Wetland Condition Assessment Tool (WetCAT): A Condition Assessment Tool for Measuring Event Recovery and Rehabilitation in Palustrine and Lacustrine Wetlands in Queensland

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Contents

Introduction

Wetlands are important features in the landscape and provide many services that are highly valued by humans. These services support social and cultural values, primary industries such as fishing and agriculture, store carbon, protect people and property from the effects of extreme climate events, connect the landscape, allowing for the movement of animals and plants, provide habitat, support chemical processes and life cycles that remove sediments and chemicals, and serve as biodiversity hot spots. Some wetlands are less healthy than they once were and have lost their ability to effectively deliver some services. The state of a wetland affects its ability to deliver services and is often referred to as the '**condition**' of the wetland. Assessments of wetland extent and type are different to condition assessments and need to be undertaken separately from condition assessments, as it is not possible to determine the condition of a wetland that may no longer exist.

The Wetland Condition Assessment Tool (WetCAT) has been designed as a rapid assessment method to measure the change in condition of **lacustrine** and **palustrine** wetlands in response to 1) an event such as a bushfire or flood, and/or 2) from management interventions such as rehabilitation activities. WetCAT is designed to demonstrate if a project has achieved an intended outcome, typically based on rehabilitation activities within the timeframe of the project or funding cycle and is primarily focussed on biodiversity. An assessment using WetCAT should be undertaken both before and after a management intervention (Steps 2,5 and 7 of the Aquatic Ecosystem Rehabilitation Process (AERP).

WetCAT has also been designed to undertake an assessment of threats to better understand the relationship between threats and changes to wetland condition.

WetCAT uses observations and other information, such as spatial data, mapping and other evidence, to support the assessment. The assessment method is based on indicators (Table 1), but the techniques used to score indicators can be user-defined, based on considerations such as project objectives, resourcing, expertise, existing data and techniques, funding, and regional setting. The user must be able to justify the score assigned for each indicator using the data sheets and causal links that underpin the indicator scores.

Table 1. The 12 condition indicators for each indicator theme - rating at the wetland-scale from 0 (Worst Possible Condition) to 5 (Best Possible Condition).

Water theme
C1 Water regime
C2 Water quality
Soil/sediment theme
C3 Soil surface destabilisation, erosion, or deposition
C4 Soil disturbance or compaction by humans (foot or vehicle) or hooved animals
Plant theme
C5 Vegetation cover
C6 Exotic wetland vegetation cover

Animal theme
C7 Wetland macroinvertebrate diversity and abundance
C8 Native aquatic fauna diversity
Other
C9 Litter and illegal dumping
C10 Appropriate connections for biodiversity
C11 Physical habitat requirements for fish and other vertebrates
C12 Fire impacts

The intent of the assessment method is to use indicators to 1) assess impacts from an event such as bushfire/flood/drought and 2) demonstrate the outcomes of a management intervention. For example, where feral pigs are excluded from a wetland, indicator scores for soil disturbance, wetland vegetation, and water quality are likely to improve over time, thereby leading to better biodiversity outcomes. WetCAT is not designed for integrated assessment of the condition of wetlands in a broader area and great care must be taken if this tool is to be used for this purpose. It may be possible to compare the *difference* in the score for each indicator over time for a particular polygon or wetland type (e.g., comparing the score for C3 Soil surface destabilisation against itself over time, rather than comparing the total score for all indicators) but not the total score for all indicators.

It should be noted that several indicators in WetCAT require a wetland to be compared to the condition that is understood to be **normal** for the wetland type in that geographic area. Normal is defined as the long-term state of a wetland based on long-term data and/or field experience but does not necessarily represent pre-European development. Therefore, WetCAT requires the user to have a good understanding of the wetlands that they are working with. Evidence for normal condition needs to be established, typically based on long-term data and/or field experience. Care must be taken to not assess wetlands based on a limited dataset and time period or based on perceptions from people with little knowledge of the wetlands being assessed.

Social connections, increased knowledge by local landholders and good working partnerships and collaborations, are critical to project success, however, such social indicators are not included in this biophysical assessment. Projects may need to find other methods for measuring the success of such aspects of a project.

Wetland types

The wetland type needs to be determined before commencing the assessment.

For the purposes of this assessment, it is essential to determine the **wetland type** in terms of **ecosystem type**, **habitat type** and the features within the wetland that modify the hydrology or flow of water (**hydromodifier**)[1] before any assessment is undertaken.

WetCAT is designed to compare the same type of wetland (including its water regime) over time. For example, if a wetland is hydrologically modified (e.g., a ponded pasture) it needs to be compared to others of the same type, not a pre-European type.

[1] This information is sourced from the attribute data table for the wetland polygon where available (see Wetland*Maps*). A full and current list of hydromodifiers is available on Wetland*Info*.

Where a management intervention is designed to change the wetland type, it is not possible to directly compare the 'start' and 'end' type over time, and indicators should be assessed against a predicted normal for the end type. For example, where a bund/ barrier is being altered and a system is shifting from palustrine to estuarine, the end type is **estuarine**, the indicator scores should track towards the predicted 'normal' state for the estuarine wetland.

Further details are provided in the Summary Wetland Information section of Appendix 1.

Whole-of-System, Values-Based Approach

Every wetland sits within a catchment or seascape, and it is essential to consider the wetland from a whole-of-catchment/ whole-of-system, values-based, perspective. Aquatic systems/wetlands are heavily influenced by water movement and **hydrological regimes** because the water in these systems is connected to other parts of the landscape, hence **landscape-scale factors** (the area surrounding the wetland to across the whole catchment) need to be considered in any wetland assessment process.

It is important to consider the **area surrounding the wetland (wetland surrounding area)**, that is, the area which directly influences the **wetland**. The extent of the **wetland surrounding area** is to be determined by the user, based on the landscape and wetland being assessed, but a default of **100m** from the edge of the wetland can be used. Incidental observations of the **wetland surrounding area** can be recorded on WetCAT data sheets to inform the assessment. Wetland surrounding area considerations might include activities such as clearing of vegetation or revegetation, litter or illegal dumping or clean ups, weeds or weed removal, pest animal usage or fencing. As an example, revegetation of the wetland surrounding area could result in an increased score for the WetCAT **soil/sediment destabilisation** indicator (e.g., the soil/sediment is stabler than before the revegetation), and records/observations of revegetation activities in the wetland surrounding area can be used to understand the sediment score, and causal links and justifications for scoring. Threats within the wetland surrounding area are assessed by WetCAT threat indicators, see Table 4.

The whole-of-system approach underpinning WetCAT includes **site-scale assessment** of condition, with a **wetland surrounding area -scale assessment** of **threats** and a **landscape-scale assessment** of **threats**. The broader assessment of threats contributes to a better understanding of the wetland and the relationships between changes in condition at the wetland site scale and threats acting within the wetlands surrounding area and/or at the landscape scale. Condition is assessed during the initial assessment (Step 2 of the AERP) and every assessment event thereafter, but threats can be assessed at the beginning of the project and then as required or where a change is observed or expected.

Useful links and other sources of information

More information about the importance of wetlands is available at Wetland*Info*, including information on wetland ecosystem type, habitat type and hydromodifiers, and information on the hydrology of a wetland and changes to vegetation cover through the Digital Earth Australia (DEA) Wetlands Insight Tool (QLD) on Wetland*Maps*. Managing of wetlands within the Whole-of-System, Values-Based Framework can be accessed here and WetCAT should be used at Stage 2 in the AERP and ongoing as part of Step 7. Mapping of the state's wetlands is also accessible through Wetland*Maps*, together with many other layers such as regional ecosystems, protected areas, drainage basins, groundwater dependent ecosystems, aquatic conservation assessments, and geology.

Additional information about working with First Nations people is provided in the Gurra Gurra Framework 2020-2026 (Department of Environment and Science 2020).

How to use this assessment tool

Section 1 provides guidance on wetland assessment and monitoring.

Section 2 provides details on each of the indicators and how they should be scored.

Section 3 provides a guide to completing the assessment.

Section 1 – Guidance on wetland assessment and monitoring

Wetland inventory, assessment and monitoring

Wetland **inventories** include standardised data about wetlands from available data sources or collected through surveys (Department of Environment and Science 2021). Wetland **assessments** use data from wetland inventories and analyse this data against criteria using specialised methodologies (Department of Environment and Science 2021). Wetland **monitoring** involves measuring wetland indicators over time that are known to indicate change in extent, condition, features, or **values** (Department of Environment and Science 2021). WetCAT is an assessment tool that can be used for monitoring where the assessment is repeated over time.

Develop a Condition Assessment Monitoring Plan (CAMP)

A successful condition assessment or monitoring program starts with good planning.

A **Condition Assessment Monitoring Plan** (adapted from Burrows and Scott 2020) should be developed to guide WetCAT assessments and should also be done as part of Step 5 of the AERP. The CAMP is a foundational process that describes the expected outcomes of the project, including a project map, summary wetland information (e.g., wetland system/type, regional ecosystem, and wetland habitats (including hydromodifier), and expected changes for each indicator. Importantly, it also serves as a record to inform others who may not have been involved in the design of the project or its assessment/monitoring approach, supporting understanding and underpinning logic for future assessments.

Having a CAMP for example, allows for an assessment of both the immediate response to project intervention and long-term trends of condition indicators during and following intervention and event recovery. An important aspect of the CAMP is that it distinguishes the **expected change** in condition due to management intervention or from natural recovery after an event within the context of **background variability** (i.e., threats in the wetland surrounding area and at the landscape scale as well as background variability from weather, biological and chemical processes).

See Appendix 1 for a CAMP template. Note that a CAMP may be developed as part of an overall AERP.

Where to assess

It is important to carefully consider where in the wetland to undertake an assessment, that is, the physical location for data collection. It is recognised that all projects are different, and even within one project area there may be several different project sites and assessment units. For this reason, this section provides guidance on what issues to consider when designing the assessment, allowing for flexibility to tailor the chosen method to the project context and region. With this flexibility comes a responsibility to clearly articulate the reasoning behind decisions on how sites are chosen, and the type of assessments undertaken.

It is important to partner with the First Nations people for the country on which the project is taking place and to understand how the other stakeholders and beneficiaries value the services provided by the wetland. First Nations values and interests should be considered from the conceptualisation of the project and throughout the entire project planning process. An engagement plan should also be included in the CAMP. Further information about working with First Nations people can be found in the Gurra Gurra Framework 2020-2026 (Department of Environment and Science 2020a) or other equivalent engagement strategies (e.g. an engagement strategy specific to a regional NRM group).

Wetland delineation

Wetland delineation is the act of determining the extent and boundaries of a wetland based on the presence and extent of **wetland characteristics,** such as wetland features, hydrological information, wetland vegetation (**flora**) extent, presence of wetland soils, and/or presence of wetland animals (**fauna**, e.g., fish, frogs, freshwater turtles).

Wetland locations and details can be obtained with Queensland Wetlands Mapping (displayed on Wetland*Maps*, the Queensland Globe and the digital data can be downloaded from QSpatial. These sources should be the first 'port of call' for determining the boundaries of the wetland. The suitability of these maps for use in the CAMP depends on several factors, such as the scale of the project and the scale and level of detail of the mapping undertaken in that geographic area. Available mapping should be reviewed for suitability and be ground-truthed during the field surveys where possible (e.g., based on the extent of **wetland vegetation**[2], noting that soil can be used, but is typically more time-consuming and requires specific expertise). Where the assessment determines a different boundary to the available mapping, the Queensland Herbarium should be notified of potential changes to the mapping, based on on-ground information.

Delineating the spatial extent of the wetland and project area based on up-to-date aerial imagery can be valuable for comparisons of features over time, and for developing a project map (described below). Wetland delineation can also inform the water regime and changes in wetland extent over time, where required by the project. Further information on the hydrology of a wetland and changes to vegetation cover is available on the Digital Earth Australia (DEA) Wetlands Insight Tool (QLD), available through Wetland*Maps*.

Further details on delineation are provided in Appendix 2.

Water regime

Each wetland system and type, and the plants and animals that depend on them, have evolved to suit the **water regime**[3] (duration, frequency, timing, variability, extent, and depth), **hydrology, connection to the landscape** and **water quality** of that wetland. Beyond these variations, wetlands can change in condition or state and type. The presence of water and the water regime are primary drivers of virtually all wetland processes. Understanding the water regime is important as many wetlands undergo natural, often extended, dry phases and support a suite of specially adapted organisms.

Conversely, wetlands that hold water permanently can also be valuable ecologically by providing **refugia** for flora and fauna during naturally extended dry periods or times of drought. These flora and fauna can potentially be a source of colonisers for nearby or connected **ephemeral** wetlands.

The water source of a wetland can be associated with groundwater through a **spring or general seepage**. WetCAT can be used to assess the condition of **spring-associated wetlands** (not the spring itself), excluding Great Artesian Basin (GAB) springs.[4]

[2] A description and list of wetland plants is available on Wetland*Info*.

[3] The main features of water regime include timing, frequency, duration, extent and depth and variability (Boulton and Brock 1999).

[4] GAB springs can be assessed using a spring wetland monitoring methodology. GAB springs are affected by issues such as groundwater and air pressure which have a major impact on the functioning of these springs and therefore, they require their own method.

Project map

The purpose of the project map is to identify project features to ensure that any assessment and monitoring is consistent over time and to make sure the critical features affecting the condition of the wetlands are considered. Hard copies (e.g. marked up topographic maps or imagery) can be adequate, but an updateable, electronic version using mapping software (e.g. using Queensland Globe[5], Google Maps, Google Earth, ArcGIS, QGIS) is preferred, where capabilities are available to the project.

Project maps and available satellite imagery should be generated before conducting any fieldwork. The project map and project location should be considered from a whole-of-landscape perspective and include specific **project areas** and **project sites**.

