Let's stop arguing with ourselves: a consistent approach to river classification that allows purpose driven typologies.

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Key Points

- **Communicate clearly:** Queensland needs a standard approach for describing rivers so that they can be effectively managed.
- **Clearly describe what you are using before you use it:** The development of a classification scheme before creating typologies means that a typology is based on relevant, clearly defined, quantifiable and categorised attributes.
- **Be targeted but flexible:** An attribute-based river classification provides the basis for creating multiple typologies targeted to a defined purpose.
- **Effective management requires sharing:** The Queensland River Classification Scheme (QRCS) methods and attributes have been published online; it is a free resource for everyone to use.

Abstract

To effectively manage rivers across Queensland a transparent and standardised approach is required for their classification, typing, mapping, and data collection. Such an approach provides rigor and consistency on how rivers and their variability are described, enables prioritisation on where interventions should be applied, and means consistency in communication. Addressing this need, this work outlines the development of the Interim Queensland River Classification Scheme (QRCS).

The QRCS is an attribute-based approach that initially provides a database of biophysical descriptors (attributes) of components (parts) and processes of river systems. These attributes can then be used to develop typologies for specific purposes. Each attribute has been designed to be quantifiable into categories meaningful to ecosystems, consistent with attribute-based approaches in other Queensland aquatic systems. A database of 192 attributes has been assembled within the eight themes of: biota; climate; geology; hydrology (chemical and physical); substrate (chemical and physical); and terrain. These attributes can be used to describe rivers throughout Australia. The database was informed by reviewing 30 existing pieces of literature about river classifications and typologies that contained 424 descriptors, followed by workshops with experts.

The review revealed the variability in the ways that attributes are described. Based on their similarities 342 descriptors (after removing duplicate terms) were condensed down into 46 groups, then matched to the eight themes of this classification. The reviewed classifications and typologies mainly focused on attributes in the terrain theme and were less likely to include attributes in the themes of substrate (chemical) or hydrology (chemical).

The attribute-based classification approach allows a specific purpose to be identified, and then a typology developed based on relevant attributes. This reduces the need to overextend or misapply generic riverine typologies outside their original intent. It also makes data collection fit for purpose and avoids having to start from scratch every time a new typology is needed.

Keywords
River classification, typology, attributes, biophysical, Queensland.

Introduction
Queensland's rivers are diverse because of their biophysical and anthropogenic development (Finlayson, 2010), and there can be significant variability within and between rivers (Figure 1). For example, an ephemeral multichannel river requires very different management to a large single-channel permanently flowing river. Understanding the parts (components) and processes of rivers enables optimisation of management, thereby increasing the likelihood of successful outcomes. This variability in river components and processes can be captured and described through the development and application of the Interim Queensland River Classification Scheme (QRCS). THE QRCS provides a standardised approach to the description and typing of rivers for a range of purposes.

The integration and alignment of this work with the classification schemes for other aquatic systems in Queensland (DSITI, 2015; Glanville et al, 2016; DES, 2019; DES, 2020) recognises the connectivity of aquatic ecosystems and enables whole-of-system management (DES, 2022a). The classification scheme also aligns with the Aquatic Ecosystem Rehabilitation Processes (AERP) (DESI, 2021) and Queensland River Rehabilitation Management Guideline (QRRMG) (DES 2022b), enabling the description of parts (components) of rivers as well as the description and quantification of the processes operating in them. Once identified, both components and processes can be used to identify ecosystem services and then appropriate management can be undertaken.

This paper will describe the development of a publicly accessible database of biophysical attributes that can be used to describe rivers. The process required to create attribute-based typologies will also be outlined, and in doing so highlight the differences between a typology and a classification.

Figure 1. Queensland water channels including: (A) single channel and (B) multi-channel systems, and rivers that (C) flow to the sea, and (D) flow inland. (Photos by Gary Cranitch © Queensland Museum)

How does a typology differ from a classification

Attribute classification provides definitions and categorisation, in this case biophysical components and processes (attributes) of the environment, and then collates them. This is similar to the way a kitchen would have an overall set of ingredients, and these can be used for different recipes. Each ingredient has enough detail to that it describes what it is and is usually placed alongside similar ingredients. So, flours would need to be named and described/labelled in a clear enough way so that the correct outcome would be produced from using them. Thus, self-raising flour is differentiated from plain flour, or rice flour, but they might be stored on the same shelf so they can be quickly found.

A typology is the next stage that assembles a relevant subset of attributes that suit the intended purpose. Using the cooking analogy, the typology is a recipe made with the purpose of creating an edible dish. It has a set of ingredients, suggests how ingredients are quantified, and provides a method. For the purpose of creating a sponge cake, self-raising flour, unsalted butter, caster sugar and eggs would be selected from the available ingredients in the kitchen. Onion or potatoes would not be needed, even though they might be available, as they do not fit the purpose. Describing in the method how to order the combination of ingredients results in greater consistency in the outcome of the cake.

