Aquatic ecosystems toolkit

MODULE 2:
Interim Australian National Aquatic Ecosystem Classification Framework
Version 1.0

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Citation

The Aquatic Ecosystems Toolkit is a series of documents to guide the identification of high ecological value aquatic ecosystems. The modules in the series are:

- Module 1: Aquatic Ecosystems Toolkit Guidance Paper
- Module 2: Interim Australian National Aquatic Ecosystem (ANAE) Classification Framework
- Module 3: Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE)
- Module 4: Aquatic Ecosystem Delineation and Description Guidelines
- Module 5: Integrated Ecological Condition Assessment (IECA) Framework
- *National Guidelines for the Mapping of Wetlands (Aquatic Ecosystems) in Australia*

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The publication can be accessed at <**http://www.environment.gov.au/water**>

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Abbreviations

AETG	Aquatic Ecosystems Task Group
ANAE	(Interim) Australian National Aquatic Ecosystems (Classification Framework)
ARI	Average Recurrence Interval
ASRIS	Australian Soil Resources Information System
BoM	Bureau of Meteorology
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
GDE	Groundwater-dependent Ecosystem
Geofabric	Australian Hydrological Geospatial Fabric
HAT	Highest astronomical tide
HEVAE	High Ecological Value Aquatic Ecosystems
IBRA	Interim Biogeographic Regionalisation of Australia
IMCRA	Integrated Marine and Coastal Regionalisation of Australia
LAT	Lowest astronomical tide
NISB	National Intertidal Subtidal Benthic Habitat Classification Scheme
NWI	National Water Initiative

1 Introduction

In response to requirements of the National Water Initiative (NWI), the Aquatic Ecosystems Task Group (AETG) has overseen the development of the Aquatic Ecosystems Toolkit. The toolkit provides practical tools developed to provide guidance on identifying high ecological value aquatic ecosystems (HEVAE), and mapping, classifying, delineating, describing and determining condition of aquatic ecosystems in a nationally consistent manner. The tools are also based on, and enhance, existing jurisdictional tools. Information on the toolkit, including the drivers, its potential use, and history of the toolkit development, are detailed in Module 1 of this series, the *Aquatic Ecosystems Toolkit Guidance Paper*.

Module 2 outlines the Interim Australian National Aquatic Ecosystem (ANAE) Classification Framework, which provides a nationally consistent process to classify aquatic ecosystem and habitat types within an integrated regional and landscape setting. This module can be applied in conjunction with Module 3 (*Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE)*) and/or Module 4 (*Aquatic Ecosystem Delineation and Description Guidelines*) of the Aquatic Ecosystems Toolkit. Alternatively, it can be used independently, as a process on its own. In an adaptive management context, Module 2 may be applied as part of the 'current understanding' phase (Figure 1).

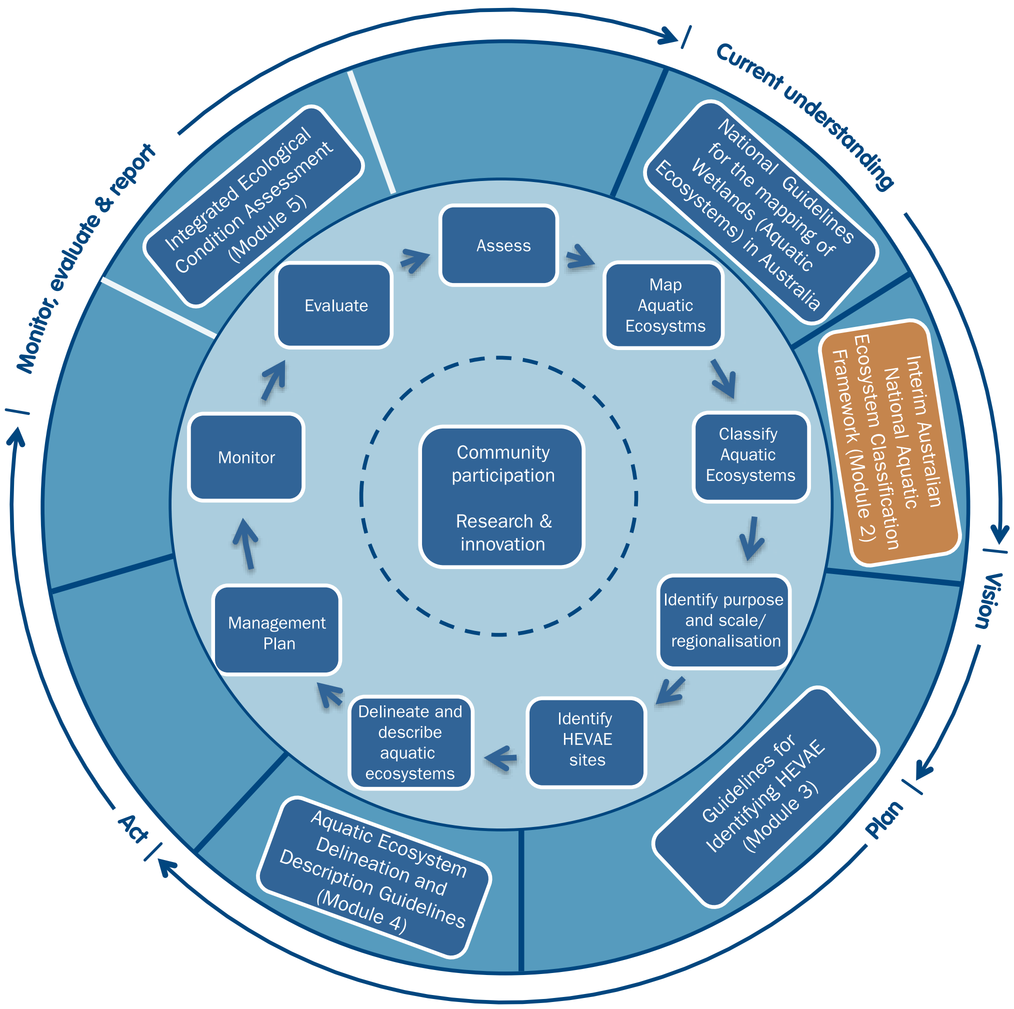


Figure 1 Potential process for implementing the Aquatic Ecosystems Toolkit within an adaptive management framework (outer and inner circles), highlighting Module 2

Glossy ibis (Jeanette Muirhead & DSEWPaC)

2 Background

Aquatic ecosystems are a ubiquitous part of the landscape. They have been described as 'inherently dynamic systems that influence and are influenced by a complex range of environmental variables and undergo cycles of wetting and drying over temporal and spatial scales' (Wetland*Info* <**http://wetlandinfo.derm.qld.gov.au/wetlands/**>). Sorting aquatic ecosystems into appropriate groups, according to their characteristics and/or ecological functioning, is a primary step in managing those systems, and for that a consistent approach for classifying them is recommended.

The tools to identify High Ecological Value Aquatic Ecosystems (HEVAE), and delineate and describe aquatic ecosystems (Modules 3 and 4 of the Aquatic Ecosystems Toolkit) require the aquatic ecosystems of the area under assessment to be classified. The Interim ANAE Classification Framework (referred to in this document as the ANAE) has been developed to meet this requirement, providing a flexible but consistent approach to classifying aquatic ecosystems that can also build on and integrate with existing classification schemes. While the ANAE has been developed to assist in the HEVAE identification process, it can also be used as an independent tool.

Broadly, the ANAE can be used to:

- support the description and identification of High Ecological Value Aquatic Ecosystems
- support assessment of the ecological significance of aquatic ecosystems
- support the identification of areas where similar processes and biodiversity may occur
- allow for a 'common language' across jurisdictions for the comparison of aquatic ecosystem information
- inform the collection of data for populating the ANAE attributes
- support the identification of appropriate indicators for monitoring purposes

- support the management of aquatic ecosystems
- support linkages with other information sources on high ecological value aquatic ecosystems (e.g. other classification schemes and mapping processes).

The ANAE builds on the attribute-based classification systems that have been applied at a jurisdictional level for lacustrine and palustrine systems in NSW, Queensland and South Australia. This flexible approach to classification has allowed for translation across jurisdictions and attribution with limited data, and can be applied to all aquatic ecosystems.

The Aquatic Ecosystems Task Group (AETG) has overseen the development of the Interim ANAE Classification Framework. It commissioned several projects to further develop and trial the ANAE and provide guidance and information for its application. Details of these projects can be found in Module 1 of the Aquatic Ecosystems Toolkit.

2.1 Concepts

Classification vs typology

Aquatic Ecosystem classification is the process of attributing with logical datasets that have been identified as being relevant to ecological functioning. Typology is an extension to classification whereby those classified aquatic ecosystems are assembled into groups for a specific purpose i.e. a naming convention. There are many different classification and typology methodologies which have been developed for different purposes (Wetland*Info* <**http://wetlandinfo.derm.qld.gov.au/wetlands/**>).

