condition or in good condition with high recovery potential, the best strategy may be to do nothing at all, or to only act to reduce the likelihood of future disturbance. Knowing when to opt out because the river is 'self healing' is critical to a practitioner's decision-making toolkit.

Further reading:

Fryirs, K., Brierley, G. J. & Erskine, W. D. 2012. Use of ergodic reasoning to reconstruct the historical range of variability and evolutionary trajectory of rivers. Earth Surface Processes and Landforms, 37 (7):763-773. https://doi.org/10.1002/esp.3210.

Fryirs, K. A. & Brierley, G. J. 2016. Assessing the geomorphic recovery potential of rivers: forecasting future trajectories of adjustment for use in management. Wiley Interdisciplinary Reviews: Water, 3(5):727-748. https://doi.org/10.1002/wat2.1158.

Fryirs, K. A., Brierley, G. J., Hancock, F., Cohen, T. J., Brooks, A. P., Reinfelds, I., Cook, N. & Raine, A. 2018. Tracking geomorphic recovery in process-based river management. Land Degradation and Development, 29:3221-3244. https://doi.org/10.1002/ldr.2984.

FACT SHEET

‘River triage’: **Prioritising river conservation and rehabilitation**

Strategic prioritisation is the key to an effective and realistic catchment management plan.

Strategic prioritisation

River managers must make decisions about where to focus conservation and rehabilitation efforts based on availability of resources and the likelihood of those efforts contributing to a positive outcome.

Strategic prioritisation of river conservation and rehabilitation is made easier with the right information: understanding river character and behaviour, river condition and recovery potential can support better decisions.

Stage 4 of the River Styles Framework uses key information from Stages 1, 2 and 3 to prioritise conservation or rehabilitation according to geomorphic river condition, recovery potential and position of a reach in relation to other reaches in the catchment.

Triaging rivers at the catchment scale

The best approach to prioritisation is a ‘conservation-first, recovery-enhancement’ approach where the less we need to intervene, the better. In this approach, first priority should be given to reaches which require no direct intervention (Figure 1). These ‘conservation’ reaches will be in good geomorphic condition and should be protected from potential future threats. Reaches that contain threatening processes are assigned a ‘strategic’ priority. The next priority is those reaches which are in good or moderate condition and have a high recovery potential. These reaches can be rehabilitated with little intervention and a high chance of success.

Only when reaches in good or moderate condition and with high or moderate recovery potential have been treated, should those reaches in poor condition with low or moderate recovery potential be considered for rehabilitation. These reaches are likely to require expensive, interventionist works and have a lower likelihood of success. Whilst it can be tempting to jump in and tackle the big problems first, a conservation-first approach will achieve much better outcomes for a similar investment.

‘Save the strongest swimmers first!’