Features that may need to be shown on the project map include:

- **Wetland Features**
    - Project area and project site(s) and assessment unit(s)
    - Wetland type/mapping
    - Waterways
    - Catchment boundaries (scale dependent)
    - Geology and groundwater sources
    - Vegetation types/mapping
    - Management zones
- **Constructed Features**
    - Roads, tracks, walkways, accesses, entrances, and/or parking
    - Buildings or other structures or landmarks (e.g., signage, landowner shed)
    - Drainage, inputs, extraction points, barriers
- **Workplace health and safety considerations**
    - Hazards

Guidance on WetCAT site selection (project areas, project sites and assessment units)

WetCAT **project areas** are where the management interventions have been planned, undertaken and/or had effect or are the areas which have been affected by an event such as a bushfire, drought or flood. The **project sites** are within the project area and need to be clearly defined. The **assessment units** are within the project sites and are where the WetCAT assessments are undertaken (e.g., 10x10m quadrat and/or 100m transect).

For guidance on how to select the **project sites** and **assessment units** within the project area, refer to Appendix 2.

Digital imagery

Digital imagery, such as photo points and videos from drone transects, are a crucial part of the assessment, as they provide a powerful visual record of change over time. The key part of **photo point monitoring** is that a photo is taken at the same spot each assessment/monitoring period so that it can be compared to previous monitoring events and show any change. Taking a copy of the photo(s) from previous monitoring surveys into the field can assist with this replication.

A simple, but effective, option for digital imagery is to take a photo or conduct a drone transect at each assessment unit in each cardinal direction (north, south, east and west) from a star picket or

[5] Queensland Globe can be used to create shareable map.

other feature (e.g., rock, bridge, path, table, waypoint). *All photos should be taken in landscape format (rather than portrait format)* to maximise the coverage of the vegetation in the plot captured by the photo. Photos can also be captured using drones.

It is important to note that digital imagery may be good for capturing some parts of the wetland at a specific point in time, but photographs and other digital imagery cannot capture all aspects of a wetland (e.g., presence of weeds that are not located in within the photo frame, the hydrological cycle). Additionally, noting the stage of the hydrological cycle and/or seasonality when the imagery was captured is essential to ensure that interpretations of the photo are accurate (e.g., a photo taken during the natural dry cycle of the wetland does not necessarily signify poor condition of that wetland).

Reference sites and reference information

Understanding whether the change of an indicator is due to recovery after an event or a management intervention rather than the result of natural fluctuations can be challenging, particularly given the relatively short timeframes of many projects. A **reference site** approach is particularly challenging in wetlands because they are naturally highly variable, making it difficult to determine which reference characteristics to compare for scoring purposes. Additionally, many Australian wetlands are impacted by human activities. Further details on how to select reference sites are available in Appendix 2.

For most projects, **reference information** is the most effective way of gathering data to assist understanding of whether the change in an indicator is related to natural recovery or management interventions rather than the result of (natural/ climatic) influence.

The WetCAT process relies on reference information obtained through **desktop assessment**. For example, existing data can be used to define appropriate benchmarks, keeping in mind that the primary comparison is to compare the indicator over time at the same site in the same season (e.g., summer which typically represents a wetter season with higher rainfall, or winter which typically represents a drier season with lower rainfall, particularly in the tropics). Regional Ecosystem (RE) information can be used to inform vegetation, and Water Quality Objectives (WQOs) and Environmental Values (EVs) can be used to inform water quality where they are available at an appropriate scale. Where appropriate, normal macroinvertebrate abundance and diversity for a wetland may be informed by sampling other wetlands of equivalent type in same hydrological state.

Reference information is useful for separating climatic influences from human influences; for example, rainfall data can be used to inform the assessment of indicators such as water quantity and wetland vegetation as these indicators are directly influenced by rainfall.[6] Knowledge of antecedent climatic events will prepare the assessor to recognise the effects of drought or post-flood conditions on current wetland state.

Desktop assessment for project planning and assessment

It is important to collate background information and studies for the project area and catchment to provide reference information (as discussed above, to plan for the project, inform the CAMP and the WetCAT field assessment). The desktop assessment provides an opportunity to discover as much as possible about the wetland, its surrounding area and how it interacts with the landscape and catchment.

[6] The Bureau of Meteorology provides climatic data at weather stations and information may also be available for locations closer to the project site (e.g. landholders rain gauge).

After carrying out the desktop assessment, it should be possible to have a clear idea of how and why the wetland came to occupy its place in the landscape, the services provided by the wetland, have knowledge of the First Nations people, the other stakeholders and / beneficiaries and what, if anything, threatens its ongoing function and trajectory. It is also important to have a broad understanding of the natural, social, cultural, and economic values of the wetland and to be able to predict likely field observations.

Questions to consider

- What type of wetland is it?
- Where is it located in the catchment?
- Is there an existing Catchment Story or a Walking the Landscape?
- What is the historical use of the wetland?
- What is the hydrology/water regime of the site and surrounding area? Has it changed? Does it flood?
- Is the site groundwater fed, surface water fed, artificially fed or a combination of all?
- What is the soil type?[7]
- What species are present and how do they use the site?
- What is the wetland's conservation status under AquaBAMM?
- How do the various components and processes of the wetland work together?
- What services does the wetland provide and who are the beneficiaries of these services?
- What are the threats to the services?
- How have the values and roles of First Nations peoples and other stakeholders been considered?
- Who owns the land (e.g., free hold, farm-owned)?

Data to gather

- Available wetland maps of each wetland type in the project area and catchment (see Wetland*Maps and Mapping help*
- Wetland mapping background (Department of Environment and Science) (des.qld.gov.au))
- Regional ecosystem maps (available on Wetland*Maps* and Queensland Globe, with further details available online)
- Lists of native wetland plants and animals in the project area and catchment (e.g. macroinvertebrates, crustaceans, fish, frogs, turtles, crocodiles, birds), including species and ecosystems listed by state and Commonwealth legislation
- Groundwater dependency
- Lists of non-native species in the project area and catchment, particularly aquatic weeds and feral animals, such as pigs and dogs
- Hydrological information, such as water source, local and regional water extraction and inputs, and hydromodifiers, such as barriers and impoundments
- Extent of the wetland subject to threats, such as feral pigs, livestock, declared weeds, fire, vegetation clearing, infilling, excavation, intensive land uses, or barriers to flow and/or movement of aquatic fauna
- Conservation assessment based on AquaBAMM

[7]Landzone or soil classes defined under the Australian soil classification (CSIRO) can be used depending on the project.

- Photographic records of the site from the landowner, local council, state agencies, or others who may have them
- Historic aerial imagery of the wetland (assists with engagement with locals)
- Historical information about the wetland (e.g., lessons learned; assists with engagement with locals)
- Water Quality Objectives (WQOs) and Environmental Values (EVs) (see fact sheet).

More information on gathering and analysing background information is available on Wetland*Info*.

Conceptual models can be used to provide the framework for condition assessments and to identify **components**, **processes** and **causal links** for a wetland (i.e., the scientific underpinning for the condition and threats, Figure 1). If a project has the resources, it can be helpful to develop site specific conceptual models to show key components (e.g., water, soil/sediment, plants and animals) and processes (e.g., hydrology, erosion, nutrient runoff, introduced species movements, changed hydrological regime or other threats) and causal links associated with condition. Multiple models considering different scenarios may be required, such as 'business as usual', following management intervention, or expected seasonal variation/effects.

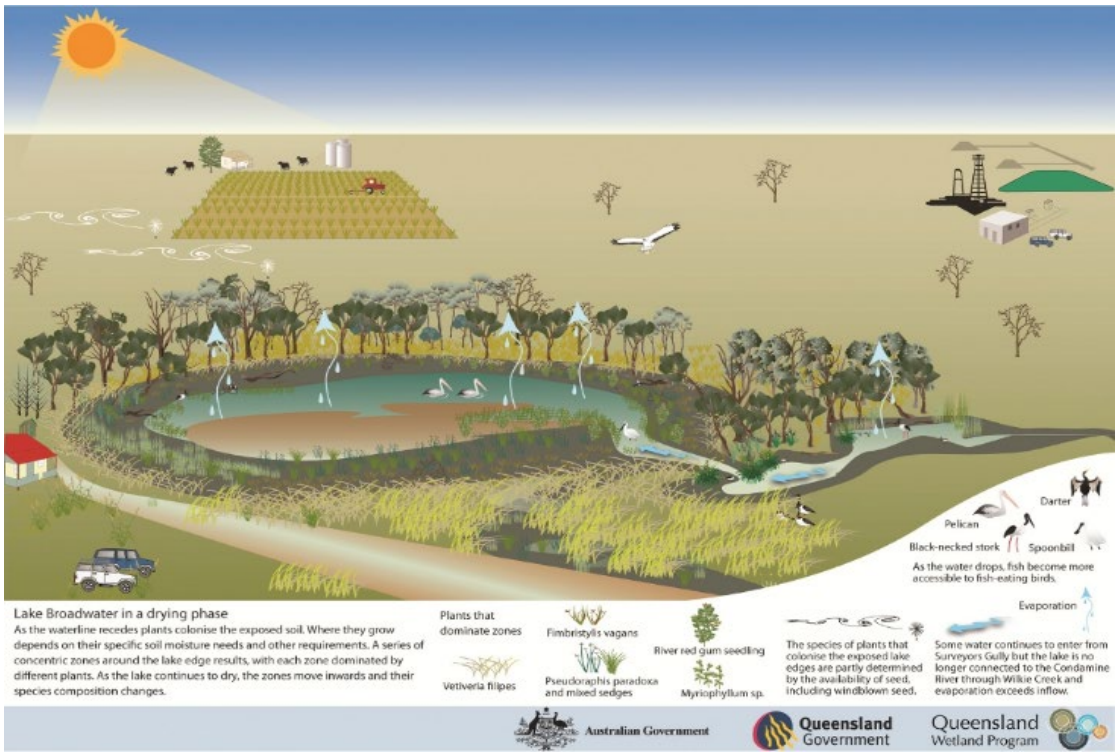

Figure 1. Basic conceptual model of a lacustrine wetland. Source: Department of environment and science, Queensland (2013b)

When to assess

A site should be assessed at least once a year, at the same (or very similar) stage of the wetland's water regime. Additionally, where feasible, a site should be assessed as soon as practicable after a management intervention or rain, flow (e.g., flood) storm, cyclone, drought or bushfire event.

It is also important to consider the timeframe in which an event or a selected management intervention should have a potential effect and design the assessment around this understanding. It is important not to assess too soon after a heavy rain/flow/storm/cyclone event as some indicators

such as water regime and quality will be affected in the short-term before 'normalising' and as such may not be reliable as indicators if scored too soon after a high flow event.

In the case of bushfires, it can be important to assess shortly after the event if the purpose is to understand the impact of fire on the system. It is important to note that fire may be normal for a wetland and thus, the timing within the fire cycle must be considered when making an assessment. The wetland may look as if it should receive a low score due to the damaged vegetation and/or soil or peat immediately after a fire, however, this may only be part of the natural cycle for the wetland.

In arid and semi-arid wetland systems, while it is important to understand the condition of these systems after a rain or flow event, it is important to note that the consistent long-term hydrological condition of these wetlands is generally one of dryness and disconnection and some areas may be dry for as long as a decade. This could make regular WetCAT assessment and monitoring in wet conditions difficult to achieve.

The number of times a site is assessed/monitored will be site and project-specific and should be justified in the CAMP/AERP. If feasible and affordable, it may be beneficial to monitor a site twice a year, capturing the early-wet and late-dry periods. These periods are when the greatest changes in a wetland would be expected due to any interventions. More frequent sampling may be required for specific indicators or occasions when there have been more targeted management interventions (e.g., a controlled discharge or stream flow occurs).

Remote sensing, (using aerial imagery or drones), or remote photo locations can be used to increase the frequency of assessment for some projects. Remote sensing as an indirect indicator for condition (i.e., biodiversity), such as vegetative cover or water quantity, should be ground-truthed, where possible.

Further details on when to assess are provided in Appendix 2.

Section 2 – Indicators

Wetland themes and indicators

WetCAT **themes** represent the four broad components that make up any wetland and a fifth (other) theme which includes indicators that may impact on the other four components:

i) Water
ii) Soil/sediment
iii) Plant
iv) Animal
v) Other.

Techniques to measure and score WetCAT indicators may be direct or indirect. Examples of direct measurements of indicators includes observations of pest species in a wetland, or water quality measures taken onsite by a water probe. Examples of indirect measurements of indicators can be evidence of pugging and algal blooms.

Scoring of WetCAT indicators may be, observational, inferred, derived from data collection methods, or from modelling. For example, algal blooms can be an indicator of nutrient enrichment of the water column, and evidence of **pugging** (the area where deformation of the soil surface has occurred as a result of hooved animals traversing the area in wet/muddy conditions; Burrows and Scott 2020) can be an indicator for the presence of pigs and other hooved animals. Water quality results from field data collect methods can provide a direct measure of a range of water quality parameters such as pH, dissolved oxygen and salinity. Field surveys can be costly, therefore choosing cost-effective indicators is an important consideration, for example, pugging or algal blooms can be captured by drone or satellite imagery (i.e., remote sensing). Sending water quality samples to laboratories for testing can be expensive. The level of confidence in the use of indicator datasets needs to be considered and recorded.

WetCAT provides several rapid assessment indicators for each theme in the following sections. Condition and threat indicator (e.g., metrics such as percent cover/impact for each indicator and distances of influence for threats) have been guided by other assessment methods, such as:

- Framework for the Assessment of River and Wetland Health (FARWH) (Storer et al. 2011)
- WETMAK: A wetland monitoring and assessment kit for community groups (Denyer and Peters 2012)
- draft Wetland Field Assessment Tool (WAFAT) (Department of Environment and Heritage Protection 2014)
- Wetland Tracker: Rapid Method for Assessing the Condition of Freshwater Wetlands in Queensland's Great Barrier Reef Catchment Area (Vandergragt et al. 2022)
- Wetland Tracker: Desktop Methods Guide (Sutcliffe et al. 2022)
- Wetland Tracker: Field Methods Guide and Workbook (Johns et al. 2022).

Indicators to provide information for more specialised assessments, such as fish communities, are not included in this method (Appendix 4).