Broad-scale v point-based classification

Two broad approaches have been used for the classification of aquatic ecosystems:

- Point-based is a 'bottom-up' approach, where there is sufficient biological/ecological data and accompanying environmental information to apply a classification based on biodiversity or ecological functioning. This approach is generally the exception rather than the rule.
- A broad-scale or 'top-down' approach can be used when point-based biological/ecological data is patchy and/or incomplete. The classification is based on physical characteristics, such as the attributes of geomorphology (e.g. shape, substrate), hydrology (e.g. wetting and drying regime), chemistry (e.g. salinity regime), and vegetation, rather than detailed biodiversity or ecological functioning. By making careful assumptions, surrogate relationships between the physical characteristics, and biodiversity and ecological functioning can be drawn, although caution should be exercised as these relationships are not uniformly strong. This approach enables the classification to be appropriate for purposes other than ecological functioning.

Aquatic ecosystems

As defined in Module 1 (Aquatic Ecosystems Toolkit Guidance Paper), aquatic ecosystems are those that are:

> dependent on flows, or periodic or sustained inundation/waterlogging for their ecological integrity e.g. wetlands, rivers, karst and other groundwater-dependent ecosystems, saltmarshes, estuaries and areas of marine water the depth of which at low tide does not exceed 6 metres.

Depending on the purpose for applying the classification, the inclusion of artificial or modified waterbodies (e.g. sewage treatment ponds, canals, impoundments) may be appropriate if they are considered to provide significant ecological value. While not addressed in this framework it would be appropriate to develop attributes which address the degree of modification of aquatic systems as it might be important to distinguish such systems from one another.

3 The Interim ANAE Classification Framework

Classifications have been used widely in environmental science to order various continua of natural systems into meaningful, discrete, broadly similar and relevant groups. Examples include species taxonomy, soil horizons, geological formations, land-use, land cover, etc. (BRS 2006, Di Gregorio & Jansen 2000, Isbell 2002, NCST 2009). Classifications attempt to add order to the natural world in a systematic and logically consistent way to gain an insight into compositional sub-parts.

Developing an aquatic ecosystem classification poses unique challenges. For example, there are often different interests or drivers (e.g. ecological, geomorphological, cultural and socio-economic), and from a physical perspective no two systems are the same. In this sense diversity occurs both spatially and temporally. The need for a robust classification framework in which to understand and manage this diversity remains.

Regionalisations are a widely recognised and applied method of providing spatial frameworks that have numerous applications for the management of natural resources. Boundaries are based on the best available data. This traditionally includes broad-scale climate, physiographic patterns, and dispersal barriers e.g. drainage catchments, plus regional and finer scale data (based on distinct physiographic types, macrohabitats, etc.) which are collated and filtered to delineate or capture patterns across a variety of spatial scales. To this end, they are an accepted international tool to assist in the description of ecosystem boundaries for planning, management and policy purposes.

3.1 Structure

The Interim ANAE Classification Framework (ANAE) is a broad-scale, semi-hierarchical, attribute-based, biogeophysical framework. It has been developed under the presumption that the majority of classification requirements in Australia will be undertaken in areas with poor and patchy biological data, thus the broad-scale (top-down) approach is the most feasible way to classify aquatic ecosystems. It consists of three levels which are designed to capture the broad spatial patterns and ecological diversity of aquatic ecosystems and habitat types. Implementation of the ANAE will, in the greater part, be undertaken through mapping and spatial analysis. The structure of the framework is depicted in Figure 2.

The structure of the ANAE can logically be separated into two parts:

- Levels 1 and 2 are large scale, national regionalisations for landform, climate, hydrology, topography and water influence (e.g. Köppen, IBRA, ASRIS, OzCoasts and Smartline Maps, etc.). They provide context relative to both the regional and landscape scales and are based on collated, existing datasets and inferred patterns across a variety of spatial scales. Depending upon the size of the area to which the ANAE is being applied, attributing at these levels might not be an essential part of the classification unless the classification is an input to a wider assessment of aquatic ecosystems. The outputs from this part should provide descriptive terms e.g. arid/tropical, coastal/inland, Great Artesian Basin, estuarine/karst, that might be used to create a typology i.e. named collections of classified wetlands. This version of the ANAE does not incorporate typology although future versions may do so. The aquatic ecosystem regionalisations proposed in Level 1 and 2 of the national classification are designed to help understand complex systems and their features. They include both aquatic and terrestrial components of the landscape.
- Level 3 identifies the classes of aquatic ecosystems in the Australian landscape (surface water and subterranean), major aquatic systems based primarily on Cowardin et al. (1979), and the pool of attributes used to classify those systems into habitats. Aquatic habitats are characterised using a set of attributes selected to reflect the ecological functioning of the systems. In many applications of the ANAE, this is the part that is most likely to be implemented.

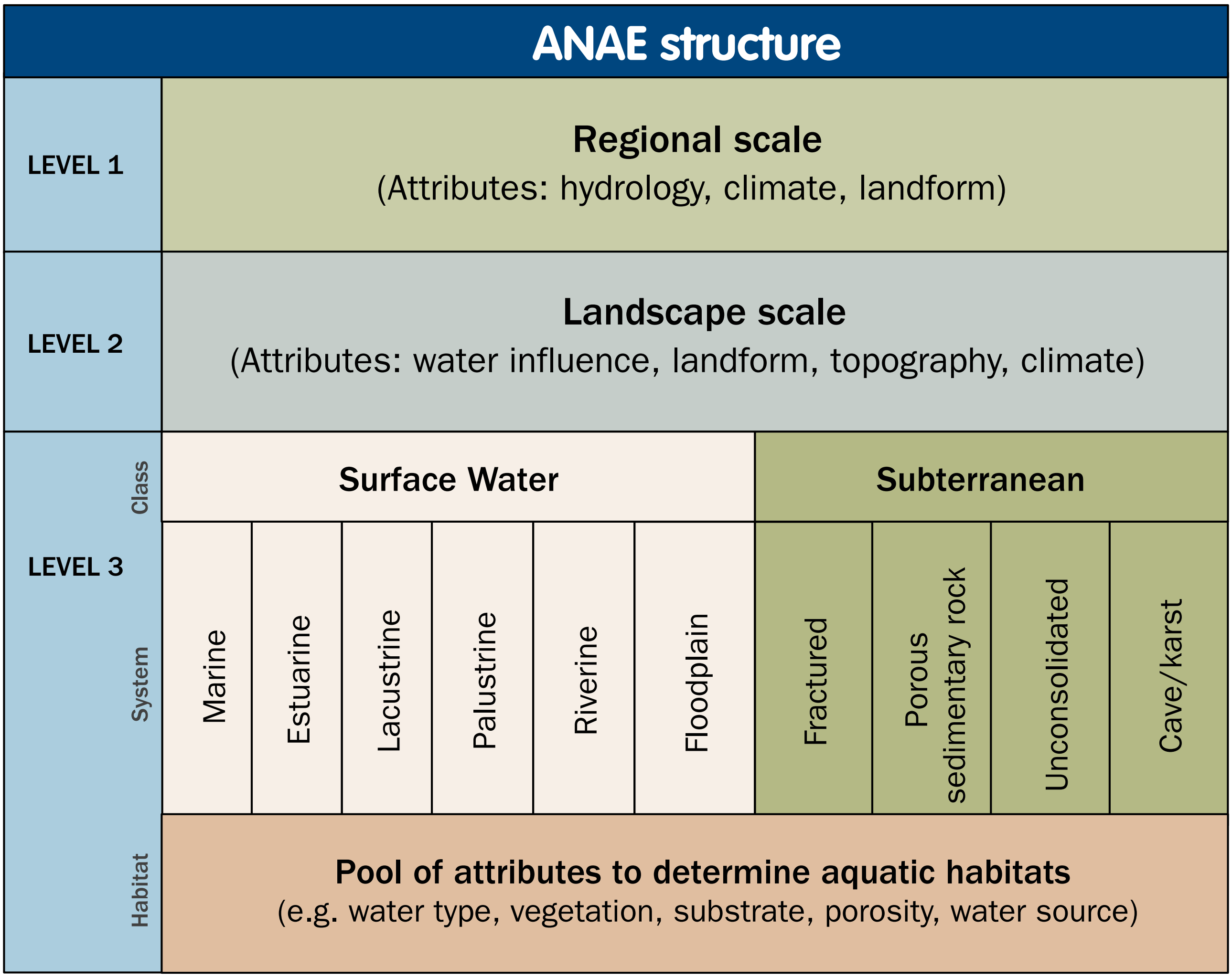


Figure 2 **Structure and levels of the Interim Australian National Aquatic Ecosystems Classification Framework**

The structure of the ANAE will promote consistency in classification while allowing flexibility through the use of a variety of different data sets to describe the attributes within the framework. The ANAE attributes should be used whenever possible, however there is the ability for the individual to determine how the attributes can be measured. Levels 1 and 2 are relatively prescriptive, solely because the existence of national datasets is limited. Level 3 has the maximum flexibility of the number and types of datasets that can be used. This approach will accommodate the various existing and appropriate datasets that each jurisdiction holds, as well as providing some direction for identifying information gaps. Tables 1, 2 and 3 (sections 3.4.1–3) provide examples of some attributes that have broad acceptance, especially for classifications undertaken for large regional or national purposes.