In the case of Queensland Rivers, creating a typology without first classifying the attributes or developing a purpose can lead to misrepresentation of the environment, lack of standardisation, and misapplication outside of the intended range of use.

An attribute-based classification approach

Classification involves simplifying complex, sometimes continuous data into practical, meaningful categories. While losing some of the detail (dimension reduction), we can more easily communicate the information. For example, while there are a range of eye colours in humans, we often refer to the colour of a person’s eyes as brown, blue, grey etc., even though there is a continuum.

The attribute-based approach separates classifications, typologies and mapping (Figure 2a). This flexibility also enables the classification to deal with dynamic ecosystems, typologies can be created that are sensitive to change (for example to enable condition assessment) or insensitive to change (for example in some baseline mapping applications). The classification incorporates relevant and readily obtained measurements. It also provides the basis for the establishment of a core knowledge base from which multiple decisions can be made.

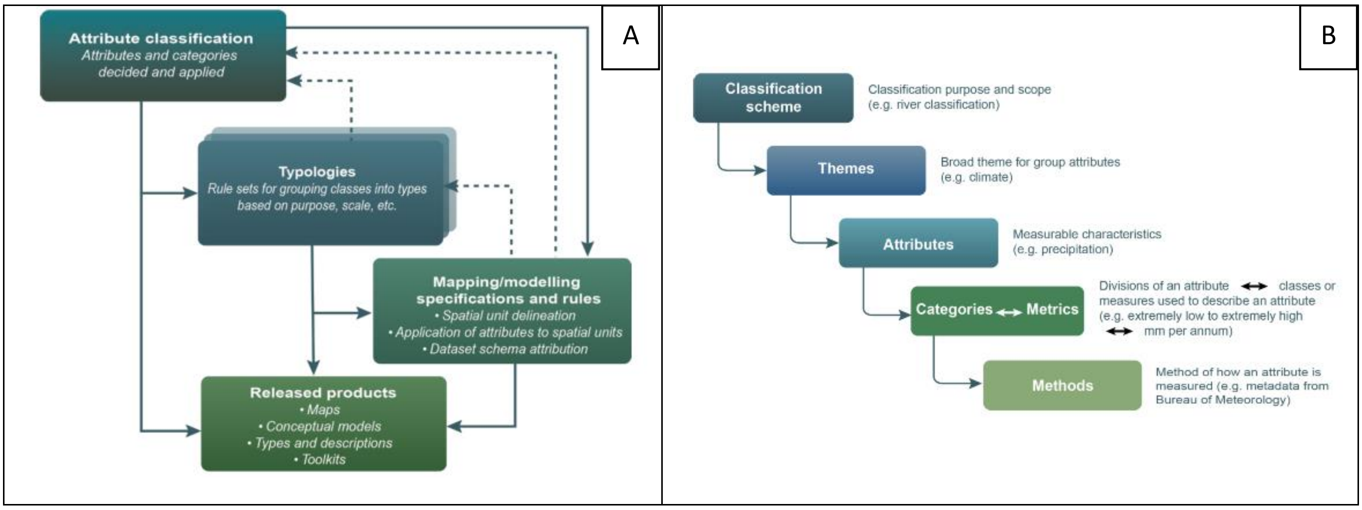

Figure 2. A) The process steps involved in developing classification and typology schemes, and B) the different key terminology used in approach (DEHP, 2017).

Themes, attributes, categories/metrics, and methods

The following descriptions and definitions provide an understanding of the processes required to develop a list of attributes before typologies can be created (Figure 2b). The **themes** are used to organise, broadly describe and group attributes together (DEHP, 2017). General themes of this classification scheme include climate, terrain, geology, substrate (physical and chemical), hydrology (physical and chemical), and biota. Geology has been included as a separate theme as it may influence several of the other themes in a variety of ways. The biota theme uses attributes of flora and fauna to describe the ecosystem rather than using them to define the ecosystem. Hence, the presence of platypus burrows may be included as ecosystem modifiers as they can change the riverbank but fauna themselves are not included, such as threatened or endangered species, as they do not define the components and processes of the ecosystem.

An **attribute** can be defined by the following criteria, with examples shown in Table 1:

- It describes a component or process of the environment that can be a physical, chemical or biological part of an aquatic ecosystem.
- It can be a mathematical / statistical indicator, or a characteristic.
- It can be broken into **categories** which are discrete. These can be measured using metrics that cover the entire possible range of the attribute, such as high, medium, low, and other. These categories can be derived based on ranges or thresholds that are ecologically or geomorphologically meaningful.
- It should be measurable, but it does not have to be mappable.
- It can be derived after preliminary mapping of an initial attribute to provide a spatial attribute that describes patterns such as “distance from”.
- It can be a **functional typology**, composed of multiple attributes (including spatial) and/or qualifiers, but only when those attributes and qualifiers are discoverable.