The BioCondition Assessment Tool (BioCAT) (Burrows and Scott 2020; Eyre et al. 2015) can be used for a more detailed assessment of wetland vegetation.

Technique to assess indicators

All indicators are to be assessed even if changes due to the event or intervention are not anticipated.

It is essential to note the difference between a true zero (worst possible condition) and the lack of a score and that failure to score an indicator could affect the indicator score and suggest poor condition.

The field technique used to score the indicators (e.g., using drones, traversing the wetland, assessment from a vantage point) will need to suit regional and project settings, purposes, and challenges. It is critical that the core purpose and meaning of the indicator is retained to enable consistent interpretations over time and across projects.

Evidence base

The **evidence base** is the information gathered to support an assessment of the wetland, particularly the scores assigned to each indicator. An evidence base:

- clarifies the reasons for each indicator score
- records anecdotal and other sources of information
- helps ensure that **comparable assessment techniques** are used for subsequent assessments of the same wetland
- is an important aspect of the **quality assurance**
- must be included in the CAMP and on data sheets for each assessment.

The evidence base should be processed and archived in a manner that will support these uses and which will allow for future retrieval.

There must be **robust scientific evidence** underpinning the assigned indicator scores, such as conceptual models or established causal links. There must also be tangible evidence for a chosen score in the field and desktop assessment, such as photographs or mapping.

Several conceptual models and instructions for developing conceptual models are available on Wetland*Info*.

Overview of indicator scoring

The condition of the wetland (state) is given a **rating** for each indicator at the wetland-scale. The threat to the wetland is given a rating for each indicator at the wetland surrounding area and landscape-scale respectively. In the indicator code, 'C' denotes condition indicator (e.g., C1) whereas T-S and T-L denote threat indicator in the wetland surrounding area - or landscape-scale, respectively (e.g., T-S 5).

A score of 5 indicates the condition is the best possible for that wetland type and a score of 0 indicates the worst possible condition (Burrows and Scott 2020):

- 5 represents no disturbance to condition or ecosystem processes generally compared to what is understood to be normal[8] for that wetland type.
- 4 represents a low-level disturbance to condition, but the ecosystem is expected to maintain ongoing processes.
- 3 represents a moderate-level disturbance to condition, with a likely change in ecosystem processes (evidence may not be clear).
- 2 represents a high-level disturbance to condition with a clear change in ecosystem processes.

[8] Normal is the long-term state of a wetland based on long-term data and/or field experience but does not necessarily represent pre-European development.

- 1 represents a severe disturbance to condition, to the point where the ecosystem processes overall are barely functioning as it should.
- 0 typically represents contribution to the collapse of the wetland ecosystem for that indicator and possibly a change in wetland type.

Approximate estimates of cover are provided for some indicators to guide scoring (Table 3), but the extent to which the coverage impacts condition and ecosystem processes is likely to be wetland specific.

Confidence in indicator scoring

A confidence rating should be assigned to each indicator score to identify the level of confidence the assessor has in the score. Confidence is rated according to the level of confidence in the method that was used to score a particular indicator (adapted from Queensland Government 2015b). Details about standardised methods for sampling and data collection can be found on Wetland*Info*.

Confidence ratings for WetCAT indicator scoring are:

- known (A): According to expert knowledge **AND** supporting evidence based on an accepted, published method (e.g., AusRIVAS; qualified hydrologist has done survey of water movement)
- derived - High confidence (B): According to expert knowledge **OR** an accepted method (but no expert has verified score). This confidence rating could be used when an assessment method that would normally generate a "known" confidence rating was used, but with caveats
- derived - Moderate confidence (C): Used inadequate data sources/method combined with a strong assessment method/adequate data and/or expert knowledge
- derived - Low confidence (D): Derived from inadequate sampling methods/frequencies and/or expert has low confidence in result
- unknown confidence (E): According to expert knowledge, the confidence in the assessment method and indicator score is yet to be determined.

The degree of expert knowledge will depend on the indicator, e.g., for litter, a high degree of expert knowledge may not be required, however for macroinvertebrate knowledge a high degree of expert knowledge would be required.

More information on condition assessment methods can be found in the Assessment Toolbox on Wetland*Info*.

Wetland condition indicators

Table 3 describes how to score wetland condition using a range of observational clues and other information.

Threat indicators

A threat is something that the has the potential to cause an adverse change in a physical, chemical or biological component, process or service. A wetland threat has potential to cause harm to wetland condition

WetCAT provides for threats to be assessed in both the wetland surrounding area and at the landscape scale (Table 4). It is important to note that not all threats will cause harm, for example, not all wetlands surrounded by intensive agriculture will be adversely impacted.

Table 4 describes how to score the threats in the: 1) wetland surrounding area (T-S) and 2) the landscape-scale (T-L).

It is important to assess the threats in the wetland surrounding area because they typically have a greater potential to impact the wetland than those further away, due to proximity to the wetland and the physical (e.g., hydrological), chemical, and biological connections.

The **distance of influence** from the wetland for each of the landscape-scale threat indicators depends on the landscape and the connection of the wetland to the landscape. It should be noted that in flatter landscapes or where floodwater or groundwater provide water to a wetland from further away, the extent of influence is likely to be much larger. For example, following a major rainfall event in many basins in Queensland, flows can spread over 30 kilometres or more across the floodplain and this can be the distance of influence for indicators, such as wetland pests (e.g., seeds distributed with the water flow) or intensive land uses (e.g., sediment and contaminants distributed with the water flow).

The **threat assessment** should be undertaken as part of the desktop assessment and CAMP process, **largely in the office**, and re-visited when changes are observed or expected (e.g., field observations or mapping updates). Threats do not need to be assessed every time the wetland is assessed. Threats in the wetland surrounding area, however, may need to be assessed more regularly than those at the landscape-scale. This is because activities occurring in the wetland surrounding area are likely to have a direct impact on the adjacent wetland, whereas threats at the landscape-scale may not eventuate

Table 3. Wetland condition indicator scores and supporting information

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Water theme		
C1 Water regime	5) The **water regime** is normal for that wetland type[9] (considering seasonal change). 4) Very small to small difference to water regime for that wetland type (e.g., up to 25% change from the **end type** area/volume/level, frequency, depth, as described in the CAMP). 3) Moderate difference to water regime for that wetland type (e.g., 26-50% change). 2) Large difference to the water regime for that wetland type (e.g., 51-75% change). 1) Very large difference to the water regime for that wetland type (e.g., >76% change). 0) Complete change to the water regime for that wetland type.	• Evidence for normal needs to be established, i.e., record the estimated upper and lower limits of inundation (typically based on wetland delineation, wetland mapping, long-term data or experience from other wetland types). ***O*** • Evidence of water regime for that wetland type needs to consider the hydrological modification of the wetland not the original type. ***O*** • Need to consider **stormwater**, that is water flow following rainfall. It can be overland or piped, both of which can alter water regimes, concentrate flows, scour soils/sediments, and introduce contaminants. Alternatively, they may divert water away from wetlands. ***F*** • Wetland delineation mapping showing changes over time. ***O*** • Observations based on satellite imagery or stacked plot of hydrological and vegetation change for wetlands in Queensland where available, see Wetland*Maps.* ***O***

[9] Further information on wetland ecosystem, habitat type, and hydromodifiers are available on Wetland*Info*. This should refer to the 'end' wetland type where an intervention is designed to change the water regime, e.g., excluding pigs, removing bund walls or altering irrigation flows.

O – information collected in office; ***F*** – information collected in the field

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
		• Observation of changes to water levels at the site based on vegetation (or sediment), supported by photographic evidence of aquatic and terrestrial plants and watermarks. ***O&F*** • Observations or records of extraction of groundwater or surface water using bores or pumps. ***O&F*** • Observations can be informed by field data (e.g., loggers) and/or records of anecdotal evidence of inundation extent***. F*** • No quadrat or /transect required
Water theme		
C2 Water quality *Where more than one water quality parameter (e.g., pH, turbidity and DO) is important to the assessment, there is the option to record a score for each parameter for tracking over time. However, where more than one parameter is*	5) The **water quality** is normal for that wetland type[11]. 4) Very small to small negative difference(s) to water quality for that wetland type (e.g., up to 25% change from the recorded normal range for that wetland type). 3) Moderate negative difference(s) to water quality for that wetland type (e.g., 26-50% change). 2) Large negative difference(s) to water quality for that wetland type (e.g., 51-75% change).	• Evidence for normal needs to be established (typically based on long-term data or experience from other wetland types). ***O*** • Evidence for negative/positive change needs to be established. ***F*** • Direct measures of water quality parameters (where project-relevant and possible) such as turbidity, dissolved oxygen (DO), salinity/electrical conductivity (EC), pH, temperature, hydrocarbons, metals, ash and other contaminants (for more information see Monitoring and Sampling Manual: Environmental Protection (Water) Policy (DES 2018) or the Queensland

[11] It is important to consider the normal water type of the wetland, for example, not all turbid waters are an indication of poor water quality. Many inland rivers are naturally turbid and the animals and plants that grow in them have adapted to these conditions. For management purposes, it is important to know what the normal water type should be.
O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
*assessed, the score for this indicator should be based on a **general impression**[10] of water quality at the site, rather than an average of all the parameters and may have an emphasis on one parameter which may be relatively more important for condition.*	1) Very large negative difference(s) to water quality for wetland type (e.g., >76% change). 0) Complete change to the water quality for that wetland type.	Environmental Values (EVs) and Water Quality Objectives (WQOs) for basin-specific WQOs). ***O&F*** • Observations of water quality, where direct measurements are not possible, such as water clarity for turbidity, salt deposits or vegetation types for salinity/EC, dead or guilds of animals for DO, pH and/or temperature, slicks for hydrocarbons, algae for nutrients, odour for low DO and **anaerobic sediments**, burnt vegetation/ash as surrogate for fire, presence/absence of environmental values (EVs) based on historical use of wetlands[12]. ***F*** • Observations of direct contaminant inputs such as stormwater drains or point source inputs (e.g., drain outlet). ***F*** • Observations of non-wetland animals (e.g., cow pat). ***F*** • Observations informed by field data (e.g., water quality probe, laboratory samples, loggers). ***F*** • Litter can impact water quality but should not be included here as it has a separate indicator. • No quadrat or transect required.
Soil/sediment theme		
C3 Soil surface destabilisation, erosion, or deposition	5) No evidence of **soil/sediment surface destabilisation**, **soil/sediment erosion** or **soil/sediment erosion/deposition or excavation/removal.**	• Destabilisation, erosion, or deposition can be related to hydrological processes (e.g., soil eroded or deposited by water movement), other natural processes (e.g., heavy rainfall associated with a cyclone or sediment burnt or ash deposits due to bushfire), or rehabilitation activities

[10] General impression in QPWS&P Natural Values Health Checks (Melzer 2019), and a similar approach is also used for some indicators in Land Condition Assessment Tool (LCAT) (Hassett).

[12] For example, a lacustrine wetland that used to be used for swimming but is no longer used for that purpose could be an indication of degraded water quality within that wetland.

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	4) Evidence of destabilisation/erosion/deposition across very small to small parts of the assessment unit (e.g., up to 25% change from the recorded normal rate for that wetland type). 3) Evidence of destabilisation/erosion/deposition across several small parts or a larger part of the assessment unit (e.g., 26-50% change). 2) Evidence of destabilisation/erosion/deposition across much (e.g., 51-75% change) of the assessment unit. 1) Evidence of destabilisation/erosion/deposition across most (>76% change) of the assessment unit with evidence of impacts to condition. 0) Extensive destabilisation/erosion/deposition.	(e.g., removal of sediment with vegetation, often aquatic weeds). ***F*** • Observations of erosion and scouring can appear as receding and/or slumping banks, beds, or bars. ***F*** • Observations of excavation and in-filling. ***F*** • Observations of deposition, accretion, and/or sedimentation can appear as fine or coarse sediments (soft muds, sands), buried plants, and/or anoxic conditions. ***F*** • Observations of **sediment mobilisation** can be used to inform how sediment was destabilised (e.g., large, or small event); that is, at a dry site, large particle sizes indicate high water velocities have moved those sediments, whereas fine particle sizes indicate low velocities have moved sediment areas. ***F*** • Increased sediment availability or transport can be associated with vegetation removal, particularly following aquatic weed mat removal or after fire (e.g., *salvinia*, typha, *hymenachne*). ***F*** • Time series of aerial photography or, if funding allows coring of sediments. ***F*** • Can use quadrat or transect
Soil/sediment theme		
C4 Soil disturbance or compaction by humans	5) No evidence of **soil disturbance** and/or **soil compaction** by humans or hooved animals.	• Observation of disturbance such as pugging, **trampling**[13], digging and/or wallowing by hooved animals (e.g., cattle, pigs, goats, horses, camels,

[13] Trampling is defined as visible disturbance to the soil surface caused by hooved animals traversing the area in dry conditions (Burrows and Scott 2020).

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
(foot or vehicle) or hooved animals	4) Very small area(s) of soil disturbance and/or compaction in the assessment unit (e.g., up to <5% disturbance by humans or hooved animals). 3) Small area(s) of soil disturbance and/or compaction in the assessment unit (e.g., 6-15% disturbance). 2) Moderate to large area(s) of soil disturbance and/or compaction in the assessment unit (e.g., 16-35% disturbance). 1) Much of the wetland is disturbed and/or compacted in the assessment unit (e.g., 36-65% disturbance). 0) Most of the wetland is disturbed and/or compacted in the assessment unit (e.g., >66% disturbance).	donkeys), or compaction of sediments by humans (e.g., popular fishing or swimming areas, bicycles, vehicles) or compacted hard surfaces (e.g., roads or paths). ***F*** • May be referenced to aerial photography or drone imagery where visual evidence of soil disturbance has been mapped. ***F&O*** • Information on water points and paddock boundaries can be useful context, noting they may not influence the result. ***O*** • Small, moderate, and large to be quantified for a wetland type wetland (e.g., 25% of a shallow wetland may be more impacted than 25% of a deeper wetland). ***F*** • Can use quadrat or transect
Plant theme[14]		
C5 Vegetation cover	5) The vegetation **cover is normal** for that wetland type (includes **native** and **exotic** species). 4) Evidence of very small to small change(s) (e.g., up to 25% change from the recorded normal coverage for that wetland type) to the cover of vegetation for that wetland end type[15].	• Includes all vegetation growing in the wetland (includes native and exotic vegetation), and vegetation considered to be aquatic (submerged, emergent, floating) and terrestrial (NB this indicator is related to the **total** cover of vegetation in the wetland, and the following indicator provides for an assessment of the

[14] BioCAT (Burrows and Scott 2020; Eyre et al. 2015) can be used for a more detailed assessment of wetland vegetation, such as surrounding area vegetation.