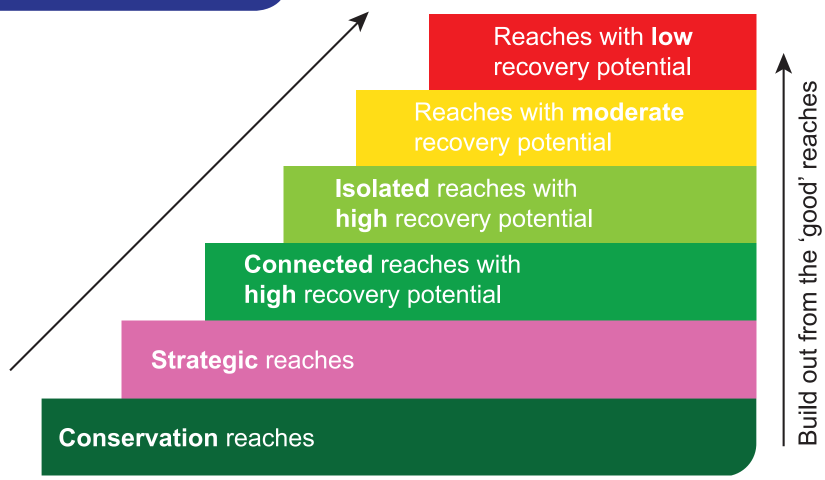
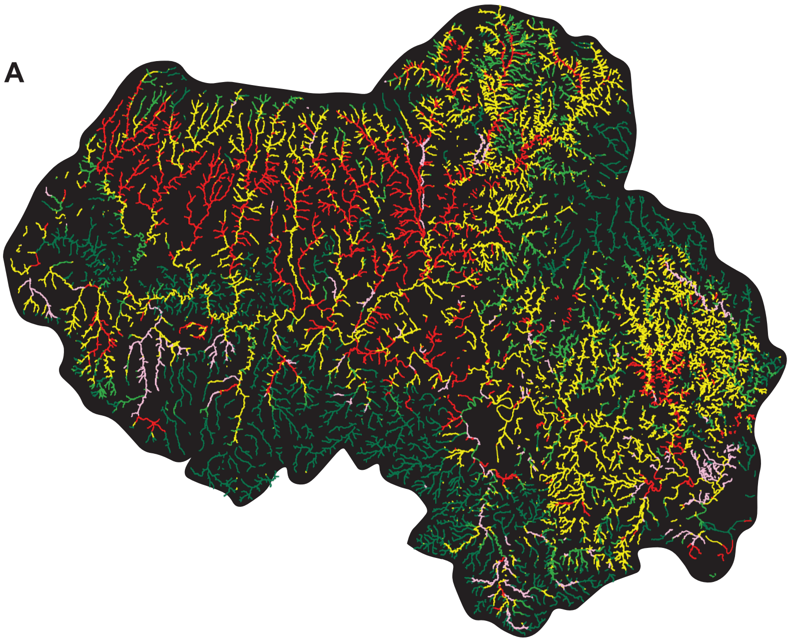


Figure 1: A hierarchy of reaches for prioritisation, based on geomorphic condition and recovery potential. Reaches in the best condition requiring the least intervention should be treated first, unless they are impacted by a threatening process in a strategic reach.

Find out more: www.riverstyles.com

Managing using strategic prioritisation

A



- Conservation
- Strategic
- High recovery potential
- Moderate recovery potential
- Low recovery potential

◄ Prioritisation map of Hunter River catchment, New South Wales using geomorphic condition and recovery potential data. Data source: NSW River Styles Database.

B

Geomorphic condition	Recovery potential: Intact	High	Moderate	Low
Good	Conservation	Strategic / High recovery potential		
Moderate		Strategic	Moderate recovery potential	
Poor			Low recovery potential	Low recovery potential

C

Priorities	1. Conservation	2. Strategic	3. High recovery potential	4. Moderate recovery potential	5. Low recovery potential
	Reach is already in good geomorphic condition or intact.	Reaches that contain threatening processes and threaten the integrity of conservation reaches.	Normally in good condition and showing signs of geomorphic recovery.	Moderate or poor condition with potential to recover if existing pressures are removed. May be showing some signs of geomorphic recovery.	Poor condition with little or no signs of geomorphic recovery. Often degradation is still occurring.
Actions	►Conserve and protect from threats and maintain current condition. (may require treating strategic reaches).	►Control the threatening processes.	►Limit further disturbance and continue to allow recovery. Minimal intervention (e.g. exclusion fencing and vegetation management) then ‘opt out’ and leave alone to recover.	►Limit further disturbance and continue to allow recovery. More intensive interventions will be required to treat these reaches.	►Work elsewhere until reach shows signs of recovery. If intervention is needed, it is likely to be highly interventionist, expensive and may fail.

Figure 1: Prioritisation procedure from Stage 4 of the River Styles Framework. Information on geomorphic river condition and recovery potential can be represented on a catchment map (A). Priorities are assigned based on relationships between geomorphic condition and recovery potential, as expressed in the decision matrix (B). Suggested actions (or non-actions where no intervention is required) are outlined at (C), beginning with those reaches that require only protection from threats and ending with the most impacted and challenging reaches.