Table 1. Examples of attributes used within the climate theme.

Climate theme attribute	Short description	Suggested spatial level							
		Region	Subregion	Landscape	Super reach	Reach	Site	Patch	Micro-patch
Air temperature	The temperature of the air	●	●	x	x	x	●	●	●
Aridity index	Aridity index refers to an indicator of the degree of dryness of the climate at a given location based on mean annual precipitation and mean evapotranspiration.	●	●	x	x	x	x	x	x
Climate class	Climate classes represent six major groups at the regional scale considering the climatic limitations of native vegetation. Climate classes at the landscape scale refine these major groups into 27 groups considering the seasonal distribution of temperature and precipitation.	●	●	●	x	x	x	x	x

Attributes are more frequently components than processes as the former are easier to classify, quantify, and map. However, processes are still included and are considered essential for effective management. Attribute qualifiers can be used to add extra information to an attribute such as whether they have been modified or what sort of temporal periodicity they have.

The **method** used to collect the attribute data (inventory) should be described. This allows for standardisation in the measurement of inventory data. In some circumstances the categories and metrics may already be set by a standard approach, such as an Australian or International Standard.

The result of this classification rigor is that the list of attributes is standardised in its description, division, and quantification. This provides the foundation material that can be assembled to create typologies.

Describing spatial levels for river attributes

Spatial levels, or scales, can aid in creating a hierarchy within a typology. Eight different scales were chosen that attributes could be associated with (Table 2). These scales were adapted from Gurnell *et al.*, (2016), who described divisions at each scale being the result of changes in drivers or boundary characteristics. This means a new reach will start when the boundary significantly changes, or attributes of flow of water and/or sediment change. For example, this might be after a significant tributary confluence or diffluence.

Table 2. A description of the different spatial levels and their indicative spatial and temporal scales.

Spatial level	Indicative spatial scale	Indicative temporal scale	Indicative features
1. Region	>10^4 km^2	>10^4 years	Climate zones in Queensland
2. Subregion	10^2 – 10^5 km^2	10^2 – 10^5 km^2	River basins or catchments
3. Landscape	10^2 – 10^3 km^2	10^2 – 10^3 years	Sub-catchments
4. Super-reach	10^1 – 10^2 km^2	10^1 – 10^2 years	Valleys divided by different floodplains
5. Reach	10^{-1} – 10^1 km^2	10^1 – 10^2 years	Channel lengths between tributary junctions
6. Site	10^0 – 10^2 m^2	10^0 – 10^1 years	Meander wavelengths or pool riffle sequences
7. Patch	10^{-1} – 10^1 m^2	10^{-1} – 10^1 years	Riffles or pools.
8. Micro-patch	10^{-2} – 10^1 m^2	10^{-2} – 10^0 years	Areas of similar in-channel vegetation

Existing river classification attributes

Before populating the attributes for the river classification, a review (DES 2023a) was made of 30 pieces of literature with existing classifications and typologies to determine what attributes were currently used. The review was not intended to be a comprehensive literature review of river classification systems to justify and contextualise the attribute-based approach. Kondolf *et al.* (2016) and Buffington and Montgomery (2022) provide recent benchmark reviews on the state of river classification that addresses this aim. The literature that was reviewed encompassed a range of time periods, geographic locations, and applications. They were intended to highlight the range of ways of classifying and typing biophysical aspects of river systems that have been used, or well cited, both in Australia and internationally. The term river system is used to encompass the whole gamut of forms and spatial extents that a river may occupy, or be influenced by, such as surface hydrology, sediment budgets, groundwater and floodplains.

There were 424 descriptors identified as part of the review that were a range of metrics, attributes and functional typologies. Many of the descriptors used to describe and delineate rivers were different terminology to describe a similar component or process. For example, in-channel bars could be described using the descriptors: presence of bars, position of bars, active lateral bars, active point bars, or depositional features in channel. To better understand the attributes needed in a classification scheme, the 424 descriptors were reduced to 342 by taking out those that appeared identical. These were then consolidated into 46 groups based on similarities in what they were attempting to describe. There were also 15 descriptors that did not readily fit into the groups and were only used in one of the reviewed classifications. These were kept as separate individual descriptors.

The group with the most descriptors was boundary sediment, with 25 different metrics, attributes and functional typologies. These ranged from the presence or absence of different bed and bank sediment sizes, the dominant grain-size class such as sand or gravel, statistical distributions of grainsize (such as D_{50} or the percentage of different grainsize classes), the resistance and mobility of the sediment to flow, the substrate on and underlying the surface, and the amount of anthropogenic material.