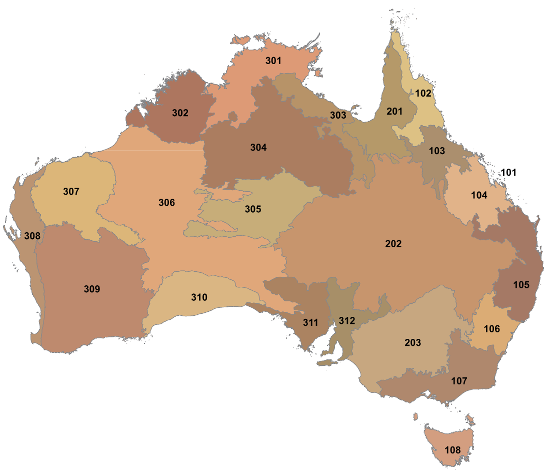
3.2 Level 1: Regional

This level uses existing broad scale, high-level regionalisations to characterise aquatic ecosystems at the national and/or regional level using datasets/spatial layers that are readily available. The intention at this level is to provide a spatial framework for broadly placing aquatic ecosystems into regions using an ecological underpinning. This provides an overall framework for subsequent finer scale levels.

Landform

Broad-scale physiographic units from existing national regionalisation datasets provide the bio-geographic and evolutionary context for aquatic ecosystems and habitats. Some examples of existing data sets that could be used to characterise landform are detailed below:

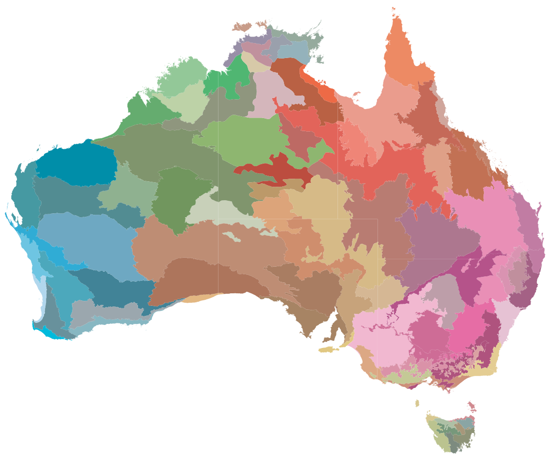
- **Physiographic Provinces of Australia** (Australian Soil Resources Information System (ASRIS)) (Figure 3). Pain et al. (2011) describe physiographic provinces as those that: 'can be compiled using landform (mountains, hills, tablelands, plains) and/or processes (erosion, deposition). The potential energy of landscapes is also important (e.g. high-energy areas have steep slopes and high relief so they will have correspondingly high rates of sediment movement). Descriptors include geology, structure, and broad regolith types. Provinces can be used to make interpretations about landscape processes at the broadest scale.'



(ASRIS; Pain et al. 2011)

Figure 3 Physiographic provinces of Australia

- **Interim Biogeographic Regionalisation for Australia** (IBRA) (Figure 4) regions are large, geographically distinct areas of land with common characteristics such as geology, landform patterns, climate, ecological features and plant and animal communities. Although a predominantly terrestrial regionalisation, IBRA may have some limited relevance.



(DSEWPaC)

Figure 4 Interim Biogeographic Regionalisation for Australia

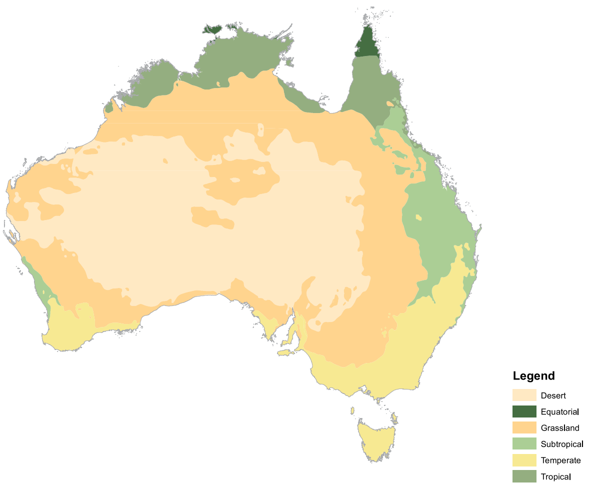
- **Integrated Marine and Coastal Regionalisation of Australia** (IMCRA) (Figure 5) provinces are based on the distribution of fish and other marine animal and habitats.

(DSEWPaC)

Figure 5 Integrated Marine and Coastal Regionalisation of Australia

Climate

Climate is the synthesis of weather observations over a long period which can be classified into zones using criteria such as rainfall, temperature and humidity. These can be considered contemporary modifiers of the biogeographic distribution and evolutionary traits of aquatic habitats, especially as they relate to quantity and seasonality. The Bureau of Meteorology (BoM) have developed an objective classification of Australian climates based on Köppen[1] (Figure 6) that potentially fulfils the requirements for the Interim ANAE Classification Framework. It recognises six principal groups of world climates that fit Level 1 of the ANAE.



(Bureau of Meteorology)

Figure 6 Climate classification of Australia

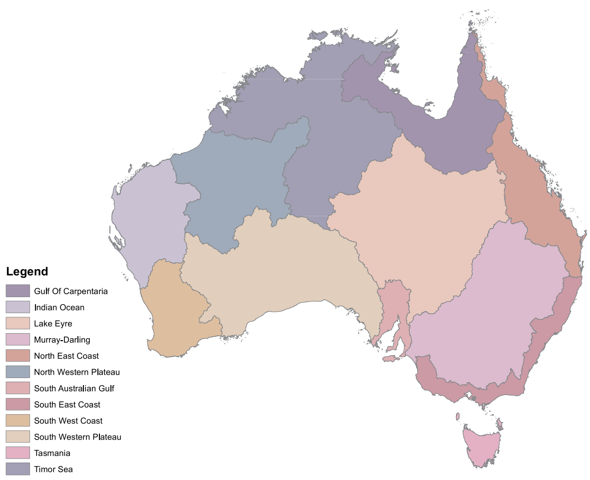
1 http://www.bom.gov.au/climate/environ/other/koppen_explain.shtml

Hydrology

Hydrology influences the form, permanency, and size of aquatic ecosystems which in turn impacts on the distribution and variation in aquatic ecosystem type, vegetation features and soil conditions. Water source and movement has a major impact on functional processes with the linkage between surface, upland, lowland, coastal, marine and subterranean systems providing a useful framework for the identification, protection and management of aquatic ecosystems.

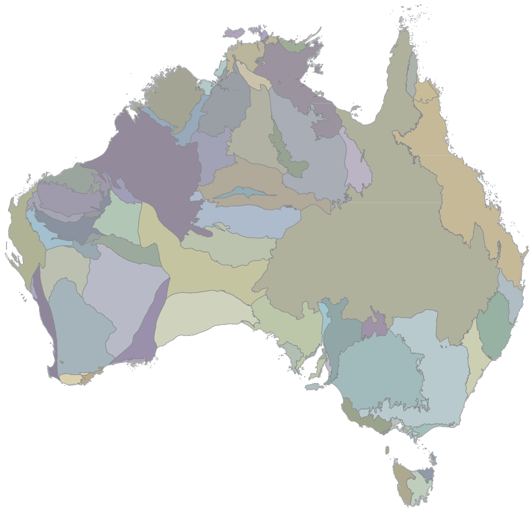
Water moving into various habitats has chemical and physical characteristics that reflect its source. For example, older groundwater generally contains chemicals associated with the geology through which it has passed, with younger groundwater generally having fewer minerals as it has had less time in contact with rocks. Given that aquatic ecosystems occur in a variety of geology and physiographic settings (and that water is a powerful driver of each system), it is prudent to assess them giving consideration to similarities in hydrology.

Broad-scale national level hydrological regionalisations which delineate catchment divisions for surface and groundwater are available from the Australian Hydrological Geospatial Fabric (Geofabric) developed by the Bureau of Meteorology (BoM) (Figures 7, 8). Additional datasets for marine currents (Figure 9) and hydrogeological divisions (Figure 10) are available from Geoscience Australia and CSIRO.



(Bureau of Meteorology)

Figure 7 Surface Water Drainage Divisions

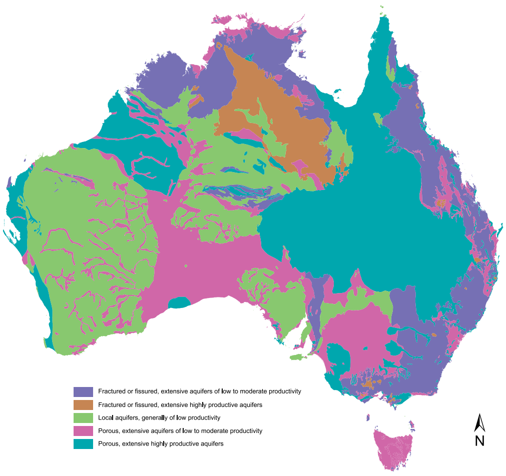


(AWR 2005)

Figure 8 Groundwater provinces

(CSIRO Australia)

Figure 9 Marine currents



(Geoscience Australia)

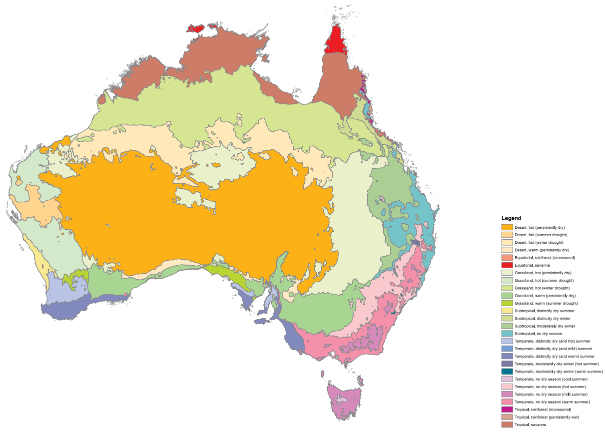
Figure 10 Hydrogeological Drainage Division

3.3 Level 2: Landscape

Level 2 Landscape is a finer-scale aquatic ecosystem regionalisation based on attributes that are relevant at a landscape scale (e.g. climate, landform, topography and water influence), providing increased contextual information and a link to existing data.