Further reading:

Rutherfurd, I., Jerie, K., Walker, M. & Marsh, N. 1999. Don’t raise the Titanic: How to set priorities for stream rehabilitation. Proceedings of the 2nd Australian Stream Management Conference. Adelaide, SA. p. 527-532. https://rbms.com.au/wp-content/uploads/2013/12/2ASM_p527_Rutherfurd.pdf.

Use of River Styles
Case studies

Case Study

Challenge

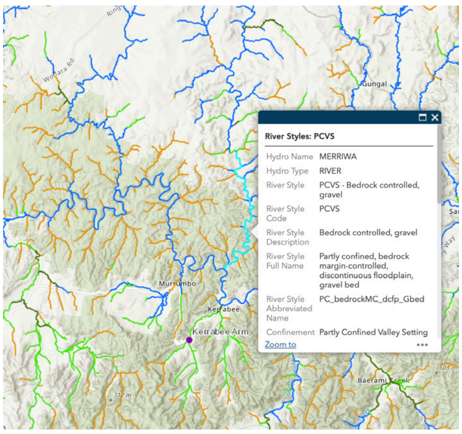
Making robust decisions about river management across a range of scales requires baseline geomorphic data in the form of a consistently applied physical template.

Solution

NSW Government used all four stages of the River Styles Framework to build a coherent, statewide geomorphic database of river character, condition and recovery potential, resolved to the reach scale.

Result

The NSW River Styles database is an international exemplar and can be used to consistently apply geomorphology for monitoring, evaluation and reporting and can be integrated with other biophysical understandings of rivers for improved management and prioritisation.



Map extract from public database, showing some of the data fields available for use in river management. [Link to NSW River Styles database](https://riverstyles.com).

Statewide River Styles database supporting river management in NSW

Fluvial geomorphology is the study of the physical structure and functioning of river systems. This is the 'physical template' within which ecological and hydrological processes operate. In river management, geomorphic insights are used to understand river processes occurring at the landform (habitat) and reach scale and for interpretation of processes, linkages and trajectories at subcatchment and catchment scales. However, these applications may be limited if relevant geomorphic data are inconsistent in content, scale or spatial coverage, or if information is held within different institutions.

To support the consistent application of geomorphology in river management, New South Wales (NSW) Government have invested in developing a statewide spatial database using all four stages of the River Styles Framework. The database is publicly available, enabling wide use by a range of end-users including government, industry and community-based organisations.

Stage 1	Stage 2	Stage 3	Stage 4
Catchment-wide baseline survey of river character, behaviour and pattern.	Catchment-framed assessment of river evolution and geomorphic condition.	Assessment of future trajectory of change and geomorphic recovery potential.	River management applications and implications.

NSW Government's River Styles database is resolved to the reach scale, enabling users to access and apply River Styles geomorphic data at scales that are meaningful for small projects right through to whole-of-catchment planning and statewide reporting.

Information from Stage 1 of the River Styles Framework includes identification of river type ('River Style'), developed using a consistent and geomorphically meaningful set of measures, procedures and naming convention. This helps to support appropriate comparisons between sites and identification of appropriate variables for monitoring, evaluation and reporting applications.

Geomorphic river condition assessment contained in Stage 2 of the River Styles Framework rates the geomorphic integrity of a reach based on variables that are appropriate for the river type in question. The reach is assessed in terms of what could reasonably be expected for a 'good condition' variant of the given river type. Geomorphic condition data from the NSW River Styles database have been applied in development of the NSW River Condition Index (RCI), which contributes to triennial statewide 'State of the Environment' and 'High Ecological Value Aquatic Ecosystem' reporting.