[15] Further information on wetland ecosystem type, habitat type and hydromodifiers is available on Wetland*Info*. This should refer to the 'end' wetland type where an intervention is designed to change the waterregime, e.g., reducing cover of wetland vegetation such as weeds, or increasing cover of vegetation on the water's edge through replanting.

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	3) Evidence of moderate change(s) (e.g., 26-50% change) to the cover of vegetation for that wetland type. 2) Much (e.g., 51-75% change) of the vegetation has been changed for that wetland type. 1) Most of the vegetation has been changed (e.g., >76% change) for that wetland type. 0) Complete change to the vegetation for that wetland type.	nature of that cover in terms of being native or exotic or non-preferred). ***F*** • Evidence for normal needs to be established (typically based on satellite imagery, wetland mapping, regional ecosystem descriptions, BioCondition benchmarks, other long-term data, or experience from other wetlands of that type). ***O*** • Observations based on satellite imagery or stacked plot of hydrological and vegetation change for wetlands in Queensland where available, see WetlandMaps. ***O*** • Ensure comparison during same season. • Small, moderate, and large (much/most) changes should be quantified for a wetland type. • Can use quadrat or transect
Plant theme[16]		
C6 Exotic wetland vegetation cover	5) Exotic or non-preferred species are not evident in the wetland, including aquatic and terrestrial species. 4) Exotic or non-preferred species are evident in small area(s) (e.g., up to 5% coverage) of the wetland. 3) Exotic or non-preferred species are evident in larger area(s) (e.g., 6-33% coverage) of the wetland.	• Exotic plants can include floating weeds (e.g., *salvinia*, water hyacinth, water lettuce, exotic typha, alligator weed), emerging (e.g., pasture grasses, Singapore daisy, *hymenachne*) or terrestrial (cat's claw creeper, willow, prickly *acacia*, Noogoora burr), including **invasive plants**[17]**.** ***F*** • Observations of site-specific, **non-preferred vegetation**, which may be native, exotic, terrestrial, or aquatic. For example, phragmites and most typha are native, but can

[16] BioCAT (Burrows and Scott 2020; Eyre et al. 2015) can be used for a more detailed assessment of wetland vegetation such as surrounding area vegetation.
[17] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/weeds-diseases/invasive-plants.
O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) Exotic or non-preferred species cover much (e.g., 34-66% coverage) of the wetland. 1) Exotic or non-preferred species cover most (>67% coverage) of the wetland. 0) Exotic or non-preferred species cover the wetland.	be non-preferred where they dominate a system and influence ecology (e.g., reduce dissolved oxygen levels, alter hydrology, encourage sediment deposition, and prevent fish passage). ***F*** • Mapping from quality aerial imagery or drone footage. ***F*** • Observations can be supported by advice from and discussions with state and local government departments. • Pestinfo. ***O*** • WildNet. ***O*** • Can use quadrat or transect.
Animal theme		
C7 Wetland macroinvertebrate[18] diversity and abundance[19]	5) Evidence of normal[20] **macroinvertebrate** communities in **abundance** and **diversity.**	• Macroinvertebrate types do not need to be taxonomically identified to species, but simply identified as different types based on **morphological[22]** features

[18] Aquatic and freshwater invertebrates are sometimes categorised as microinvertebrates or macroinvertebrates. Macroinvertebrates are invertebrates that are large enough to be seen with the naked eye (DES 2018). Some common macroinvertebrates found in wetlands include dragonfly nymph, worms, snails, beetles, leeches, mayflies, caddisflies, small crustaceans (excluding macrocrustaceans included in indicator C8, such as macrobrachium, other prawns, crayfish, and freshwater crabs), and other insects. See WetlandInfo for further information.

[19] Macroinvertebrates can be found in the water column, on the surface of the substrate, or within the sediment. In the case of dry wetlands, note if the sampled invertebrates are terrestrial. Be clear about where within the wetland macroinvertebrates are being assessed.

[20] Normal macroinvertebrate abundance and diversity is influenced by the biophysical features of a wetland. For example, the hydrology of non-permanent wetlands will influence what invertebrates there are at any time. Just filled – no time to colonise, on verge of emptying – environmental conditions of wetland may become intolerable and so minimal macroinvertebrates may be present

[22] Morphological features of invertebrates refers to the physical features of an organism to a group level. See Waterwatch Murray and Government of South Australia (no date) for a key to identifying aquatic macroinvertebrates.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	4) Evidence of macroinvertebrates but slightly altered abundance OR diversity compared to normal[21]. 3) Evidence of macroinvertebrates, but altered abundance OR diversity (e.g., dominated by one type) compared to normal. 2) Evidence of macroinvertebrates, but altered abundance AND diversity compared to normal. 1) Evidence of macroinvertebrates, but very altered abundance AND diversity compared to normal (e.g., one individual macroinvertebrate). 0) Lack of macroinvertebrates in the wet (i.e., aquatic macroinvertebrates) or dry (i.e., terrestrial macroinvertebrates) wetland.	and ecological preferences[23] (e.g., high tolerance to low DO). ***F*** • Normal to be determined based on historic sampling of the wetland or that wetland type in the literature. ***O*** • Aquatic macroinvertebrates can be sampled using a dip net or bucket from the water's edge or a safe vantage point (DES 2018). ***F*** • Dry wetlands can also be assessed by sampling terrestrial invertebrates, such as ants, beetles, and spiders, using pit fall traps (Stewart et al. 2018). ***F*** • Diversity and abundance observations of live aquatic macroinvertebrates. ***F*** • iNaturalist. ***O*** • Assessments at night greatly increase the species richness and abundance detected for invertebrates. ***F*** • No quadrat or transect required.
Animal theme		
C8 Native aquatic fauna diversity *This indicator is to be assessed at the project area level given the highly*	5) Evidence of normal abundance and diversity of native aquatic vertebrate communities and typically no exotic fauna (e.g., toads, gambusia or tilapia) or non-preferred fauna (e.g., translocated native fish or crayfish). Exotic birds may be present if they do not have an adverse ecological impact.	• Normal to be determined based on historic sampling of the wetland for that wetland type in the literature. ***O*** • It is important to note some wetland types do not support diverse fauna due to natural factors, such as connectivity or habitat.

[21] If there is not enough information and/or the assessor has limited experience with identifying macroinvertebrates, scores 5, 3, and 1 should be used and justification for those scores should be recorded.

[23] Sensitivity ratings (based on SIGNAL2 system) for groups of macroinvertebrates can be found in Waterwatch Murray and Government of South Australia (no date) and Chessman (2003) for sensitivity ratings for families of macroinvertebrates.

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)

mobile nature of these species.	4) Evidence of native aquatic fauna, but slightly altered abundance OR diversity compared to normal.
	
	3) Evidence of native aquatic fauna, but altered abundance OR diversity (e.g., dominated by one or few types) compared to normal.
	
	2) Evidence of native aquatic fauna but altered abundance AND diversity compared to normal.
	
	1) Evidence of native aquatic fauna, but very altered abundance AND diversity compared to normal
	
	0) Lack of native aquatic fauna
		• NB native fauna, excluding aquatic macroinvertebrates included in indicator C7, such as:
		  ○ macrocrustaceans (*macrobrachium*, other prawns, crayfish, such as yabbies and red claw, and freshwater crabs)
		  ○ freshwater mussels
		  ○ fishes
		  ○ birds
		  ○ frogs
		  ○ turtles
		  ○ other wetland-associated reptiles (e.g., crocodiles, goannas, water dragons).
		• Observations of site-specific, non-preferred fauna, which may be native, exotic, terrestrial, or aquatic. For example, native translocated fish or crayfish. ***F***
		• WildNet. Ground-truthing where possible. ***O***
		• Assessments at night greatly increase the species richness and abundance detected for frogs. ***F***
		• No quadrat or transect required.

Other		

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
C9 Litter and illegal dumping[24]	5) No evidence of **litter**[25] or **illegal dumping**[26]**.** 4) Very minor litter (e.g., 1-2 items per quadrat), with no accumulation and no evidence of **toxic** or **dangerous** materials. 3) Minor litter or dumping, with minor accumulation and/or some evidence of toxic or dangerous materials (but impact may be unclear). 2) Obvious litter, but not extensive, with moderate accumulation and/or evidence of toxic or dangerous materials (but impact may be unclear). 1) Litter or dumping (> 200 litres in volume) is obvious, but not extensive, and includes toxic or dangerous materials, with evidence of physical impacts, such as altered water or sediment/soil quality. 0) Litter or dumping is extensive, with major accumulation and includes toxic or dangerous materials, with evidence of impacts to ecosystems, such as vegetation dieback, entanglement/dead fauna.	• Evidence of **toxic**[27] materials can include details or labels from containers indicating poison (e.g., skull and crossbones), oil slicks or slurries, hydrocarbon slicks or 'shimmering' on sediments, yellowing/dying vegetation, or dead animals. ***F*** • Evidence of **dangerous**[28] materials can include discarded fishing equipment (traps, nets, hooks, fishing line), plastic, cigarette butts, broken bottles or glass, metal, barbed wire, toilet tissue or asbestos. ***F*** • Aquatic biodiversity can be impacted by litter through ingestion of litter (e.g. birds, turtles, fish and other aquatic fauna), entanglement from discarded fishing equipment (particularly birds and turtles), toxicity associated with microplastics, nanoplastics, heavy metals, etc., fire associated with cigarette butts, habitat destruction (e.g. smothering, introduction of pest animals and plants), injury associated with sharp and broken materials, littered food, contaminated water, or other debris. ***F*** • The Litter and Illegal Dumping Management Framework (LIDMF) provides further details on assessing and monitoring litter. It is underpinned by an attribute-based classification scheme and

[24] For more information on litter and illegal dumping see https://www.qld.gov.au/environment/pollution/management/waste/litter-illegal-dumping. Indicator informed by QPWS&P Natural Values Health Checks (Melzer 2019) and Scottish Executive Environment Group (2006).

[25] Littering is the unlawful deposit of any type of waste material that is less than 200 litres in volume (about the volume of a wheelie bin) (Department of Environment and Science 2018a).

[26] Illegal dumping is the unlawful deposit of any type of waste material that is 200 litres or more in volume (about the volume of a wheelie bin) (Department of Environment and Science 2018b).

[27] Toxic refers to any substance that may have a negative biochemical effect on flora, fauna, or the wetland environment (Heads of EPA Australia and New Zealand 2020).
O – information collected in office; ***F*** – information collected in the field.

[28] Dangerous refers to any material that is harmful to and may entangle, injure, or destroy flora, fauna, or the wetland environment.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
		LIDPrograms@des.qld.gov.au should be contacted for further information on data collection.[29] ***O*** • Can use quadrat or transect.
Other		
C10-A Appropriate connections for biodiversity *C10 indicator scores have been split into A and B; only score A **or** B.* *Suffix A (C10-A), indicates systems that require connections, and involves most systems in Queensland.*	5-A) Movement of flora and fauna is **appropriate** to maintain connections of populations. 4-A) Barrier(s) to movement of flora and fauna are likely to be appropriate, but evidence is not clear (e.g., a barrier with a fishway that has not been assessed for efficiency). 3-A) Barrier(s) to movement of flora and fauna are not likely to be appropriate, but evidence is not clear (e.g., chemical barriers, such as poor water quality, have not been sampled). 2-A) Barrier(s) to movement of flora and fauna are likely to negatively influence fauna movement. 1-A) Barrier(s) to movement of flora and fauna are negatively influencing fauna movement. 0-A) Movement of flora and fauna is not appropriate to maintain populations due to barriers.	• Evidence for appropriate needs to be established, that is flora and fauna can move appropriately to maintain populations and should consider different stages of a life cycle such as breeding, spawning, nursery, grow out, etc.[30].***O&F*** • Lack of connectivity due to barriers can be used as a surrogate for flora and fauna movement (biodiversity/condition). ***F*** • Observations of barriers at the wetland (e.g., roads, railways, fences, bunds, poorly designed culverts, weed chokes, or poor water quality), which can inhibit the movement of water, aquatic flora, and aquatic fauna, such as fish and turtles (noting fences can be major barriers to turtles). ***F*** • Aerial imagery and mapping**.** ***O*** • Water use (e.g., farm dams and bunds) and linear infrastructure (e.g., roads, railways, and pipelines). ***O&F*** • Survey data. ***F*** • Observations of fish passage structures, such as fishways or fish-friendly culverts. ***F***