Climate

The Australian climate classification (based on the Köppen classification for climate), can be furthered separated into 27 subcategories, to provide finer climate resolution (Figure 11).



(Bureau of Meteorology)

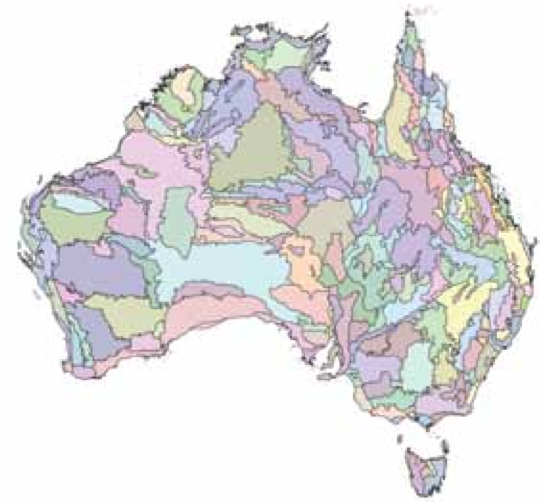
Figure 11 Climate classification sub categories

Landform

Similarly to Level 1 above, the ASRIS Physiographic regional dataset (Figure 12) can be used to characterise Landform at Level 2, as can the IBRA sub-regions (Figure 13) and the IMCRA bioregions (Figure 14). Datasets such as Geoscience Australia's OzCoasts and Smartline datasets, and the Kingsford Murray–Darling Basin extent/ inundation layer, also provide information to identify major landscapes for the classes:

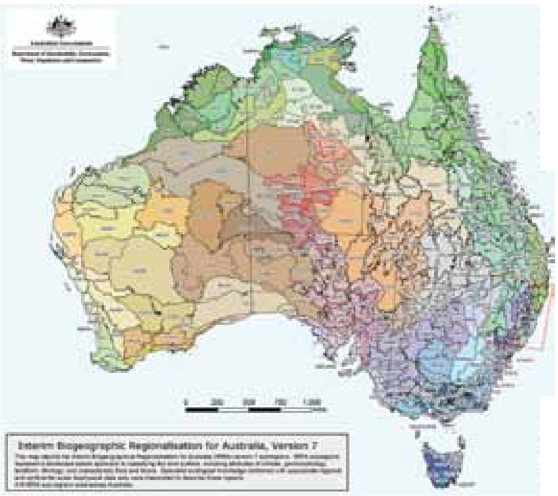
- Surface Waters (lacustrine, palustrine, riverine), to add additional contextual information regarding the landform such as floodplain/non-floodplain.

- Estuaries, to assign biophysical estuary types and catchment source.
- Marine, to integrate IMCRA and/or Smartline coastal data layers, providing contextual information to various spatial units.
- Subterranean, to assign void size to various spatial units.



(ASRIS; Pain et al. 2011)

Figure 12 Physiographic Regions of Australia



(DSEWPaC)

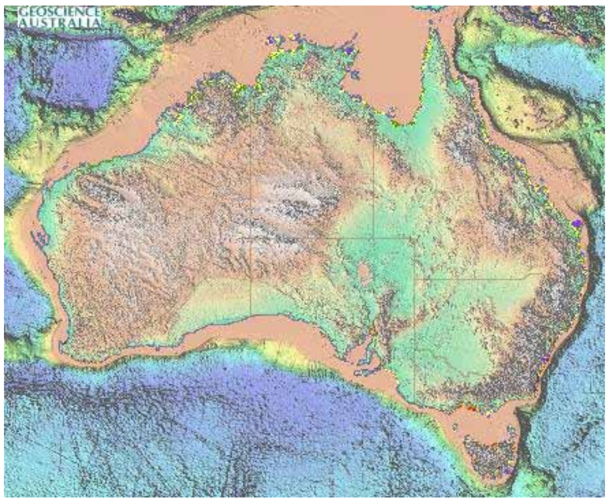
Figure 13 IBRA Sub-regions

(DSEWPaC)

Figure 14 IMCRA Bioregions

Topography

Topography has a large influence on the characteristics of aquatic ecosystems. The intention is to develop a simple topographic regionalisation to categorise the landscape into upland, slope and lowland e.g. Geofabric, Geoscience Australia's topographic dataset (Figure 15). Spatial units could be in the form of sub-catchments, or another appropriate unit at the landscape level.

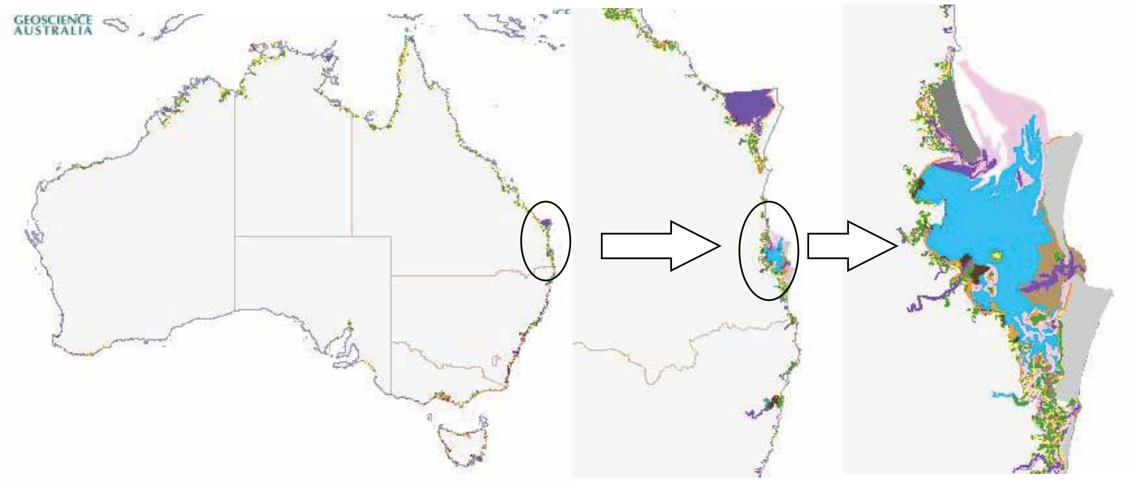


(Geoscience Australia)

Figure 15 Topography of Australia

Water influence

This attribute is included to assist in characterising estuaries as tide, wave or river-dominated and the marine environment by water movement sources i.e. prevailing currents. An appropriate dataset is the OzCoasts Smartline Maps (Figure 16).



(Geoscience Australia)

Figure 16 Example of the use of OzCoasts Smartline maps to characterise estuaries

Fivebough and Tuckerbil Swamps Ramsar site near Leeton NSW (Bruce Gray & DSEWPaC)

3.4 Level 3: Aquatic classes, systems and habitats

Level 3 focuses on those aspects of the landscape that are dependent on water. It is separated broadly into two major sections: surface waters and subterranean. These are further broken down into major aquatic systems based on Cowardin et al. (1979) for surface waters (marine, estuarine, lacustrine, palustrine, riverine and floodplain) and Tomlinson and Boulton (2008) for subterranean systems (fractured, porous sedimentary rock, unconsolidated and cave/karst). There is an understanding that these are descriptive terms for the component parts of aquatic ecosystems e.g. a lake may have lacustrine and palustrine components; an estuary may have several estuarine components including the deep-water habitat, mangroves, and saltmarsh.

The only recognised aquatic system not found on the Australian mainland and Tasmania is nival—water that is mostly frozen including snowfields and glaciers where the water regime is affected by extreme cold temperatures (Johnson & Gerbeaux 2004). Australian alpine aquatic ecosystems are adequately covered by the lacustrine, palustrine, riverine and floodplain systems.

A pool of attributes, based on ecological theory and their general use for aquatic ecosystem mapping, have been selected to characterise each system. Collectively, these attributes will identify the habitats. Descriptions of each system and their relevant attributes are below. Because many of the attributes are common to marine and estuarine systems, lacustrine, palustrine, riverine and floodplain systems, and the subterranean systems, they are dealt with under those headings. It should be noted that many of these attributes are under review, and the metrics and thresholds subject to change as the ANAE is implemented and refined.