In Stage 3 of the River Styles Framework, insights from Stages 1 and 2 scaffold into assessment of the future trajectory of a river reach and its potential to recover (improve in geomorphic condition) or degrade, given its current condition and position in the catchment. Assessment of recovery potential is particularly useful for prioritisation of river rehabilitation actions and has supported strategic catchment-scale prioritisation in NSW (Stage 4).

The NSW River Styles database has been tried, tested and applied by various government agencies to support river management. Making this database available via Creative Commons means that there is greater potential for consistent application of geomorphology in river management across agencies and scales. The database supports opportunities for integration with other biophysical information for improved river management and prioritisation outcomes.

Learn more about the River Styles Framework at riverstyles.com

Case Study

Challenge

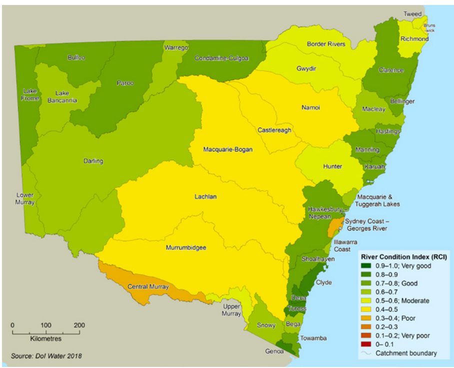
Prioritisation of river management actions is difficult when there are so many different types of rivers, different types of data and different agencies responsible.

Solution

NSW Government applied the River Styles Framework to fulfill the geomorphic component of their integrative River Condition Index (RCI).

Result

The RCI, incorporating Stages 1 and 2 of the River Styles Framework, helps to prioritise river management actions based on river condition and risk, harmonising catchment management planning with water sharing plans and establishing a rigourous and repeatable monitoring protocol.



River Condition Index for catchments in New South Wales.
Source: NSW State of the Environment Report 2018.

Prioritising river management actions based on the NSW River Condition Index (RCI)

As in many locations around the world, responsibility for river management in New South Wales (NSW), Australia, is shared between a range of different agencies, who use different approaches. This makes it difficult to plan, coordinate and evaluate river management activities.

When the NSW Government recognised the need to better align river management activities and to develop an integrated planning, management and monitoring protocol (as required by the National Water Initiative), they developed the River Condition Index (RCI). The RCI assesses river condition at the subcatchment scale for bioregional planning and assessment.

The River Styles Framework features as a foundational component of the RCI, recognising geomorphology as setting the 'physical template' within which hydrological and ecological processes operate. River Styles data and insights contributed to assessment of river condition, river value and risk to river values, as a basis for strategic prioritisation of actions. Other layers that contribute to the RCI are 'hydrological stress' and 'instream value'.

Stage 1	Stage 2	Stage 3	Stage 4
Catchment-wide baseline survey of river character, behaviour and pattern.	Catchment-framed assessment of river evolution and geomorphic condition.	Assessment of future trajectory of change and geomorphic recovery potential.	River management applications and implications.

Assessing river condition using Stage 2 the River Styles Framework involves development of condition indicators that are appropriate to each river type (Stage 1). This meant that developers of the RCI could be confident that they were measuring the right variables in the right place, that give a reliable and relevant signal about geomorphic river condition and values.

Assessment of risk to instream values used indexes for geomorphic recovery potential and fragility (sensitivity to change), combined to determine the likelihood of a physical disturbance to instream values.

Developers of the RCI produced an action prioritisation tool based on the risk rating and RCI condition index rating. The action prioritisation tool adopts a strategic approach where conservation of reaches in better condition is prioritised.

To date, the RCI has been applied to develop management goals and strategies for monitoring, evaluation and reporting as part of catchment action planning and water sharing in NSW, working towards harmonisation of these functions. The RCI has also supported the statewide, triennial 'State of the Environment' reporting. The RCI – and River Styles – continue to be used by the NSW Department of Planning, Industry and Environment in their planning, implementation and monitoring of river management across NSW.