[29] The Litter and Illegal Dumping Compliance Operations team can be contacted for advice if concerning litter or dumping is found on site at illegaldumping@des.qld.gov.au
[30] See Wetland*Info* Connectivity and the Landscape for more information, including the Framework for evaluating aquatic ecosystem connectivity
O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
		• Effectiveness of fish passage would need to be assessed by a suitably qualified fish biologist; further information on barriers to fish passage is provided on Wetland*Info*[31]. • No quadrat or transect required.
Other		
C10-B Appropriate connections for biodiversity *C10 indicator scores have been split into A and B; only score A **or** B.* *Suffix B (C10-B) indicates systems that need fewer connections or disconnections from other systems. This could include species such as threatened or endemic species that require isolation. For example, honey blue eye, Oxleyan pygmy perch,*	5-B) Movement of flora and fauna is appropriate to maintain populations. 4-B) Natural barrier(s) to movement of fauna are likely to be appropriate, but evidence is not clear (e.g., natural disconnections/barriers in place but populations have not been sampled). 3-B) Natural barrier(s) to movement of fauna are likely to be inappropriate or modified, but evidence is not clear (e.g., natural disconnections/barriers have been altered but populations have not been sampled). 2-B) Modified natural barrier(s) to movement of fauna are likely to be influence fauna movement (e.g., fish are likely to be entering a pool that would not naturally be accessible due to a rock bar or similar natural barrier). 1-B) Modified natural barrier(s) to movement of fauna are influencing fauna movement (e.g., fish are entering a pool that would not naturally be accessible).	• Evidence for appropriate needs to be established, that is flora and fauna can move appropriately to maintain populations[32]. ***O&F*** • Observations of barriers at the wetland (e.g., roads, railways, fences, bunds, poorly designed culverts, weed chokes, or poor water quality), which can inhibit the movement of water, aquatic flora, and aquatic fauna, such as fish and turtles (noting fences can be major barriers to turtles). ***F*** • Aerial imagery and mapping. ***O*** • Water use (e.g., farm dams and **bunds**) and linear infrastructure (e.g., roads, railways, and pipelines). ***O&F*** • Survey data. ***O*** • Observations of fish passage structures such as fishways or fish-friendly culverts. ***F***

[31] https://wetlandinfo.des.qld.gov.au/resources/static/pdf/resources/fact-sheets/fs-aewrr-20200715-final.pdf
See Wetland*Info* Connectivity and the Landscape for more information, including the Framework for evaluating aquatic ecosystem connectivity
O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
freshwater crabs, colour morphs of rainbowfish, or spring or lake systems which are naturally isolated and protected from predatory exotic fish, such as mosquitofish.	0-B) Movement of flora and fauna is not appropriate to maintain populations due to modified natural barriers.	• Effectiveness of fish passage would need to be assessed by a suitably qualified fish biologist; further information on barriers to fish passage is provided on Wetland*Info*[33]. • No quadrat or transect required.
Other		
C11 Physical habitat requirements for fish and other vertebrates	5) Evidence of normal physical **habitat** (structure) for fish and other vertebrates is present, noting some wetland types do not necessarily support diverse or abundant fauna due to natural factors such as connectivity or habitat (e.g., some wetlands are naturally low in nutrients). 4) Evidence of normal habitat for fish and other vertebrates; however, the condition of that habitat may be impacted (e.g., overhanging banks that are eroding or **slumping**, sand banks with minor accumulation of sediments). 3) Evidence of normal habitat for fish and other vertebrates; however, the condition of that habitat is degraded. 2) Habitat requirements for fish and other vertebrates are likely (e.g., turbid water, but woody debris has been seen at lower water levels). 1) Habitat requirements for fish and other vertebrates are not likely.	• Normal to be determined based on historic sampling of the wetland or that wetland type or in the literature. ***O&F*** • Observations of habitat types such as **refugia**, feeding or breeding habitat for fish or other vertebrates, such as frogs, turtles, crocodiles, goannas, and water dragons (e.g., woody debris, instream vegetation, overhanging banks, sand banks and the water itself (e.g., water holes). ***F*** • Species habitat mapping and information about habitat requirements, including species recovery plans***. O*** • No quadrat or transect required for fish. • Can use quadrat or transect for other vertebrates.

[33] https://wetlandinfo.des.qld.gov.au/resources/static/pdf/resources/fact-sheets/fs-aewrr-20200715-final.pdf

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	0) Normal habitat requirements for fish and other vertebrates are not evident.	
Other		
C12 Fire impacts[34]	5) There may be evidence of fire, however the **fire regime** appears appropriate and the wetland plants and wetland soil/sediment/peat[35] are normal for that wetland type. If peat is burnt a lower score should be assigned. 4) Very minor evidence of fire impacts to wetland plants and/or wetland soil/sediment/peat. The fire regime is appropriate, and the wetland is highly likely to return to the normal state (e.g., mapped regional ecosystem) in terms of components and processes. 3) Minor evidence of fire, such as impacts on the abundance and/or coverage of wetland plants (e.g., canopy and subcanopy un-scorched, shrubs may be scorched, fire-sensitive low shrubs may be dead), and/or wetland soil/sediment/peat. The fire regime is appropriate, and the wetland is likely to return to the normal state.	• Fire regime is defined by frequency, intensity, and season. Many ecosystems require fire to persist and are fire adapted (e.g., wet heaths) but others are fire sensitive (e.g., rainforest). • If fire is being assessed, then the timing within the fire cycle must be considered when making an assessment. When a fire initially passes through a wetland, the expectation is that the wetland will receive a low score due to the damaged vegetation and/or soil or peat, and that the score will increase as the wetland recovers over time. However, if the wetland does not recover as expected (e.g., subsequent and/or excessive burning or a shift in the normal vegetation for that wetland type from native to exotic, or peat beds are damaged or receding, or peat-generating vegetation does not return), then the score will remain low. ***F***

[34] Aligns with QPWS&P Natural Values Health Checks (Melzer 2019).

[35] Peat wetlands are intricately linked to water; however, peatland hydrology is often poorly understood, and fire is one of the major threats to Australian peatlands (Pemberton 2005) ***O*** – information collected in office; ***F*** – information collected in the field. There are a wide range of peat wetland in Queensland, including temperate coastal peatlands (e.g. coastal wallum from the New South Wales border to K'gari (Fraser Island)), montane swamps (e.g. Byfield), inland spring mounds (Great Artesian Basin, e.g. near Boulia), tropical peatlands of Northern Australia including floodplains (e.g. Russell – Mulgrave, Moresby, Murray and Tully River systems), mountain swamps and lakes (e.g. Atherton Tablelands), inter-dune swales (e.g. Whitsunday Island, Cape Flattery, and Olive River), and mangrove peat (e.g. Bowling Green Bay and Orpheus Island) (Whinam and Hope 2005)

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) Moderate evidence of fire, such as impacts on the abundance and/or coverage of wetland plants (e.g., partial canopy scorched, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly dead), and/or peat and peat-generating plants. The fire regime is unlikely to be appropriate and the wetland is unlikely to return to the normal state. 1) Evidence of severe fire in terms of the abundance and/or coverage of wetland plants (e.g., full canopy scorch to partial canopy consumed, subcanopy fully scorched or consumed), and/or loss of peat across <15% of the site and/or peat-generating plants. The fire regime is inappropriate, and the wetland is highly unlikely to return to the normal state. 0) Evidence of extreme fire in terms of the abundance and/or coverage of wetland plants (e.g., full canopy, subcanopy and understorey consumed), and/or loss of peat across >15% of the site with loss of peat-generating plants. The fire regime is completely inappropriate, and the wetland is not expected to return to the normal state (e.g., mapped regional ecosystem).	• Peat can be burnt on the surface; however, fire can also pass through the peat, under the surface, and this can appear as collapsed surfaces, including large cracks and crevices and changes in colour from dark brown fibrous appearance to red, orange, yellow, grey, white or black [36]. ***F*** • Peat-generating plants can include *Astelia alpina, Baeckia gunnii, Brachycome* spp.*, Callistemon sieberii, Calythrix tetragona, Carex* spp.*, Celmisia* spp., *Chionogentiana* spp.*, Cyperus gymnocaulos, Drosera* spp., *Eleocharis sphacelata, Empodisma minus, Epacris breviflora, Epacris paludosa, Eucalyptus* spp. *(E. robusta and E. ovata), Gahnia* spp., *Isolepis aucklandicus, Juncus* spp. *(J. kraussi), Leptospermum juniperinum, Leptospermum lanigerum, Melaleuca* spp. *(M. quinquenervia, M. ericifolia, M. squarrosa, M. argentea), Oreobolus pumilio, Pandanus* spp.*, Phragmites australis, Richea continentis, Sphagnum* spp. moss*, Sprengelia incarnata, Typha angustifolia, Typha domingensis.* ***F*** • Can use quadrat or transects.

[36] Lavinia State Reserve, King Island Post-fire Geomorphology and Vegetation Assessment (Corbett 2010) Detailed assessments of fire impacts to peat wetlands have not been undertake in Queensland, and these scores are based on studies in temperate systems (Corbett 2010, Flanagan et al. 2020, Fryirs et al 2021) together with Melzer (2019).
O – information collected in office; ***F*** – information collected in the field.

Table 4. Threat indicator scores and supporting information. Threats are to be scored twice – once at the WETLAND SURROUNDING AREA (T-S)-scale (100 m from the edge of the wetland) and again at the LANDSCAPE SCALE (T-L) (1 or 5 km from the edge of the wetland depending on the indicator).

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Water theme		
T1 Land use	5) No intensive land use present. 4) 1- 25% intensive land use is present. 3) 26-50% intensive land use is present or road, track, building within wetland surrounding area. 2) 51-75% intensive land use is present. 1) 76%-95% intensive land use present. 0) 96-100% intensive land use is present.	• Queensland Land Use Mapping Program (QLUMP)/Australian Land Use and Management (ALUM) intensive land use (ALUM PRIMARY[37] categories 3, 4 and 5). ***O*** • GIS and/or aerial photograph interpretation. ***O*** • Score to 5 km for the landscape scale.
T2 Major hydrological modifications	5) No major hydrological modifications and no major dam(s) affecting the wetland in the catchment. 4) Major hydrological modifications are not likely (but evidence is not clear) and with no major dam(s) in the catchment. 3) Major hydrological modifications are likely (but evidence is not clear) and no major dam(s) in the catchment.	• Major hydrological modifications, such as major impoundments (dams, weirs), irrigation systems, or drainage systems, which inhibit water from moving across the landscape. ***O&F*** • Wetland hydromodifier mapping. ***O*** • Aerial photograph interpretation. ***O*** • Barriers and instream structures (Department of Environment and Science) (des.qld.gov.au). ***O&F*** • Score to 5 km for the landscape scale.

[37] https://www.agriculture.gov.au/sites/default/files/abares/aclump/documents/ALUMv8.pdf

O – information collected in office; ***F*** – information collected in the field.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) One major hydrological modification, but no major dam(s) in the catchment. 1) Two to three major hydrological modification, but no major dam(s) in the catchment. 0) More than three major hydrological modification, and/or major dam(s) in the catchment.	
T3 Minor hydrological modifications	5) No hydrological modifications. 4) Minor hydrological modifications are not likely (but evidence is not clear). 3) Minor hydrological modifications are likely (but evidence is not clear). 2) One minor hydrological modification is evident. 1) Two to three minor hydrological modifications are evident. 0) More than three minor hydrological modifications are evident.	• Recordings and observations of modifications/barriers, such as roads, railways, fences, bunds, weed chokes, poor water quality, infilling, or earthen farm dams, which can inhibit the movement of water, and aquatic fauna, such as fish and turtles. ***O&F*** • Wetland hydromodifier mapping. ***O*** • Aerial photograph interpretation. ***O*** • Barriers and instream structures (Department of Environment and Science) (des.qld.gov.au). ***O*** Score to 1 km for the landscape scale.
T4 Inflows from modified landscapes	5) Inflows from modified landscapes are not evident. The area (i.e., 'wetland surrounding area-scale) is unmodified. 4) Inflows from modified landscapes are not likely (but evidence is not clear). 3) Inflows from modified landscapes are likely (but evidence is not clear).	• T4 should be assessed at the wetland surrounding area only (not at the landscape scale), that is, record as 'not scored' at the landscape scale, do not assign 0 as that would suggest >18 inflows. NB the same needs to be done during subsequent threat assessments so the change in score is meaningful. • Stormwater is defined as water flow following rainfall, which can be diffuse, overland, or piped, both of which can alter water regimes, concentrate flows, scour soils/sediments, and introduce contaminants. ***O&F***

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) <4 inflows are evident. 1) 4-18 inflows are evident. 0) More than 18 inflows are evident.	• Mapping layers of point sources, such as major roads, residential areas, resource and primary production/extraction activities, stormwater drains. ***O&F*** • Licensed pollutant delivery sites (DES compliance pollution database). ***O*** • Aerial photograph interpretation. ***O***
T5 Septic systems[38]	5) No septic systems. 4) Septic systems are not likely (but evidence is not clear). 3) 1-2 septic systems are evident. 2) 3-4 septic systems are evident. 1) 5-8 septic systems are evident 0) >8 septic systems are evident.	• There is a need to understand the local aquifers to understand the extent of influence associated with septic tanks, noting groundwater systems can be very complicated (e.g., springs and fractured metamorphic geologies, and sand systems with indurated layers) and different geology have different porosity and nutrient treating potential (e.g., sand is typically poor at capturing and/or treating septic tank inputs). ***O&F*** • T5 should be assessed at a wetland surrounding area only (not at landscape scale). Record as 'not scored' at the landscape scale, but do not assign 0 as that indicates >8 septic tanks. NB the same needs to be done during subsequent threat assessments so the change in score is meaningful. • Local government area (LGA) information about the extent of sewered residential areas. ***O*** • Aerial photo interpretation***. O***
T6 Extraction of groundwater or surface water[39]	5) No extraction. 4) Extraction is not likely (but evidence is not clear). 3) Extraction is likely (but evidence is not clear).	• There is a need to understand the local aquifers to understand the extent of influence associated with groundwater extraction, noting groundwater systems can be very complicated (e.g., localised aquifers in fractured metamorphic geologies, layered aquifers in sand systems with **indurated layers**, and large regional aquifers such as the Great Artesian Basin). ***O***

[38] Adapted from the draft Wetland Field Assessment Tool (Department of Environment and Heritage Protection 2014) and *Wetland Tracker: Field methods guide and workbook* (Department of Environment and Science 2022)

[39] Adapted from the draft Wetland Field Assessment Tool (Department of Environment and Heritage Protection 2014)