3.4.1 Marine/Estuarine

Level 2 attribution will identify marine areas and estuaries through the application of national datasets. In order to classify these systems further (Level 3), the ANAE refers to the work of the marine and estuarine scientific community at a national workshop (*National Intertidal Subtidal Benthic (NISB) Habitat Classification Scheme* (Mount & Prahalad 2009).

For the purposes of the Interim ANAE Classification Framework, *marine* systems consist of that portion of open ocean overlying the continental shelf and its associated high-energy coastline down to a depth of 6 metres below Lowest Astronomical Tide (LAT). Marine habitats are exposed to the waves and currents of the open ocean. Shallow coastal indentations or bays (or parts thereof) without appreciable freshwater inflows, and coasts with exposed rocky islands that provide the mainland with little or no shelter from wind or waves, are also considered part of the marine system. Water regimes are determined primarily by the ebb and flow of oceanic tides, and salinities exceed 33‰ with little or no dilution outside the mouths of estuaries. (Cowardin et al. 1979; Blackman, Spain & Whitely 1992).

Estuarine systems (deep-water habitats, tidal wetlands, lagoons, salt marshes, mangroves etc.) are the component parts of estuaries i.e. those areas that are semi-enclosed by land with a permanently or intermittently open connection with the ocean, and where ocean water can be diluted by freshwater runoff from the land. Water levels inside an estuary vary in a periodic way in response to fluctuations in tides, weather patterns and freshwater inflow. Typically, estuarine systems are low-energy. The upstream boundary of an estuarine system is dependant upon the habitat and is variously described as the limit of tidal influence in the lower reaches of creeks and rivers draining into an estuary, where ocean-derived salinity is less than 0.5‰, or the Highest Astronomical Tide (HAT) mark (Creese et al. 2009; Cowardin et al. 1979). The lateral and downstream boundaries should also be considered. More information is provided on the OzCoasts[2] and Wetland*Info*[3] websites.

2 http://www.ozcoasts.gov.au/conceptual_mods/index.jsp
3 http://www.epa.qld.gov.au/wetlandinfo/site/WetlandDefinitionstart/WetlandDefinitions/Systemdefinitions.html

Attributes to classify the marine and estuarine environments were developed by expert consensus at the NISB Habitat Classification Scheme workshop for use in systems extending from the Highest Astronomical Tide (HAT) mark to the approximate outer edge of the continental shelf (i.e. approximately 200 metres deep). Marine/estuarine attributes and preliminary metrics and thresholds are detailed in Table 1. The NISB Scheme is an attribute-based structure which divides habitats according to broad substrate types (consolidated/unconsolidated) and then by whether or not they are dominated by structural macrobiota or by the substrate. A secondary set of attributes are environmental in nature and provide contextual information to enhance and extend the classification. The ANAE marine/estuarine classification is preliminary and requires more work.

3.4.2 Lacustrine/Palustrine/Riverine/Floodplain

Lacustrine systems or lakes have been described by Cowardin et al. (1979) as those aquatic ecosystems situated in a topographic depression or a dammed river channel, having sparse vegetation coverage (less than 30 percent of their coverage area is made up of vegetation such as trees, shrubs or persistent emergent vegetation), and the total area exceeds 8 hectares. Similar habitats less than 8 hectares are also included if active wave-formed or bedrock shoreline features make up all or part of the boundary, or their depth is greater than 2 metres. Ocean-derived salinity is always less than 0.5‰. This definition also applies to modified systems (e.g. dams), which possess characteristics similar to lacustrine systems.

Palustrine aquatic ecosystems, typically described as swamps, bogs, marshes and prairies, are dominated by trees, shrubs, persistent emergents, emergent mosses, and lichens (greater than 30 percent). Aquatic ecosystems that lack emergent vegetation might also be palustrine if they are less than 8 hectares, active wave-formed or bedrock shoreline features are lacking, and water depth in the deepest part of the basin is less than 2 metres at low water. As for other inland waters, salinity from ocean-derived salts is less than 0.5‰. Palustrine wetlands may be situated shoreward of lakes, river channels, or estuaries, on river floodplains, in isolated catchments, or on slopes. They may also occur as islands in lakes or rivers (Cowardin et al. 1979).

Riverine systems, for the purposes of this framework, are those systems that are contained within a channel and its associated streamside vegetation. This definition refers to both single channel and multi-channel systems. The beds of channels are not typically dominated by emergent vegetation, may be naturally or artificially created, periodically or continuously contain moving water, and may form a connecting link between two bodies of standing water. As for other inland waters, salinity from ocean-derived salts is less than 0.5‰ (Cowardin et al. 1979).

Floodplains are a difficult concept to attribute in a classification scheme. They can be described at the landscape level (Level 2 of the ANAE) and determined through large-scale datasets, and they can be associated locally with lacustrine, palustrine and riverine systems (Level 3 of the ANAE). As described above they include the 'active' floodplain areas that are intermittently inundated by the lateral overflow of riverine systems, and the flood-out areas of lacustrine and palustrine systems, by direct precipitation, or by groundwater.

When lacustrine, palustrine or riverine systems occur on a floodplain (identified through Level 2 classification), they should each be associated with the 'active' floodplain. For riverine systems, this is defined in the ANAE as that area with an average recurrence interval (ARI) of 10 years or less; for lacustrine and palustrine systems this is often called the 'flood-out' area. The riverine ARI<10 is the recommended ARI for systems in relatively natural condition, determined by broad agreement at an ANAE workshop. It was noted at the workshop that in modified systems, the ARI required to achieve the same level of flooding as natural systems could be as high as 80 years. This variation should be taken into consideration when attributing systems. It should also be noted that the ecosystem and the active floodplain or flood-out areas should be mapped separately, to accommodate different attribute thresholds.

In addition, there are some areas that fall outside the systems described above, but are still considered to be areas of floodplain with an acknowledged aquatic phase. Often these areas have terrestrial characteristics, but extreme events can initiate processes associated with the floodplain. This type of floodplain is common in the more arid areas of Australia.

Floodplains can be, physically, extremely broad e.g. the Macquarie Marshes area where the boundary between the river and the floodplain is not always clear, or quite narrow e.g. entrenched rivers. In some cases, for example where terrain is flat and rainfall intermittent, a floodplain may completely take the place of the river i.e. instead of a streambed, there is a broad flat area where water flows from time to time. This is especially prevalent in drainage basins with low relief e.g. the Lake Eyre Basin. Regardless of form or shape, all floodplains involve a complex interaction of fluvial processes with their character and evolution essentially being the product of stream power and sediment character.

From an ecological perspective, floodplains support a particularly rich array of ecosystems, both in quantity and diversity, and are extremely important from an ecosystem 'services' perspective. Wetting of the floodplain soil releases an immediate surge of nutrients, those left over from the last flood, and those that result from the rapid decomposition of organic matter that has accumulated. Many microscopic organisms thrive when floodplains are inundated and larger species enter a rapid breeding cycle. Opportunistic feeders (especially birds) enter floodplain environments during such situations to take advantage of the favourable conditions. In a nutrient sense, values peak and fall away quickly during flood periods, however the resultant surge of growth often lasts for some time. A wide variety of species grow within floodplains compared to areas outside. Floodplains are also important for connectivity, both in a hydrological and ecological context, providing corridors for flora and fauna to move between different aquatic systems.

All four systems (lacustrine, palustrine, riverine and floodplain) are likely to be found within or adjacent to each other: palustrine systems can be found around the shoreline of (or as islands in) lakes and rivers, lakes have entry and exit channels, and palustrine, lacustrine and riverine systems are common on floodplains.

The attributes to classify lacustrine and palustrine systems were based on considerable jurisdictional work developed over a number of years, and have been successfully used in those areas. The riverine attributes were developed by broad agreement at an ANAE workshop using the lacustrine/palustrine attributes as a basis. Additional work on floodplains, and several trials further informed the development of these attributes. The attributes, listed in Table 2 are, unless identified as such, pertinent to lacustrine, palustrine, riverine and floodplain systems.

3.4.3 Subterranean

Australia supports a rich array of subsurface aquatic environments ranging from the aquifers of the Great Artesian Basin to the extensive subterranean karst system which dominates aquatic environments of the Nullarbor Plain (Boulton, Humphreys & Eberhard 2003; Webb, Grimes & Osborne 2003). In the ANAE, the subterranean class is restricted to underground areas in the phreatic or saturated zone. Saturated sediments beneath and alongside rivers where surface water exchanges with groundwater (hyporheic zone) are included although the endogean (edaphic) environment, which is the soil zone separating the soil surface (epigean) from the hypogean (subsurface saturated) environment is excluded (Sket 2004). Also included are coastal phreatic habitats (saturated environments beneath the coastal surface) which are influenced by sea water e.g. anchialine caves[4], such as Bundera Sinkhole in Cape Range Peninsula, WA (Humphreys 1999); groundwater estuaries i.e. the seawater-groundwater interface (Hancock,

4 Anchialine pools/caves are a feature of coastal aquifers with a subterranean connection to the ocean. They are density stratified with the water near the surface being fresh or brackish, and saline water intruding below.

Boulton & Humphreys 2005); and drowned sea caves (Halliday 2004). Vadose (unsaturated subsurface) environments are generally excluded although aquatic habitats within certain voids in the unsaturated zone are included in the cave/karst sub-class. These include vadose caves in karst (minimum 5–15 mm diameter), and caves/voids large enough for human entry in all other substrates.