Learn more about the River Styles Framework at riverstyles.com

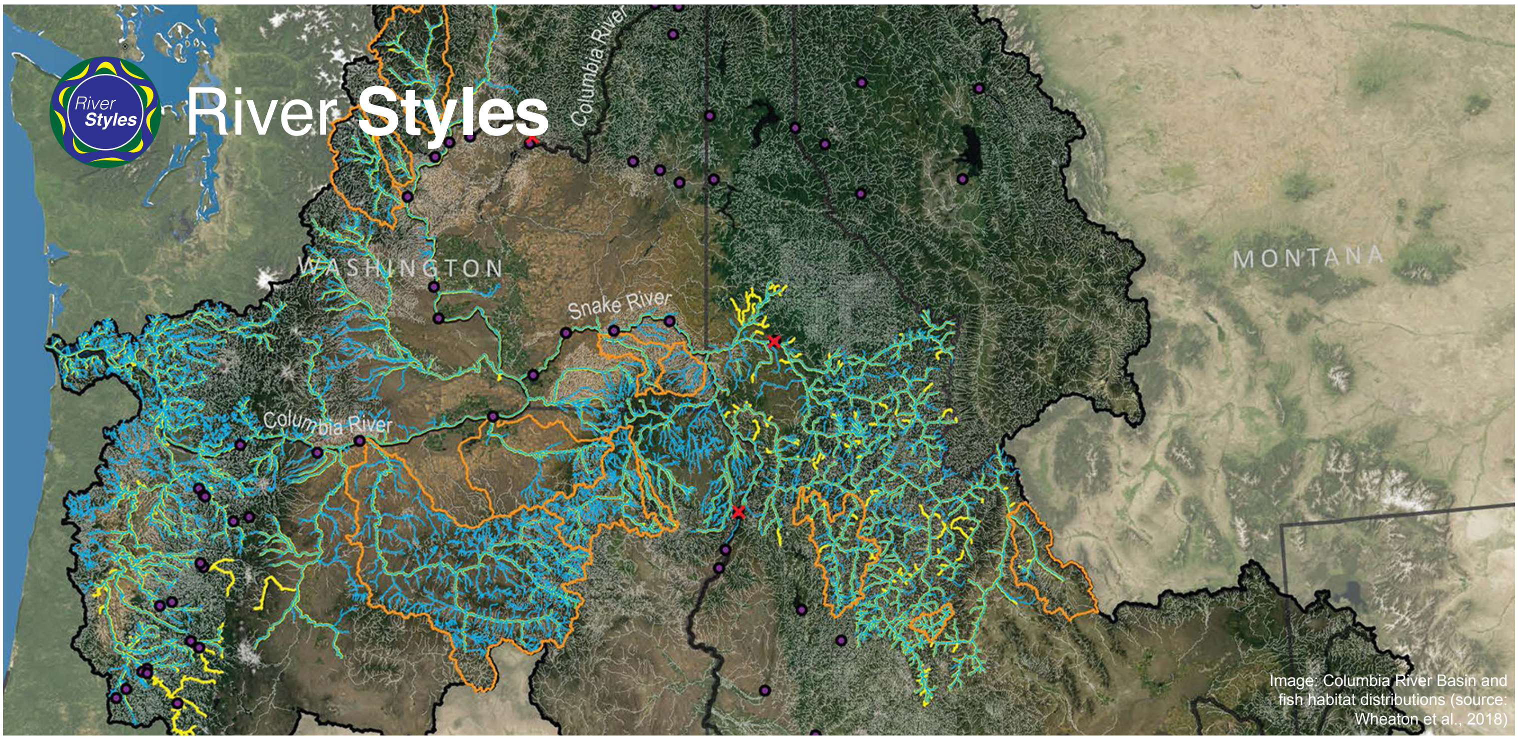


Image: Columbia River Basin and fish habitat distributions (source: Wheaton et al., 2018)

Case Study

Challenge

Physical habitat monitoring is time intensive and the transferability of findings from reach-based surveys to the network or catchment scale is often limited.