O – information collected in office; ***F*** – information collected in the field.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) 1 extractive groundwater bore is evident. 1) 2-5 extractive groundwater bores are evident. 0) >5 extractive groundwater bores are evident	• T6 should be assessed at the wetland surrounding area only (not at the landscape scale). Record as 'not scored' at the landscape scale, do not assign 0 as that would suggest >5 extractive groundwater bores. The same needs to be done during subsequent threat assessments so the change in score is meaningful. • Groundwater bore mapping on Queensland Globe (filtered for extractive and active bores). ***O*** • Recordings and observations of groundwater or surface water pumps based on mapping or information from landholders, water utilities, water boards, industry, etc., or other extraction. ***O&F*** • The volume of groundwater or surface water extracted can be used where available, instead of the number of bores/pumps***. O***
Soil/sediment theme		
T7 Soil disturbance or compaction by humans or hooved animals	5) No evidence of soil disturbance and/or soil compaction by humans (e.g., foot, bicycle, vehicle) or hooved animals (e.g., livestock, pigs, goats, horses). 4) Very small area(s) of soil disturbance and/or compaction (e.g., <5%). 3) Small area(s) of soil disturbance and/or compaction (e.g., 6-15%). 2) Moderate to large area(s) of soil disturbance and/or compaction (e.g., 16-35%). 1) Much of the area (e.g., 36-65%) has soil disturbance and/or compaction.	• LGA and NRM plant/animal pest advice. ***O*** • Aerial photo interpretation***. O*** • Score to 1 km for the landscape scale.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	0) Most (e.g., >66%) of the area is disturbed by hooved animals.	
Plant theme		
T8 Native vegetation clearing	5) Native vegetation clearing is not evident (other than natural seasonal change). 4) Very small area(s) of native vegetation clearing is evident (e.g., <5%). 3) Small area(s) of native vegetation clearing is evident (e.g., 5-25%). 2) Moderate area(s) of native vegetation clearing is evident (e.g., 25-50%). 1) Much of the area is clear of native vegetation (e.g., 50-75%). 0) Most of the area is clear of native vegetation (e.g., >75%).	• Clearing of native vegetation where it previously existed, as indicated by **pre-clear vegetation** mapping (i.e., current **remnant vegetation** and **regrowth vegetation** layer compared to preclear layer). ***O*** • QLUMP cleared land or similar composite (e.g., Herbarium Integrated Vegetation Dataset). ***O*** • Cartographic interpretation of contemporary imagery if required. ***O*** • Recordings or observations are taken***. O&F*** • Score to 1 km for the landscape scale.
T9 Exotic wetland plants	5) Exotic or non-preferred species are not evident, including aquatic and terrestrial species. 4) Exotic or non-preferred species are evident, but percent cover is not clear in area of interest (wetland surrounding area- or landscape-scale).	• Recordings or observations of exotic plants that grow in wetlands, such as *salvinia*, water hyacinth, water lettuce, Singapore daisy, *hymenachne*, exotic *typha*, alligator weed, cat's claw creeper, willow, prickly *Acacia*, Noogoora burr or pasture grasses, including invasive plants[40]. ***O&F*** • Recordings or observations of site-specific, non-preferred vegetation, which may be native or exotic, or terrestrial or aquatic. For example, *phragmites* and

[40] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/weeds-diseases/invasive-plants
O – information collected in office; ***F*** – information collected in the field.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	3) Exotic or non-preferred species cover <5% of the area of interest. 2) Exotic or non-preferred species cover 5-25% of the area of interest. 1) Exotic or non-preferred species cover 26- 50% of the area of interest. 0) Exotic or non-preferred species cover >50% of the area of interest.	most typha are native, but can be non-preferred where they dominate a system and influence ecology (e.g., reduces dissolved oxygen levels and prevents fish passage). ***O&F*** • Includes aquatic and terrestrial species, given terrestrial species can also influence the condition of a wetland. • DAF, NRM, LGA, QPWS&P advice. ***O*** • Pestinfo. ***O*** • WildNet ***O*** • Score to 5 km for the landscape scale.
Animal theme		
T10 Wetland animal pests	5) Exotic or non-preferred wetland animals are not evident, such as cattle or feral pigs. 4) Exotic or non-preferred wetland animals are not likely (but evidence is not clear). 3) Exotic or non-preferred wetland animals affect <5% of the area of interest. 2). Exotic or non-preferred wetland animals affect 5-25% of the area of interest.	• Recordings and observations of exotic animals that inhabit (e.g., toads, fishes or turtles) or regularly use (e.g., feral pigs, cattle, goats, horses) wetlands, including **invasive animals**[41]**.** ***O&F*** • Recordings or observations of site-specific, non-preferred fauna, which may be native or exotic, or terrestrial or aquatic. For example, native predatory fish, such as spangled perch, may predate other native fish in a wetland system that was previously isolated from predators. ***O&F*** • Noxious fish are listed under Queensland legislation[42] and include several fish species, such as tilapia, carp and gambusia. • Declared animals are pests listed under Queensland legislation and include water buffalo and red-eared slider turtles. • See 'Exotic predators' indicator (T11) for non-wetland specific predators, such as feral dogs, cats, and foxes

[41] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/pests/invasive-animals
[42] https://www.qld.gov.au/environment/plants-animals/animals/pests-diseases/invasive-fish/legal-obligations
O – information collected in office; ***F*** – information collected in the field.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	1). Exotic or non-preferred wetland species affect 26-50% of the area of interest. 0) Exotic or non-preferred wetland animals affect > 50% of the area of interest**.**	• DAF, NRM, LGA, QPWS advice. ***O*** • Pestinfo. ***O*** • WildNet ***O*** • Score to 5 km for the landscape scale.
T11 Exotic predators	5) Exotic predators, such as predatory fish, dogs, cats, and foxes, are not evident. 4) Exotic predators are not likely (but evidence is not clear). 2). Exotic predators affect <5% of the area of interest. 3). Exotic predators affect 5-25% of the area of interest. 1). Exotic predators affect 26-50% of the area of interest. 0) Exotic predators affect > 50% of the area of interest.	• Recent recordings and observations of native and exotic animals (including invasive animals) that are predators and use wetlands, such as direct observations of dead or alive feral predators, such as fish, dogs, cats or foxes, or indirect observations such as predated birds and small mammals, scats, tracks, or burrows. ***O&F*** • Local knowledge, land use mapping***. O&F*** • DAF, NRM, LGA, QPWS advice. ***O*** • Pestinfo. ***O*** • WildNet. ***O*** • Score to 5 km for the landscape scale.
T12 Collection and harvesting of wetland species	5) Collection or harvesting of wetland species is not evident. 4) Collection or harvesting of wetland species is not likely (but evidence is not clear). 3) Limited collection or harvesting of wetland species is evident (e.g., limited to scientific collection). 2) Minor evidence of collection or harvesting of wetland species. 1) Moderate evidence of collection or harvesting of wetland species (e.g., fishing spot).	• DAF advice on licenses for fisheries and wildlife collection. ***O*** • QPWS advice on wildlife collection. ***O*** • NRM advice. ***O*** Cross check with evidence of infrastructure (e.g., jetties, and signage). ***O&F*** Score to 1 km for the landscape scale.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	0) Popular for collection or harvesting of wetland species (e.g., popular recreational fishing spot or commercial fishery).	

Section 3 – Completing the WetCAT assessment

Indicator scores

For each assessment unit:

- define the area of the assessment unit (e.g., 10x10m quadrat, 100m transect)
- from the location centroid, take photographs in all cardinal directions
- traverse the area of the assessment unit where possible
- gather information required to score the indicators on the data sheet, noting the score is for the defined assessment unit (with incidental observations recorded on the data sheet to provide context for the assessment but not the score directly)
- *all indicators must be scored*
- condition (at the assessment unit) and threat (at the wetland surrounding area scale and landscape scale) indicators must be scored separately.

Example data sheet

The example data sheet on the following page can be used to record scores for each indicator and can be tailored for different projects.

Do not enter personal information, such as landowner names or addresses, property names, or other personal identifiers for privacy reasons.

Data analysis and reporting

Data analysis and reporting should be tailored to the project and outlined in the CAMP to ensure consistency over time.

A simple bar graph or radar diagram (Figure 2) can be used to show differences in individual indicators, or a subset of indicators, over time.

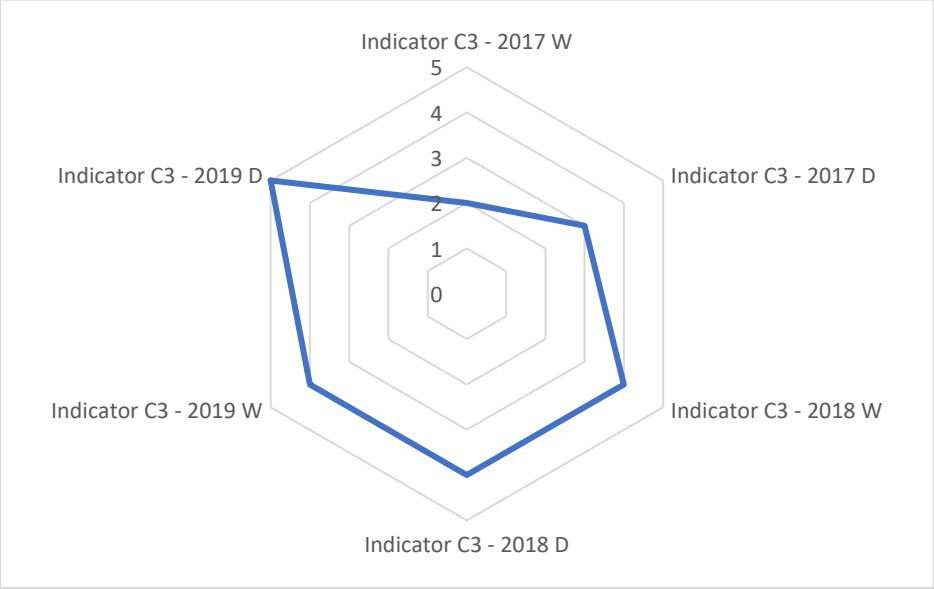

Figure 2. An example of using a radar diagram to show differences in individual indicators over time. In this example, the year and the time period (e.g., dry (D) or wet (W) season) are included alongside the indicator being measured.

WetCAT is not designed for integrated assessment of the condition of wetlands over broad areas. The intent is to use the indicators to demonstrate recovery after an event and achievement of intended outcomes after a management intervention. The *difference* in the total score for each indicator (not the total score for all indicators) can be compared over time for a particular area/site or wetland type to assess the extent of improvement to condition associated with the intervention or recovery (e.g., comparing the score for C3 Soil surface destabilisation against itself over time, rather than comparing the total score for all indicators).

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Glossary

Unless otherwise referenced, sources for each definition can be found on Wetland*Info*.

Abundance is a large a quantity of something (Oxford English Dictionary). It is total number of individuals, as opposed to diversity which is the number of morphological or taxonomic types.
Anaerobic sediments are aquatic sediments that have a high organic matter content. The organic matter is subject to a bacterial decay process that causes the oxygen level in sediments to sharply decline, producing anaerobic conditions. If this situation continues, hydrogen sulfide can form which combines with iron to give the sediments a black appearance (EPA South Australia 2021).
Appropriate means suitable, acceptable or correct for the particular circumstances (Oxford English Dictionary)
Assessment unit are a relatively homogenous units that is one habitat type in one broad condition state (adapted from Eyre et al. 2015).
Background variability is the ecological conditions, and the spatial and temporal variation in these conditions, that are relatively unaffected by people, within a period of time and geographical area (e.g., wetland buffer or landscape) (adapted from Landres et al. 1999).
Best-on-offer is the best available site within the same wetland complex that represents near optimal wetland conditions (e.g., minimal impacts from humans) (Eyre et al. 2015)
Bunds are a hydrological modification (e.g., an embankment or causeway) that reduces inundation in a wetland (Department of Environment and Resource Management 2011b).
Causal links are relationships between the socio-ecological system (system) and the ecosystem services (service) of that system, meaning an occurrence in the system causes the service as a response. **Causal –** if there is a causal relationship between two things, one thing is responsible for causing the other (Collins Dictionary) **Link –** if there is a link between two things or situations, there is a relationship between them, for example, because one thing causes or effects the other (Collins Dictionary). See Wetland*Info* for more information.
Comparable assessment techniques are standardised methods that allow for repeatable assessments of a wetland to accurately measure changes in that same wetland.
Comparative sites are survey sites that are similar to the project site in terms of ecosystem type, habitat type, hydromodification and disturbance, but not undergoing the intervention.
Components are the physical, chemical and biological parts that make up the environment (e.g., topography, the various animals that live there, the geology, the climate, rainfall). See Wetland*Info* for more information.
Condition is the state of something (Oxford Learner's Dictionaries). For a wetland, it is that state of a wetland, which affects its ability to deliver ecosystem services.
Consume is to use fuel, energy, or time especially in large amounts. For example, if a fire consumes something, it destroys it completely (Cambridge Dictionary).