Four systems have been identified in the subterranean class based on ecological principles rather than geomorphology: fractured, porous sedimentary rock, unconsolidated, and cave/karst aquifer systems. The attributes in Table 3 were developed by broad agreement at ANAE workshops and consideration of the concurrently developed GDE Atlas classification, before undergoing trialling in south-east South Australia. The following information on each system has been derived from Tomlinson and Boulton (2008).

Unconsolidated aquifers consist of particles of gravel, sand, silt or clay that are not bound by mineral cement, by pressure or by thermal alteration of the grains (Freeze & Cherry 1979). Deposition can be by wind (aeolian aquifers, for example in sand dunes), flowing water (alluvial aquifers), or by settlement of sediment in lakes (lacustrine aquifers). On a larger scale, alluvial aquifers provide the connectivity between spatially discontinuous subterranean ecosystems and surface waters (Ward & Palmer 1994). (primary porosity).

Porous sedimentary rock aquifers are consolidated sandstone aquifers without fractures. In sedimentary rock, groundwater flow might permeate the rock matrix. Depending on the geology there can be a complex and spatially variable dual porosity environment. Fissures and joints can become enlarged solution cavities that eventually form large voids (primary porosity).

Fractured rock aquifers occur in rocks of sedimentary, igneous or metamorphic origin (secondary /dual porosity). Fissures or cracks develop along bedding planes or in zones of stress caused by pressure changes due to tectonic movement, glaciation, erosion of overburden, or rapid temperature changes (Fetter 2001). Groundwater flow follows and is stored in these fractures.

Cave/Karst describes subterranean systems with a large void size, characterised by voids greater than 5–15 mm in solutional systems, and humanly-enterable caves in others. Australian karst caves have developed most commonly in carbonate rocks where significant solution of the rock has occurred in flowing water (tertiary porosity) (Ford & Williams 2007). However, recent investigations have also described complex cave systems developed through solution of siliceous rocks (e.g. Whalemouth Cave in WA) and laterites (Grimes et al. 2009). Karst caves are hydrologically linked with a suite of surface landforms and ecosystems (such as sinkholes and springs) also developed through solution of bedrock. These distinct underground and surface landforms are produced primarily by solution in subterranean drainage, however caves and associated karst-like terrain can also develop by other processes including weathering, mass movement, hydraulic action, tectonics, meltwater and the evacuation of molten rock (lava). Because the dominant process in these cases is not solution, this suite of landforms is termed pseudokarst (Halliday 2004) e.g. the Undara Lava Tubes in north Queensland.

Table 1 Attributes, metrics and thresholds for marine and estuarine systems

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
SUBSTRATE		
Benthic diversity has complex relationships with numerous sediment variables. Research has demonstrated that percentages of substrate elements has an influence in determining the habitat of a location. (McArthur et al. 2010) The non-living seabed, divided into meaningful Udden-Wentworth Scale classes.	• Unbroken rock • Broken rock/boulder/cobble • Pebble/gravel • Sand • Silt	McArthur, M.A., Brooke, B.P., Przeslawski, R., Ryan, D.A., Lucieer, V.L., Nichol, S., McCallum, A.W., Mellin, C., Cresswell, I.D., and Radke, L.C. (2010). On the use of abiotic surrogates to describe marine benthic biodiversity. *Estuarine, Coastal and Shelf Science*, 88: 21–32. Cherry, J.A. (2011). 'Ecology of Wetland Ecosystems: Water, Substrate, and Life'. *Nature Education Knowledge* 2(1):3. <http://www.nature.com/scitable/knowledge/library/ecology-of-wetland-ecosystems-water-substrate-and-17059765>.
STRUCTURAL MACROBIOTA (SMB)		
Sessile habitat-forming species that, by their presence, increase spatial complexity and alter local environmental conditions, often facilitating a diversified assemblage of organisms (Lilley & Schiel 2006). In the marine environment this includes seagrasses, macroalgae, stromatolites, corals, sponges and other macroinvertebrates that form large enough patches to provide places for other organisms to live (Cocito 2004).	• Mangroves • Saltmarsh • Seagrass • Macroalgae • Coral • Filter feeders	Cherry, J.A. (2011). 'Ecology of Wetland Ecosystems: Water, Substrate, and Life'. *Nature Education Knowledge* 2(1):3. <http://www.nature.com/scitable/knowledge/library/ecology-of-wetland-ecosystems-water-substrate-and-17059765>. Lilley, S. E., and D. R. Schiel (2006). Community effects following the deletion of a habitat-forming alga from rocky marine shores. *Oecologia*, 148: 672–681. Cocito, S. (2004). 'Bioconstruction and biodiversity: their mutual influence'. *Scientia Marina*, 68 (Supplement 1): 137–144.

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
WATER DEPTH		
Water depth influences pressure, light penetration, the degree of carbon mineralisation in the water column and tide/wave energy at the sea floor which collectively influence the habitat and subsequent biota found at a location. (McArthur et al. 2010) Metrics have been chosen that reflect the major depth classes influencing habitat conditions.	• Supratidal • Intertidal • Subtidal – Shallow – Deep – Abyssal	McArthur, M.A., Brooke, B.P., Przeslawski, R., Ryan, D.A., Lucieer, V.L., Nichol, S., McCallum, A.W., Mellin, C., Cresswell, I.D., and Radke, L.C. (2010). On the use of abiotic surrogates to describe marine benthic biodiversity. *Estuarine, Coastal and Shelf Science*, 88: 21–32.
LIGHT AVAILABILITY		
Light availability impacts many biotic processes in the estuarine and marine environments including photosynthesis (primary productivity) and vision (e.g. colour). The photic zone has significantly higher productivity and levels of biotic activity than aphotic zones. Light availability is limiting for seagrasses at approximately 10–15% of surface incident light (Caruthers et al. 2001; Dennison et al. 1993), whereas macroalgae species can grow with light levels down below 0.1%. Critical thresholds at seabed (annual average) for seagrass, phytoplankton (1%) and benthic microalgae.	• >15%, • 5–15% • <5% OR • Photic zone • Low-light zone • Aphotic zone	Carruthers, T.J.B., Longstaff, B.J., Dennison, W.C., Abal, E.G., and Aioi, K. (2001). 'Measurement of light penetration in relation to seagrass'. In *Global Seagrass Research Methods* by F.T. Short, R.G. Coles and C.A. Short (eds). Amsterdam, Elsevier. pp 369–392. Dennison, W.C., Orth, R.J., Moore, K.A., Stevenson, J.C., Carter, V., Kollar, S. et al. (1993). Assessing water quality with submersed aquatic vegetation—habitat requirements as barometers of Chesapeake Bay health. *BioScience*, 43: 86–94.
NUTRIENT AVAILABILITY		
A major source of nutrients in wave-dominated estuaries is released from benthic sediments during decomposition. On an annual basis this far exceeds catchment sources (though in the bigger picture, the nutrients are catchment derived).	• High • Medium • Low OR • Oligotrophic • Mesotrophic • Eutrophic	Qualitative assessments of nutrient status are available for many estuaries—especially the southern part of Australia.

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
EXPOSURE		
Energy at the seabed is important. Geoscience Australia has produced an estimate of seafloor exposure for Australia based on modelling.	• Sheltered • Exposed	Hughes, M.G., and Heap, A.D. (2010). National-scale wave energy resource assessment for Australia. *Renewable Energy*, 35: 1783–1791.

Jocks Lagoon Ramsar site, Tasmania (Michelle McAulay & DSEWPaC)

Table 2 Attributes, metrics and thresholds for lacustrine, palustrine, riverine and floodplain systems

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
LANDFORM		
Whilst this attribute is dealt with at the landscape and regional levels, there is also scope to use it at the system level, particularly to address reach scale issues. It is more commonly used as a riverine attribute, but may have application to describe lacustrine and palustrine systems as well. Local landform often has a major role in influencing the environment and subsequent habitat conditions, biota etc. at a location. For example, high energy, upland and slope areas result in higher water velocity which in turn influences the types of biota that inhabit the area. Metrics have been chosen that differentiate between the major influence landform has on aquatic ecosystems at the local level.	• High Energy – Upland – Slope* • Low Energy – Upland (Plateau) – Lowland * This zone is a transitional zone between the high-energy eroding upland zone and the low-energy depositional lowland zone. It is often referred to as the 'transport' zone.	Potential sources include Nanson and Croke (1992), however could use Valley Bottom Flatness Index (VBFI) or Digital Elevation Model (DEM) to determine valley position, i.e. is energy based (slope vs flat).
CONFINEMENT (RIVERINE ONLY)		
Confinement defines the channel character of riverine systems i.e. how easily channel dimensions adjust to flow events. For example, a confined channel is usually associated with bedrock, partly confined channel is a mix of bedrock and unconsolidated sediments, and unconfined is purely unconsolidated. Unconfined channels are usually associated with floodplains. These metrics are based on River Styles. Confinement influences the type of environment and biota occurring at a location.	• Unconfined (floodplain) • Semi-confined (discontinuous floodplain) • Confined (non-floodplain)	GeoFabric, DEM River Styles <**http://www.riverstyles.com/outline_catchmentwide.php**>

<table>
<tr><th>ATTRIBUTE</th><th>METRICS AND THRESHOLDS</th><th>REFERENCES</th></tr>
<tr><td colspan="3">SOIL/SUBSTRATE</td></tr>
<tr><td>This attribute is somewhat complex, depending upon the systems being attributed

Soils are potentially powerful indicators of aquatic ecosystem dynamics because of the specific morphological features that develop in wet environments impacting directly on other system characteristics (e.g. water quality, fauna and vegetation) and can be a reflection of the physical processes occurring within the system (e.g. water inflow and water chemistry). Broad categories for soil include peat (organic), mineral (soil) and rock (non-soil).