The number of different descriptors in a group does not necessarily indicate its relative importance. It may indicate the lack of standardisation in the measurement of the component or processes, or that nuances are important in different applications. For example, if the classification is biologically based, the types of descriptions may differ in their intent compared to a geomorphological focus.

The groups helped to inform what attributes should be included in the classification. By arranging each group into the themes used in this river classification the gaps in the currently used attributes could also be identified (Table 3). The dominant theme was terrain with 13 different groups. While this could be the most useful attribute theme to develop channel typologies, the classification system should have the flexibility in attributes to be applied so that it can develop biophysical typologies for a range or purposes. This meant that there were gaps identified from the review that suggested extra attributes needed to be developed, especially in the climate, geology, substrate (chemical), hydrology (chemical) and biota themes.

Table 3. Attribute themes and the number of groups from the literature review within each theme.

Theme	Number of review groups
Biota	4
Climate	3
Geology	1
Hydrology (chemical)	1
Hydrology (physical)	8
Substrate (chemical)	0
Substrate (physical)	6
Terrain	13

The initial suite of QRCS attributes

The QRCS contains a complete list of attributes, their description and in some cases categorisation (DESI, 2023). The list has been compiled and published on the internet, so it is publicly accessible (Figure 3). A summary of the number of attributes and their likely spatial levels of application is shown in Table 4. A total of over 190 attributes have been developed. At the region scale climate attributes dominate. The reach and site spatial scales have the most attributes and terrain theme has the largest number at these scales.

An example of some of the climate theme attributes is shown in Table 1. A cross mark has been used to show where there is a suggested level that an attribute may be applied which is not the same as the spatial scale used to create the attribute categorisation. For example, the attribute of precipitation may be useful to understand processes and forms at the reach scale (shown with a cross) but the categories of precipitation would probably not be developed at the reach scale. Instead, the categorisation of precipitation is likely to be derived at the region and landscape scales (shown with a circle) to encompass the likely possible range that the reach could experience.

Table 4. The number of attributes developed for each theme and the spatial levels over which they may be applied. A single attribute may be used at several different spatial levels.

Theme	Total number of attributes	Number of attributes suggested at each spatial level							
		Region	Subregion	Landscape	Super reach	Reach	Site	Patch	Micro-patch
Biota	20	1	3	9	9	11	17	13	12
Climate	17	16	16	17	17	16	15	15	15
Geology	1	1	1	1	1	1	1	1	0
Hydrology (chemical)	30	0	0	1	5	28	30	29	29
Hydrology (physical)	32	4	5	8	20	24	26	18	14
Substrate (chemical)	17	0	0	0	0	17	17	17	17
Substrate (physical)	18	0	2	3	17	17	18	15	12
Terrain	57	6	16	32	56	43	40	11	7
All themes	192	28	43	71	125	157	164	119	106

Soil texture

Theme
Substrate (physical)

Attribute
Soil texture

Description
Soil texture refers to the relative proportion of clay, sand, and silt in the soil.

Rationale for use
Knowledge of the soil texture can help understand the degree of energy required to erode the soil and can also indicate the likely permeability.

References and links
Queensland wetland mapping data – Soil texture (GEO_TEXT_H)

Categories
- clay
- clay-clay
- clay-sandy clay
- clay-silty clay
- loam
- loam-loam
- loam-clay loam
- loam-sandy clay loam
- loam-silty clay loam
- loam-silty loam
- sand
- sand-sand
- sand-loamy sand
- unknown

Figure 3. An example of the online information available for attributes provided for the attribute of soil texture (https://wetlandinfo.des.qld.gov.au/wetlands/what-are-wetlands/definitions-classification/classification-systems-background/queensland-river-classification/riverine-attributes/#q=)

Conclusions

The interim Queensland River Classification Scheme (QRCS) (DES, 2023b) provides a structured system for classifying riverine ecosystems. The QRCS was developed through expert workshops and consultation involving policy makers and scientists from state, local and federal government bodies, universities, and consulting firms with input from a wide range of disciplines. It is effectively a synthesis of concepts and ideas that are currently being applied to specific areas and datasets in less transferable ways.

The strengths of this product are that it enables integration across all aquatic ecosystems where attribute-based classifications have also been developed, and it provides a classification scheme which can be used for a range of purposes rather than having significant investment every time a new classification purpose is identified. Government agencies, research organisations and consulting groups can all utilise the same classification scheme for whatever purpose they may need it for. When populating the attributes, the scheme also enables gaps to be identified where more research or data is needed across the state.

As typologies are developed for different purposes the attribute categories will be refined and new attributes created. This is why the scheme is an interim classification as it is expected to develop and grow as it is applied.

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