Distance of influence are the landscape-factors (e.g., flatness) that influence the size of the impact of catchment/landscape-scale threats on a wetland
Diversity is the condition or fact of being different or varied; variety (Cambridge Dictionary). It is the total number of morphological or taxonomic types, as opposed to the number of individuals.
End type (wetland) is the wetland type that will be in place after an intervention.
Ephemeral is lasting only a short time; short lived; transitory.
Evidence base is information gathered to support an assessment.
Exotic is not native to the place where found (Merriam Webster Dictionary).
Habitat is the locality in which a plant or animal naturally grows or lives. It can be either the geographical area over which it extends, or the particular site in which a specimen is found (General Multilingual Environmental Thesaurus).
Habitat type (wetland) (e.g., Coastal/ Sub-coastal floodplain grass, sedge and herb swamps). See WetlandInfo website pages for Lacustrine ecology; and Palustrine ecology.
Hydrological regime is defined under 'regime)'
Hydromodifier are features within wetlands that modify the hydrology or flow of water (e.g., H2M2a Modified - bunded)
Illegal dumping is the unlawful deposit of any type of waste material that is 200 litres or more in volume, and commonly includes household rubbish and garden waste, household goods (such as whitegoods, TVs, mattresses, and furniture), building waste (construction and demolition materials), tyres, chemical drums, and paint tins or asbestos.
Improvement in the context of this document, is an increase in the score for indicators, noting that the overall change in individual indicator scores is used to determine an improvement, not the total of all the indicator scores.
Indicators are facts, measurements, or conditions that show what something is like or how it is changing (Cambridge Dictionary). In the context of WetCAT it is the indicators are used to assess wetland condition with regards to biodiversity, each indicator is assigned a score of 0 (being the worst condition) to 5 (being the best condition)
Indurated layers are soil layers that have cemented due to the residual accumulation of secondary minerals or the accumulation and precipitation of soluble materials, such as silica and/or iron (Wilson and Taylor 2012). Coffee rock is an example of indurated sand layers.
Intensive land use is defined as Australian Land Use and Management (ALUM) categories 3, 4 and 5.
Invasive animals are non-native animal species that have been introduced to the environment, such as introduced mammals, reptiles, and amphibians (Department of Agriculture and Fisheries 2016a).
Invasive plants are non-native plant species that have been introduced to the environment, such as pond apple (Department of Agriculture and Fisheries 2016b).
Wetland inventory is a platform to record standardised data about wetlands from available data sources or through surveys
Lacustrine wetlands (lakes) are dominated by open water, although lakes may have fringing vegetation.
Landscape-scale (catchment) factors are influences on the wetland from across the whole catchment i.e., ranging from 1 or 5 km from the edge of the wetland itself.
Litter is the unlawful deposit of any type of waste material that is less than 200 litres in volume (about the volume of a wheelie bin), and commonly includes cigarette butts,

drink bottles and fast-food packaging, food scraps like apple cores, green waste such as palm fronds and grass clippings, fishing tackle or balloon.
Macroinvertebrates are invertebrates that are large enough to be seen with the naked eye.
Monitoring see monitoring page Wetland*Info*.
Morphology is the branch of biology which is concerned with the form of animals and plants, and of structures, homologies, and metamorphoses which govern or influence that form (Oxford English Dictionary).
Native for plants and animals means existing naturally in a place (Oxford English Dictionary).
Non-preferred fauna is fauna causing an adverse ecological impact and is location specific. For example, native predatory fish, such as spangled perch, may predate other native fish in a wetland system that was previously isolated from predators.
Non-preferred vegetation is vegetation causing an adverse ecological impact and is location specific, e.g., phragmites and most *typha* are native, but can be non-preferred where they dominate a system and influence ecology (e.g., reduce dissolved oxygen levels and/or prevent fish passage).
Normal is the long-term state of a wetland based on long-term data and/or field experience but does not necessarily represent pre-European development.
Photo point monitoring involves taking a photo at the same spot each monitoring period, typically in each cardinal direction, so that it can be compared to previous monitoring events to show change in condition.
Palustrine refers to vegetated, non-riverine, or non-channel systems. They include billabongs, swamps, bogs, springs, soaks, etc., and have more than 30% emergent vegetation.
Peat is a brown deposit resembling soil, formed by the partial decomposition of vegetable matter in the wet acidic conditions of bogs and fens, and often cut out and dried for use as fuel and in gardening (Oxford English Dictionary).
Peat-generating plants are plants that produce partly decomposed biomass (peat) during the decaying process (FAO n.d.). Such plants include *Astelia alpina, Baeckia gunnii, Brachycome spp., Callistemon sieberii, Calythrix tetragona, Carex spp., Celmisia spp., Chionogentiana spp., Cyperus gymnocaulos, Drosera spp., Eleocharis sphacelata, Empodisma minus, Epacris breviflora, Epacris paludosa, Eucalyptus spp. (E. robusta and E. ovata), Gahnia spp., Isolepis aucklandicus, Juncus spp. (J. kraussi), Leptospermum juniperinum, Leptospermum lanigerum, Melaleuca spp. (M. quinquenervia, M. ericifolia, M. squarrosa, M. argentea), Oreobolus pumilio, Pandanus spp., Phragmites australis, Richea continentis, Sphagnum spp. moss, Sprengelia incarnata, Typha angustifolia, Typha domingensis*
Pre-clear vegetation is the area of the broad vegetation group before clearing (in hectares) (Neldner et al. 2019).
Processes are the interactions between different components (e.g., water eroding soil and depositing it somewhere else). Sometimes interactions between different processes can also occur (e.g., two different chemical processes interacting with each other).
Project area is the area where the where the event has occurred and/or the management intervention has had effect.
Project site is where WetCAT assessments are undertaken.
Pugging is defined as the area where deformation of the soil surface has occurred as a result of hooved animals traversing the area in wet/muddy conditions (Burrows and Scott 2020)

Quality assurance is a system of documented procedures and plans established to ensure that the water monitoring program produces data of known precision and bias (Department of Environment and Science 2018c).
Rating is a classification or ranking of someone or something based on a comparative assessment of their quality, standard, or performance (Oxford English Dictionary).
Reference sites are survey sites that are undisturbed or 'original' (i.e., not impacted by human activity) and can, therefore, be used to represent natural influences (e.g., climate) in the absence of human influences
Refugia are areas where an organism can survive during a period of unfavourable conditions (singular: refugium)
Regrowth vegetation describes native vegetation recurring on an area of land that has previously been cleared (Department of Environment and Natural Resources 2018).
Remnant vegetation is vegetation, part of which forms the predominant canopy of the vegetation— (a) covering more than 50% of the undisturbed predominant canopy; and (b) averaging more than 70% of the vegetation's undisturbed height; and (c) composed of species characteristic of the vegetation's undisturbed predominant canopy (Neldner et al. 2019).
Scorched is slightly burned or damaged by fire or heat (Cambridge Dictionary).
Sediment mobilisation is the transport or setting in motion by wind or water of insoluble particulate matter (General Multilingual Environmental Thesaurus).
Slumping is a type of mass failure (e.g., bank erosion or sliding) associated with bank erosion (Department of Natural Resources and Water 2006).
Soil/sediment deposition is the process of particles and adsorbed pollutants from the water column settling by force of gravity. The sedimentation efficiency is a function of eddy forces in the settling basin, and the period of detention of flow in the basin. Typical pollutants affected include sediment, hydrocarbons and metals (also referred to as sedimentation).
Soil/sediment erosion is the detachment and movement of topsoil or soil material from the upper part of the profile, by the action of wind or running water, especially as a result of changes brought about by human activity, such as unsuitable or mismanaged agriculture (General Multilingual Environmental Thesaurus).
Soil/sediment surface destabilisation is generally a consequence of sediment reworking, resulting in a decrease in the critical erosion velocity of the seabed (e.g., due to changes in sediment grain size and microtopography), or in the direct displacement and resuspension of particles by the infauna (Rhoads and Young 1970).
Site-scale assessment is an assessment conducted at the project site.
Soil compaction occurs when soil density is increased by an energy input into moist or wet soil. The force may be exerted by tyres, tillage tools, or animal hooves (Queensland Government 2015a).
Soil disturbance occurs when potentially damaging forces are applied to habitat space occupied by a population, community, or ecosystem. Disturbances should be defined by the nature of their damaging (mainly abiotic) properties, especially the intensity and forms of their forces, along with parameters such as frequency, predictability, spatial extent, and temporal duration (Lake 2000).
Sources of information are anything that might provide knowledge to somebody. Information sources may be observations, documents, pictures, etc. (Varshney 2011).
Springs are hydrogeological features by which groundwater discharges naturally to the land surface or cave. This includes springs with:

• permanent and non-permanent (i.e., intermittent or ephemeral) saturation regimes • dynamic or static spatial locations • diffuse or point source spatial locations.
Spring-associated wetlands are wetlands dependent on the surface expression of groundwater (a spring), for example, palustrine wetland (e.g., swamps), lacustrine wetland (e.g., lakes), riverine wetland (e.g., streams) and estuarine and near-shore marine (Queensland Government 2015b).
Stormwater is water flow following rainfall. It can be overland or piped, both of which can alter water regimes, concentrate flows, scour soils/sediments, and also introduce contaminants.
Themes in the context of this document are the four broad components that make up any wetland: water, soil/sediment, plants and animals
Threats are potential adverse changes in a physical, chemical or biological component, process or service. A wetland threat has potential to cause harm to wetland condition.
Trampling is defined as visible disturbance to the soil surface caused by hooved animals traversing the area in dry conditions (Burrows and Scott 2020)
Values is the relative worth, utility or importance (Merriam-Webster Dictionary). For wetlands, see Wetland services and values page, Wetland*Info* website.
Water quality is the chemical characteristics of water in terms of suitability of the water for various intended uses
Wetland Assessments in the context of WetCAT are WetCAT assessments.
Water regime is characterised by the presence and pattern of water levels including timing, frequency, duration, extent, depth and variability (Wetland*Info* 2022). See, water regime page on Wetland*Info* for more information
Wetland surrounding area is the area which directly influences the wetland. The extent of the **wetland surrounding area** is to be determined by the user, based on the landscape and wetland being assessed but a default of **100m** can be used.
Wetland landscape are areas surrounding the wetland to across the whole catchment **1 or 5 km** from the edge of the wetland that influence the wetland.
Wetland characteristics include wetland features, hydrological information, wetland vegetation extent, presence of wetland soils, and/or presence of wetland fauna.
Wetland delineation is the act of determining the extent and boundaries of a wetland site based on the presence and extent of **wetland characteristics**, see Queensland Wetland Definition and Delineation Guideline for more information.
Wetland type is the collective description of the wetland, which includes wetland system (broad types) (e.g., lacustrine, palustrine, riverine or estuarine), wetland types (habitat types) (e.g. Coastal/ Sub-coastal floodplain grass, sedge and herb swamps) and features within the wetland that modify the hydrology or flow of water i.e. hydromodifiers, e.g. H2M2a Modified – bunded, climate, substrate, salinity, water regime, geomorphology and topography, and vegetation, see Wetland*Info* for more information
Wetland vegetation is vegetation that grows in water or need a waterlogged environment (also known as hydrophytes) (Department of Environment and Science 2013c).

Acronyms

Term	Acronym
Aquatic Ecosystem Rehabilitation Process	AERP
Aquatic Biodiversity Assessment Mapping Method	AquaBAMM
Australian River Assessment System	AusRIVAS
Australian Land Use and Management	ALUM
BioCondition Assessment Tool	BioCAT
Condition Assessment Monitoring Plan	CAMP
Civil Aviation Safety Authority	CASA
Australian Land Use and Management	ALUM
Department of Agriculture and Fisheries	DAF
Department of Environment and Science	DES
Department of Resources	Resources
Dissolved oxygen	DO
Electrical conductivity	EC
Environmental Values	EVs
Framework for the Assessment of River and Wetland Health	FARWH
Geographic Information System	GIS
Ground Control Points	GCPs
Great Artesian Basin	GAB
Land Condition Assessment Tool	LCAT
Local Government Area	LGA
Occupational health and safety	OH&S
Potential hydrogen	PH
Natural resource management	NRM
Natural Resources and Investment Program	NRIP
Queensland Land Use Mapping Program	QLUMP
Queensland Parks and Wildlife Service and Partnerships	QPWS&P
Regional Ecosystem	RE
Unmanned aerial systems	UAS
Draft Wetland Field Assessment Tool	WAFAT
Water Quality Objectives	WQOs
Wetland Monitoring and Assessment Kit for Community Groups	WETMAK
Wetland Condition Assessment Tool	WetCAT

Appendix 1 – Condition Assessment Monitoring Plan

The **Condition Assessment Monitoring Plan (CAMP)** can be built from existing documents, such as funding applications and project plans. Information that is already available in the funding application, project plan, Aquatic Ecosystem Rehabilitation Process(AERP) or similar planning documents can be referenced, rather than re-writing, for the purposes of the CAMP.

The purpose of the CAMP is to record the logic and reasoning for the assessment/monitoring of changes in the condition in a wetland after an event or resulting from management interventions. The CAMP sets out the decisions, the reasoning (rationale) behind those decisions, and what changes are expected against each of the selected indicators.

Where possible, the CAMP should also include an **engagement/communications plan** outlining how the project will work with First Nations people, landholders, community groups, and other stakeholders. It should outline which groups will be consulted and worked with (e.g., how, and when) and any expected outcomes specific to those groups. Details of any formal arrangements should be included (e.g., contracts, in-kind support, confidentiality, conflict of interest).

Through documenting the background to the project, the CAMP provides:

- credibility – It is the basis for demonstrating the credibility of the approach to condition assessment and monitoring
- clarity – It records the decisions made at the beginning of the project and why, ensuring that everyone has the same understanding of the condition monitoring approach (including new people coming into the project team).

Considerations for determining the purpose or outcome of the wetland recovery and/or management intervention:

- why manage and/or rehabilitate – see Aquatic Ecosystem Rehabilitation Process
- what are the services/values that are to be managed or enhanced?
- what are the threats to the services/values?
- who will be affected (stakeholders and beneficiaries) by the activities?
- are permits or permissions required?
- who can help?

Considerations for maintenance and monitoring:

- has the recovery or management intervention been successful (have the values and services provided by the wetland been maintained/reinstated/achieved)?
- what are the next steps for further management/recovery actions?
- what needs to be done to maintain the wetland and when should the work be undertaken?
- have the ongoing costs been considered for both monitoring and maintenance?
- is there clarity on who will undertake the maintenance?
- are the timeframes realistic?

Components of the Condition Assessment Monitoring Plan

A suggested outline for the CAMP is as follows:

- introduction to the region and the wetland
- summary project information

- summary wetland information
- short summary of what the project is trying to achieve (services to be provided to beneficiaries)
- approach and rationale for determining sites, and the location of the sites
- approach and rationale for determining timing and frequency for assessments/monitoring.
- indicate rationale for choice of metrics/assessment approaches for scoring indicators
- expectations at end of project for condition indicators
- expectations for threat indicators
- other expectations not captured through indicators.
- review of monitoring and management regime

A brief description of each component of the CAMP is below.