The substrate layer refers to material lying below the soil layer that shows no pedological development. Its source may be from the parent material of the aquatic habitat or from other processes e.g. aeolian deposition. This attribute is often used as a secondary layer that may be useful in classifying various aquatic systems but is not always available or essential. The substrate layer can play a role in determining vegetation communities, water quality and connectivity with groundwater.

Where there is more infrequent wetting on, for example, floodplains, the porosity of the soil/substrate layer may be of importance.</td><td>Soils*
• Porous
– Peat (organic)
– Mineral (soil)
– Sand (non-soil)
• Non-porous
– Rock (non-soil)
Substrate
• Clay
• Sedimentary (chemical/organic)
• Sedimentary (detrital)
• Unconsolidated
• Volcanic

* The use of soils as an attribute for riverine systems is limited due to the lack of soils mapping, and the fact that the surrounding soils do not often match the soils of the riverine system.</td><td>National Committee on Soil and Terrain (2009). Australian Soil and Land Survey Field Handbook 3rd Edition (summarises more than 70 categories of the more recognisable substrate types e.g. igneous, dolerite, limestone).

Refer to ASRIS for access to soils data. In some cases access to soil information at the catchment level is important for providing additional contextual information. Such spatial information is generally available <http://www.asris.csiro.au/index_other.html>.</td></tr>
</table>

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
VEGETATION/FRINGING VEGETATION		
Dominant vegetation and non-dominant vegetation conditions contribute significantly to the habitat and biodiversity found in any location. As such vegetation has a large influence on typology and differentiating different types of aquatic ecosystems and is especially important in palustrine systems. Although this attribute is about dominant vegetation there may be situations where non-dominant vegetation is also important. There is often a difference between grass and sedge in relation to inundation frequency—especially in the rangeland/arid zone areas. In such cases it may be appropriate to split this at a lower level. Care needs to be taken however to ensure that the process is distinguishing between wetland types.	**Dominant vegetation** • Forested • Shrub • Sedge/grass/forb • No emergent vegetation	
WATER SOURCE		
Water source (along with type and regime) has a significant impact on the specific environmental conditions found at a location and therefore influences habitat and biota (along with other facets). As such, water source, type and regime contribute strongly to typology.	Dominant water source (>70%): • Surface water • Groundwater • Both surface and ground (where there is temporal dominance by one or the other) • Localised rainfall	Localised rainfall relates to non-riverine floodplains areas.

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
WATER TYPE		
As described above, water type has a major impact on both habitat conditions and biota found at a location. It also impacts on many other facets. Within the ANAE, 'water type' relates to chemistry and is influenced by the surrounding landscape (geological setting, water balance, quality, type of soils, vegetation and land use) which in turn dictates habitat of the aquatic environment. Water type information can be used to determine the 'normal' water chemistry of a waterbody. Metrics and thresholds have been chosen that provide a suitable basis for differentiating and characterising different systems. Whilst these salinity thresholds have been proposed, it is acknowledged that they may not be appropriate for some parts of the Australian landscape. They should be critically evaluated before using, and substituted with more appropriate local levels if necessary. The AETG should be notified of the changes made and their justification, to ensure that future versions of the ANAE reflect the scientific advances in this area.	1. Salinity: • Fresh (<3000 mg/L) • Brackish* (3000–5000 mg/L) • Saline (>5000 mg/L) OR 2. pH** • Acidic (<6) • Neutral (6–8) • Alkaline (>8) *Brackish may not be important for all systems. If so, change saline metric to 3000 mg/L. **pH may change with the changing hydrograph; if so, the 'normal' pH should be used.	Vegetation mapping layers are one source of remote sensing information that may be used to derive this attribute, as well as other documented ground-based information. Radke (2003, pers. comm.) proposes that more appropriate salinity thresholds are: fresh <1000 mg/L; brackish 1000–3000 mg/L; saline 3000–10000 mg/L; hypersaline > 10,000 mg/L. The calcium carbonate branchpoint occurs at ~1000–1200 mg/L in Australian waters (lac/pal/riverine). This is when calcium carbonate starts to precipitate, and causes a very major change in the ionic composition of water. New aquatic genera emerge at this time (see also Buckney & Tyler 1976). Significant ion pair formation occurs at ~10,000 mg/L, causing another major change in the ionic structure of the water and ecological transition (e.g. emergence of halobionts).

ATTRIBUTE	METRICS AND THRESHOLDS	REFERENCES
WATER REGIME		
Water regime conditions have a major influence in determining the nature and persistence of aquatic ecosystems. For example, permanent systems are often highly important in providing refugia for plants and animals during dry/drought conditions, while the unique nature of ephemeral systems, especially those in arid areas, leads to interesting endemic and highly adapted flora and fauna. As such, water regime is a key attribute used to characterise and differentiate between different habitats and ecosystems. A range of metrics and thresholds have been identified which differentiate the range of influence water regime has on aquatic ecosystems.	Presence of water*: • Permanently inundated • Seasonally inundated • Aseasonally inundated • Waterlogged*** OR** • Commonly wet (>70% of time) • Periodic inundation • Waterlogged*** * This attribute may include sub-metrics to support environmental flow assessment where data is available. Potential sub-metrics for detailed flow regime include flow to achieve inundation/commence-to-flow, duration, 10-year representation of flow etc. available from records or modelling. ** Where data is limited. Based on remote sensing plus expert knowledge. *** Included to accommodate seasonally waterlogged areas in temperate Australia and Alpine bogs etc. that are generally not inundated.	Information for this category is often derived from remote imagery to identify extent over a range of wet and dry periods. The following information is derived from Boulton and Brock (1999): • Permanent—may be static or flowing, with varying levels, however is predictably filled. • Seasonally—covers intermittent with wet and dry periods on a regular basis according to season. Such areas often have a higher flora and fauna diversity than permanently inundated areas. • Aseasonal—captures areas that alternate between wet and dry but not on a predictable basis. This includes such regimes as: – Intermittent—alternating wet and dry periods but less frequently and regularly than seasonal. – Episodic—dry most of the time with irregular wet phases that may persist for months. Annual inflow is less than minimum annual loss in 90% of years. – Ephemeral—only filled after unpredictable rainfall and runoff. Surface water dries within days of filling and seldom supports macroscopic aquatic life. • Waterlogged must have hydric soils as a minimum (and associated wetland flora and fauna).

Table 3 Attributes, metrics and thresholds for fractured, porous sedimentary rock, unconsolidated, and cave/karst aquifer systems

ATTRIBUTE	METRICS AND THRESHOLDS
CONFINEMENT	
An unconfined aquifer, or water-table aquifer, receives recharge from the land surface directly above. Ecological conditions in unconfined aquifers are responsive to rainfall and land use. A confined aquifer is overlain by a low permeability layer, so it does not receive direct recharge and is less responsive to surface conditions. Water in a confined aquifer is under pressure. A semi-confined aquifer is overlain by a lens of lower permeability material, such as a clay lens in an unconfined aquifer composed of gravel and sand.	• Unconfined (often superficial): • Depth to water table: – shallow (0–20 m) – Deep (> 20 m) • Confined • Semi-confined
DOMINANT POROSITY (AQUIFER TYPE)	
Porosity is the percentage of rock or soil that is void of material. Primary porosity consists of the spaces between grains in consolidated or unconsolidated aquifers. Secondary porosity is the void caused by fractures. Fractures may be enlarged by solution or other processes, creating large voids or conduits. This is termed tertiary porosity. Porosity determines available habitat and affects the rate of water flow.	Primary porosity dominant (porous consolidated and unconsolidated aquifer) Secondary porosity dominant (fractured rock aquifer) Tertiary porosity dominant (conduit-type aquifer [includes Karstic])

ATTRIBUTE	METRICS AND THRESHOLDS
WATER TYPE	
Water type has a major impact on both habitat conditions and biota found at a location. It also impacts on many other facets.	• Saline > 3,000 mg/L • Fresh: < 3,000 mg/L pH: – acidic (<6), – neutral (6–8) – alkaline (>8) • Stratified (a freshwater zone or lens fed by input from land area which sits above a 'denser' saline zone fed by marine water)
RESIDENCE TIME	
Residence time is the amount of time that groundwater is present in an aquifer from recharge to discharge. Residence times in deep confined aquifers may be thousands of years. In shallow unconfined aquifers in close connection with surface waters, residence time can be minutes. These differences have a large influence on the habitat conditions and subsequent biotic assemblages.	• Short (days to weeks) • Long (months to years)
DOMINANT RECHARGE SOURCES	
Recharge source determines water quality characteristics, e.g. salinity which in turn has an influence on environmental conditions and habitat. Meteoric = Contemporary—days/weeks or longer.	• Meteoric (rainfall, flood and stream source) • Non-meteoric (deep-seated, thermal and fossil groundwater) • Marine • Combination 1 & 3 (= Estuarine) • Combination 1 & 2