Solution

The River Styles Framework provides a geomorphic basis for 'scaling-up' ground-level assessments of physical habitat in conjunction with larger-scale spatial datasets.

Result

Physical habitat condition can be understood at a network scale, with prediction of future conditions in context of conservation and rehabilitation made possible, leading to better management of valuable fish habitat.

Monitoring and restoring valuable fish habitat in the Columbia Basin, USA

Maintaining healthy fish populations in freshwater environments requires a strong understanding of the quality and distribution of appropriate habitats throughout a catchment and over time. Particularly in large catchments, collecting the right information and using it to make robust interpretations is a significant challenge.

In the northwest USA, CHaMP (Columbia Habitat Monitoring Program) set out to design a protocol for monitoring physical salmon habitat and guiding rehabilitation activities with accuracy, efficiency and transferability in mind. Recognising the fundamental importance of geomorphology in providing structural habitat, the developers of CHaMP chose the River Styles Framework as a foundational element in their monitoring protocol.

The River Styles Framework consists of four stages for characterising rivers, assessing their geomorphic condition, predicting their potential for recovery and prioritising conservation and/or rehabilitation activities. The Framework provides a consistent and structured approach to understanding rivers as diverse systems and managing them according to their particular habitat characteristics and settings.

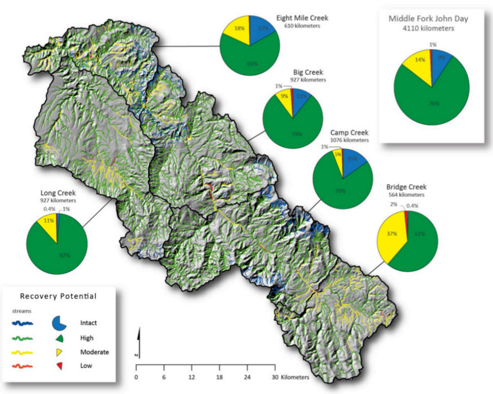
Stage 1	Stage 2	Stage 3	Stage 4
Catchment-wide baseline survey of river character, behaviour and pattern.	Catchment-framed assessment of river evolution and geomorphic condition.	Assessment of future trajectory of change and geomorphic recovery potential.	River management applications and implications.

CHaMP used the River Styles Framework as a basis for making comparisons between river types in the Columbia River Basin, predicting fish habitat suitability and prioritising conservation and rehabilitation activities. The developers found that geomorphic condition (Stage 2), when combined with River Style (reach type; Stage 1), was "likely to be the best network-scale predictor of fish habitat character in individual reaches".[1] They then used assessments of geomorphic recovery potential (Stage 3) to develop realistic visions for future habitat condition and possible management actions (Stage 4).

The River Styles Framework provided a robust geomorphic basis for 'scaling-up' ground-level assessments of physical habitat in conjunction with insights from larger-scale spatial datasets.

Integration of processes and data from the River Styles Framework with ecological and hydrological assessments in the CHaMP protocol is an excellent example of how geomorphology can be used to scaffold information and decision-making in ambitious environmental monitoring programs. CHaMP continues to support understanding fish and habitat status and trends and the evaluation of success in river rehabilitation throughout a large proportion of the 668,000 km^2 Columbia River Basin.

For more information, see: champmonitoring.org, riverscapes.xyz and joewheaton.org.



Map of recovery potential for the Middle Fork John Day Catchment, USA. *Source: O'Brien & Wheaton, 2015, River Styles Report on Middle Fork John Day Watershed, Oregon.*

References:

1. Wheaton, J. M., Bouwes, N., Mchugh, P., Saunders, C., Bangen, S., Bailey, P., Nahorniak, M., Wall, E. and Jordan, C. 2018. Upscaling site-scale ecohydraulic models to inform salmonid population-level life cycle modeling and restoration actions – lessons from the Columbia River Basin. Earth Surface Processes and Landforms, 43 (1), 21-44: https://onlinelibrary.wiley.com/doi/10.1002/esp.4137.