ATTRIBUTE	METRICS AND THRESHOLDS
SATURATION REGIME	
Saturation regime describes the extent and timing of saturation of the habitat and therefore influences ecology; over a 5–20 year time frame Unsaturated: under the current 5–20 year period is not saturated, which may be due to extraction or change in environment.	• Permanently saturated • Non-Permanent – Intermittent – Ephemeral • Unsaturated
HYDRAULIC CONDUCTIVITY	
Hydraulic conductivity is a measure of water movement through aquifers. High rates of water movement creates different habitat conditions compared to low rates and therefore influences biota occurring at a location. There is the potential for subclasses to be developed for this attribute. (Flow potential) ('K' in metres/day)	• High (> 1K) • Low (< 1K)
GROUNDWATER (GW) TO SURFACE WATER (SW) CONNECTIVITY REGIME	
Connectivity regime reflects the direction and timing of interactions between surface water and groundwater which has an influence on habitat conditions and subsequent biota. Point source relates to a single, localised or focussed point of connection. Diffuse or 'non-point source' relates to a large area or non-focussed zone of connectivity	• Permanent • Diffuse • Point source X • Gaining • Losing • Non-Permanent • Diffuse • Point source X • Gaining • Losing X • Seasonal • Episodic • Disconnected • Diffuse • Point source • Unconnected

4 Guidance on applying the ANAE

4.1 Application of attributes and metrics

For consistency at a national scale, and in cross-jurisdictional classifications for national purposes, only those attributes and metrics/thresholds presented in this document should be applied, although in some cases there might be limitations on their application due to lack of data. However, depending on the purpose and scale of application of the Interim ANAE Classification Framework, additional attributes and metrics can be selected as appropriate. Where additional attributes and/or metrics or thresholds are applied, they should be ecologically justified and recorded.

4.2 Attribution of current versus historic states

Generally, the Interim ANAE Classification Framework would be applied to the current or 'typical' state of aquatic ecosystems. However, depending on the purpose for classifying the aquatic ecosystems of a particular area, it may be more useful to apply the ANAE to their historic (or natural) state, or both. For example, if the classification is for the purposes of management and reporting, applying the ANAE to both current and historic states may determine the extent of change since European occupation, or help track future changes between reporting times.

When applying the ANAE to the current state of aquatic ecosystems, consideration should be given to the natural cycles of that aquatic ecosystem, and what would be considered 'typical'. The longer term state (or natural variability) of the aquatic ecosystem should be considered.

4.3 Outputs

It is essential that a full record of applying the Interim ANAE Classification Framework is maintained, through both a report and metadata statement.

A database containing the data and outputs for attributes and metrics should be produced. A set of spatial layers will also be developed throughout the course of applying the Interim ANAE Classification Framework, and these should be maintained along with any other supporting documentation.

The outputs of applying the Interim ANAE Classification Framework can be incorporated into other modules of the Aquatic Ecosystem Toolkit, if they are also to be applied (see Modules 3 and 4 for guidance).

4.4 Updates

The Interim ANAE Classification Framework is under constant revision. New attribute identification and recommendations following implementation will guide new versions of the framework. The current version will be available from the Department of Sustainability, Environment, Water, Population and Communities website <http://www.environment.gov.au/>.

5 Glossary

Aquatic ecosystems	Ecosystems that depend on flows, or periodic or sustained inundation/waterlogging for their ecological integrity (e.g. wetlands, rivers, karst and other groundwater-dependent ecosystems, saltmarshes and estuaries) but do not generally include marine waters (defined as areas of marine water the depth of which at low tide exceeds 6 metres, but to be interpreted by jurisdictions). For the purpose of the Aquatic Ecosystems Toolkit, aquatic ecosystems may also include artificial waterbodies such as sewage treatment ponds, canals and impoundments.
Attribute	An attribute is a mathematical or statistical indicator, or characteristic of a HEVAE criterion that provides the basis for scoring. An attribute may contain several metrics that are aggregated to provide an attribute score. It is also used in the Interim ANAE Classification Framework to describe characteristics of aquatic ecosystems in order to classify them.
Biodiversity	Biodiversity (or biological diversity) is the variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes.
Components	The physical, chemical and biological parts of an aquatic ecosystem e.g. habitat, species, genes etc.
Condition	The state or health of individual animals or plants, communities or ecosystems. Condition indicators can be physical-chemical or biological and represent the condition of the ecosystem. They may also be surrogates for pressures and stressors acting within the ecosystem.
Connectivity	Environmental connectivity consists of links between water-dependent ecosystems that allow migration, colonisation and reproduction of species. These connections also enable nutrients and carbon to be transported throughout the system to support the healthy functioning and biodiversity of rivers, floodplains and wetlands. Hydrologic and ecological links are between upstream and downstream sections of river (longitudinal connectivity) and between rivers and their floodplains (lateral connectivity).
Ecological value	Ecological value is the perceived importance of an ecosystem, which is underpinned by the biotic and/or abiotic components and processes that characterise that ecosystem. In the Aquatic Ecosystems Toolkit, ecological values are those identified as important through application of the criteria and identification of critical components and processes in describing the ecological character of the ecosystem (or another comparable process).
Ecosystem	An ecosystem is a dynamic combination of plant, animal and micro-organism communities and their non-living environment (e.g. soil, water and the climatic regime) interacting as a functional unit. Examples of types of ecosystems include forests, wetlands, grasslands and tundra (Natural Resource Management Ministerial Council 2010).

Ecosystem function	Activities or actions which occur naturally in ecosystems as a product of the interactions between the ecosystem structure and processes e.g. floodwater control, nutrient, sediment and contaminant retention, food web support, shoreline stabilisation and erosion controls, storm protection, and stabilisation of local climatic conditions, particularly rainfall and temperature.
Ecosystem services	Benefits that people receive or obtain from an ecosystem (Ramsar Convention (2005), Resolution IX.1 Annex A). The components of ecosystem services (MEA 2005) include: *Provisioning* services such as food, fuel and fresh water. *Regulating* services are the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation. *Cultural* services are the benefits people obtain through spiritual enrichment, recreation, education and aesthetics. *Supporting* services are the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit in the long term.
Endemic species	A species or higher taxonomic unit found only within a specific area.
Estuarine systems	Are those with oceanic water sometimes diluted with freshwater runoff from the land.
Floodplain	Those aquatic systems that are either seasonally or intermittently flooded flat areas that are outside the riverine channels or palustrine/lacustrine systems but that display characteristics of hydric soils or vegetation that are characteristically adapted to the seasonal or intermittent presence of water.
Flow regime	The characteristic pattern of a river’s flow quantity, timing and variability.
Groundwater	Subsurface water located in the zone of saturation in pores, fractures and cavities in rocks.
Groundwater-dependent ecosystem (GDE)	Natural ecosystems that require access to groundwater to meet all or some of their water requirements on a permanent or intermittent basis so as to maintain their communities of plants and animals, ecological processes and ecosystem services.
Habitat	The environment where an organism or ecological community exist and grows for all or part of its life.
High Ecological Value Aquatic Ecosystems (HEVAE)	For the purposes of the toolkit, HEVAE are sites, comprising one or more aquatic ecosystems, that are considered to be of high ecological value as determined by a consistent and objective process such as that provided by Module 3: *Guidelines for Identifying High Ecological Value Aquatic Ecosystems (HEVAE)*.

Lacustrine	Lacustrine systems (or lakes) are open-water dominated systems, characterised by deep, standing or slow-moving water with little or no emergent vegetation.
Metric	A metric is a specification for how an attribute will be measured. It may be binary (‘yes’ or ‘no’, ‘present’ or ‘absent’), a ranking (high, medium, low), or a number.
Palustrine	Palustrine systems are primarily shallow, vegetated, non-channel environments, including billabongs, bogs, swamps, springs, soaks etc.
Processes	Processes are the dynamic forces within an ecosystem. They include all processes that occur between organisms and within and between populations and communities, including interactions with the non-living environment that result in existing ecosystems and that bring about changes in ecosystems over time.
Refugia	A place where organisms can survive during periods of stress.
Riverine	Those systems that are contained within a channel and its associated streamside vegetation. This definition refers to both single channel and multi-channel systems e.g. braided channel networks. The beds of channels are not typically dominated by emergent vegetation, may be naturally or artificially created, periodically or continuously contain moving water, and may form a connecting link between two bodies of standing water. See Module 2 for more information.
Subterranean	Subterranean aquatic systems comprise all underground areas containing water.
Surface water	Includes water in a watercourse, lake or wetland, and any water flowing over or lying on the land after having precipitated naturally or after having risen to the surface naturally from underground.

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Freshwater wetland near Horseshoe Bay on Magnetic Island Queensland (Maryanne Humphreys & DSEWPaC)

Australian Government

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