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Case Study

Challenge

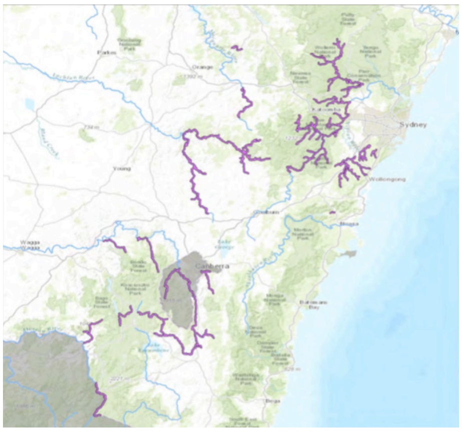
Distribution of biodiversity resources are often not well understood due to gaps in spatial data. Tools are needed that can reliably predict species distributions to support natural resource management decision making.

Solution

NSW Fisheries have developed a rigourous predictive model that integrates biological and physical data – including River Styles data – to more accurately predict distributions and status of fish communities and threatened species in NSW.

Result

Expected distributions of fish communities and threatened species have been mapped at reach scale across the state of NSW, allowing planning and decision-making processes to better account for fish communities and their habitat.



Indicative distribution of Macquarie Perch in NSW, produced using NSW Fisheries' spatial model. Source: Fish Communities and Threatened Species Distributions of NSW – NSW Fisheries.

Predicting distributions of fish communities and threatened species across NSW

It is a requirement in many jurisdictions to consider threats to biodiversity in assessment of planning proposals. However, decision-makers are often faced with problems relating to inconsistent spatial coverage of biological data, limiting their ability to assess and mitigate potential impacts on biodiversity resources.

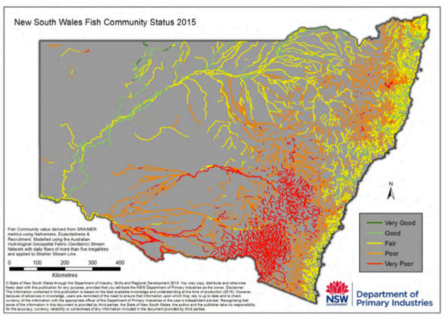
The New South Wales (NSW) Government aimed to improve the information base upon which planning decisions are made by developing maps of the distributions and status of fish communities and threatened fish species across the state, at the reach scale. Since there was not field-derived fish distribution data for all streams in the state, they developed a predictive model using physical and biological data.

The model to predict fish distribution and status integrated physical and biological data, recognising the importance of geomorphology as a 'physical template' for hydrological and ecological processes. Physical attributes of streams were sourced from the NSW River Styles database, which provided meaningful reach boundaries as well as information relevant for fish habitat.

Stage 1	Stage 2	Stage 3	Stage 4
Catchment-wide baseline survey of river character, behaviour and pattern.	Catchment-framed assessment of river evolution and geomorphic condition.	Assessment of future trajectory of change and geomorphic recovery potential.	River management applications and implications.

Data from the NSW River Styles database were from Stage 1: Catchment-wide baseline survey of river character, behaviour and pattern. The model used the attributes of 'planform' and 'bed material texture' to characterise reaches. These data were combined with available biological data to predict fish distributions based on habitat.

The NSW Government's fish communtiy and threatened species distribution mapping is available to decision-makers in a GIS resolved to the reach scale. This means that the insights are ecologically meaningful as well as being relevant for planning decisions. The result is that planning decisions in NSW can better account for potential impacts on fish communities and threatened species.



◄ Status of fish communities in NSW, produced using the integrative model. Source: Fish Communities and Threatened Species Distributions of NSW – NSW Fisheries.

Learn more about the River Styles Framework at riverstyles.com