Introduction

The CAMP should outline the objectives for doing WetCAT assessments and should be prefaced with an introduction to the region including First Nations people and key stakeholders. Information included in the introduction could comprise, but is not limited to:

- information about the hydrology of the region
- the location of the wetland (can include latitude and longitude)
- access points to the wetland
- other introductory information that is important including threats.

Summary Project Information

Relevant summary project information can be tabulated for easy reference (Table A1.1). This summary should include a brief description of the project, who developed the CAMP, including their expertise and where they are from (e.g., from a Natural Resource Management (NRM) group, from a governmental department), and key dates for the project (e.g., when the CAMP was completed, when baseline data was collected). Any additional relevant information, such as a brief description of what on-ground works have taken place (e.g., clearing of weed chokes), can also be included in the table as well.

Table A1.1. Summary project information

Project description	
Land tenure	
Planning team, including expertise and where they are from	
Key Dates and relevant information	
- Completion of Condition Assessment Monitoring Plan	
- Baseline data collection	
- On-ground works	

- Follow-up monitoring	
- Add additional as necessary	

Summary Wetland Information

As above, the summary wetland information can be tabulated for easy reference (Table A1.2). Summary wetland information can include, but is not limited to:

- project site (can include Wetland Mapping Identifier)
- wetland type
- local hydrology modifier
- wetland regional ecosystems (RE), including percentages of each RE
- salinity modifier
- water regime (e.g., ephemeral, permanent)
- habitat type
- hydrology stack line plot (linked from the Wetland Insight Tool).

Hyperlinks to wetland polygons (sourced from Wetland*Maps*) can also be included.

Table A1.2. Summary Wetland Information[43]

Project site	Wetland type	Local hydrology modifier	Wetland RE list	Wetland RE %	Salinity modifier	Water regime	Habitat type	Hydrology stack line plot	Additional information
1	*Palustrine*	*H2M2a Modified - bunded*	*8.3.4*	*100*	*Fresh*	*Uncertain*	*Coastal/ Sub-coastal floodplain grass, sedge and herb swamps*		

Short summary of what the project is trying to achieve

Provide a succinct description of what the project is trying to achieve – this could be from the project application. The summary should be clear about the services/values to be enhanced, what

[43] This information is sourced from the attribute data table for the wetland polygon where available (see Wetland*Maps*). Hydromodifiers are features within the wetland that modify the hydrology or flow of water. A full and current list of hydromodifiers is available on Wetland*Info*.

the threats are to those services/values, what success would look like at the end of the project, within the context of the wetland system, local hydrology modifier (hydromodifier), and habitat type of the wetland and the landscape context.

Approach and rationale for determining sites, and the location of the sites

Provide a site map (ideally on aerial imagery including wetland mapping and other important information, such as waterways and access) and describe the site. Care should be taken in looking at hydrological pathways during different hydrological periods (wet, dry, extreme events).

If there is more than one project site for the wetland project area, and the rationale for determining assessment units and project sites is different, include commentary for all project sites (e.g., project site A; project site B). Alternatively, there could be a separate CAMP for each project site.

Approach and rationale for determining timing and frequency (when and how often) for assessment and monitoring approaches used.

Describe when the monitoring will take place. The best approach is to revisit the site at the same time of year or after a specific event (e.g., hydrological event such as a rain event). Specify how often the project site will be revisited, providing a short justification for decisions.

Indicate rationale for choice of metrics/assessment approaches for scoring indicators

It is important to clarify expectations for each of the indicators during the planning phase, including project-specific details on each of the indicators, such as:

- a description of the indicator
- rationale for choice of method for scoring the indicator
- desktop information relevant to scoring this indicator
- recording the evidence base for the score and guidance about what evidence to record, including notes to assist the assessor in scoring the indicator
- entering both an indicator score and an assessment of confidence in that score at each of the chosen assessment units
- additional information, such as evidence related to antecedent hydro-climatic conditions (e.g., floods and droughts), that may help to distinguish between human and natural disturbance processes.

This information can be captured in Table A1.3, where the expected change is listed against each of the condition indicators. Alternatively, if time and budget allow, more extensive expectations can be collated, such as the example shown in Table A1.4 (courtesy of NQ Dry Tropics).

Expectations at end of project for condition indicators

Table A1.3. Expected changes to wetland condition over time

Indicator	Expectation of the difference to be seen against each indicator over the duration of the project
C1 Water regime	
C2 Water quality	

C3 Soil surface destabilisation, erosion, or deposition	
C4 Soil disturbance or compaction by humans (foot or vehicle) or hooved animals	
C5 Vegetation cover	
C6 Exotic wetland vegetation cover	
C7 Aquatic macroinvertebrate abundance and diversity	
C8 Native aquatic fauna diversity	
C9 Litter and illegal dumping	
C10 Appropriate connections for biodiversity	
C11 Physical habitat requirements for fish and other vertebrates	
C12 Fire impacts	

Table A1.3a. Detailed wetland condition expectations for an indicator (courtesy of: NQ Dry Tropics)

C2 Water quantity	Site 1: Complete dry-down expected outside wet season. May occasionally experience tidal flush. Site 2: Complete dry-down expected outside wet season. May occasionally experience tidal flush. Site 3: Level in lagoon expected to stay below spillway outfall level by around 300mm.
Included: Control of water input and output in the system is key to improving fish passage and extending water residence times which is expected to increase the likelihood of sediment capture by macrophytes and through settling. Logger data at Site 3 may be important in checking correct operation of water control infrastructure installed upstream.	
Description: Perennial water flows have eliminated seasonal drydown in the Assessment Areas and as a result fish passage has largely been lost (see indicator C1). Water flowing over the spillway and under or through the floodgate and fishway promotes permanent, dense freshwater macrophyte growth, limiting the access fish might have otherwise had to upstream reaches of the system.	
Scoring Method: Water levels are logged at Site 1, 2 and 3. At Site 1 and 2, seasonal drydown sufficient to kill off the macrophyte growth is the necessary outcome. This typically takes around 3 months of dry conditions. Score sites according to the drydown period achieved using these criteria: Dry for 11 weeks (90% of desired drydown) or more = 5 Dry for 9 to 11 weeks (75% to 90% of desired drydown) = 4 Dry for 6 to 9 weeks(50% to 75% of desired drydown) = 3 Dry for 3 to 6 weeks(25% to 50% of desired drydown) = 2 Dry for up to 3 weeks(up to 25% of desired drydown) = 1	
Desktop Information: Use logger data downloaded at each monitoring event. Follow instructions in the Wetland Floristic Surveys Monitoring Guide.	
Recording the Evidence: Download and store logger data in the relevant folder. Add logger records to the spreadsheet for each project area.	
Scores: Baseline 2020 - Wet Season 2021 - Dry Season 2021 - Wet Season 2022 - Dry Season 2022 - Wet Season 2023 - Dry Season 2023 -	

Expectations for threat indicators

Complete Tables A1.5 and A1.6, specifying what is expected to be seen for each of the threat indicators at the wetland surrounding area scale and the landscape scale, respectively, at the beginning of the project. This component is designed to provide context for the management intervention and track changes of threats over time. The assessment of threats should be undertaken as part of the planning process, largely in the office, and re-visited when changes are observed (e.g., field observations or mapping updates).

Table A1.5. Wetland surrounding area-scale threats (100 m from the edge of the wetland)

Indicator	What is expected to be seen against each indicator at the specified scale (see indicator scoring table) at project onset/monitoring event to provide context for assessment
T1-S Intensive land use	
T2-S Major hydrological modifications	
T3-S Minor hydrological modifications	
T4-S Inflows from modified landscapes	
T5-S Septic systems	

T6-S Extraction of groundwater or surface water	
T7-S Soil disturbance or compaction by humans or hooved animals	
T8-S Native vegetation clearing	
T9-S Wetland plant pests	
T10-S Wetland animal pests	
T11-S Feral predators	
T12-S Collection and harvesting of wetland species	

Table A1.6. Landscape-scale Threats (1 km or 5 km depending on the wetland indicator)

Indicator	What is expected to be seen against each indicator at the specified scale (see indicator scoring table) at project onset/monitoring event to provide context for assessment
T1-L Intensive land use	
T2-L Major hydrological modifications	
T3-L Minor hydrological modifications	
T4-L Inflows form modified landscapes	*Not applicable at landscape scale (see wetland surrounding area scale)*
T5-L Septic systems	*Not applicable at landscape scale (see wetland surrounding area scale)*
T6-L Extraction of groundwater or surface water	*Not applicable at landscape scale (see wetland surrounding area scale)*
T7-L Soil disturbance or compaction by humans or hooved animals	
T8-L Native vegetation clearing	
T9-L Wetland plant pests	
T10-L Wetland animal pests	
T11-L Feral predators	
T12-L Collection and harvesting of wetland species	

Other expectations not captured through indicators

If there are other expected changes, which are not captured in the above indicators, this is an opportunity to record them.

Monitoring and evaluation and sharing

It is important to outline in the CAMP when the monitoring results should be reviewed to determine whether the condition of the wetland has improved, and the intervention has been successful. Conclusions should not be draw about the success of a management intervention until enough monitoring data has been obtained.

Appendix 2 – Supporting information on when and where to assess

When to assess

Further details on when to assess the wetland are provided in Table A2.1.

Table A2.1. Identifying appropriate periods to sample (modified from Waltham 2020).

Sample Period	Months	Lacustrine & Palustrine
Event based (episodic)	As required	Baseline before management intervention, after rainfall or flow event
Post wet (Autumn)	March - June	Once wetland has been refilled and aquatic vegetation has begun to establish
Late dry (spring)	October - December	As the wetland is drying down and retracting in size

Where to assess

Table A2.2 provides some resources which may aid in preparing project maps and delineating wetlands. Examples of project maps are provided below (Figures A2.1, Figure A2.2).

Table A2.2. Resources for mapping (taken from Waltham 2020).

Product	Description
Spatial information	
Wetland*Info* https://wetlandinfo.des.qld.gov.au	Find wetland information for regions of Queensland. First-stop-shop for wetland management resources
QLD geospatial data http://qldspatial.information.qld.gov.au	Provides public access to a variety of spatial and associated data. Discover, display, select and download or order data over an area of interest in selected formats, including map coverage data, image data and text file data.
Google Earth https://earth.google.com/web	Current and historic satellite imagery
Nearmap (subscription required) https://www.nearmap.com.au	Current and historic satellite imagery
Hydrological information	
Bureau of Meteorology http://www.bom.gov.au/waterdata/	Water Data Online. The Bureau of Meteorology now has responsibility for compiling and disseminating comprehensive water information across Australia.
QLD Government https://water-monitoring.information.qld.gov.au/host.htm	Water Monitoring Information Portal
Local Government / Council	
Regional water provider	(e.g., SunWater, Burdekin Water, DNRME)
On-farm gauging	

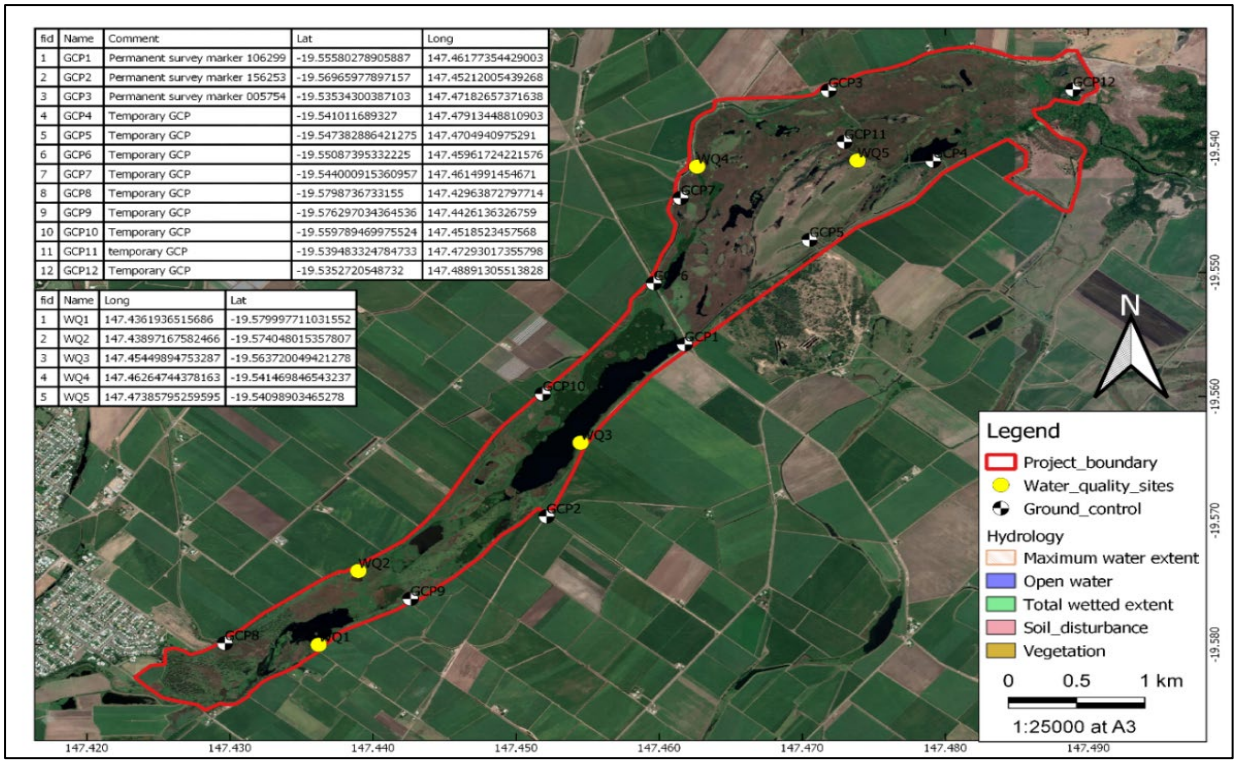

Figure A2.1. An example map to take to the field. Indicated are locations for placing drone ground control points (black/white) and location of water quality project sites (yellow). Imagery source: Google Earth (taken from Waltham 2020).

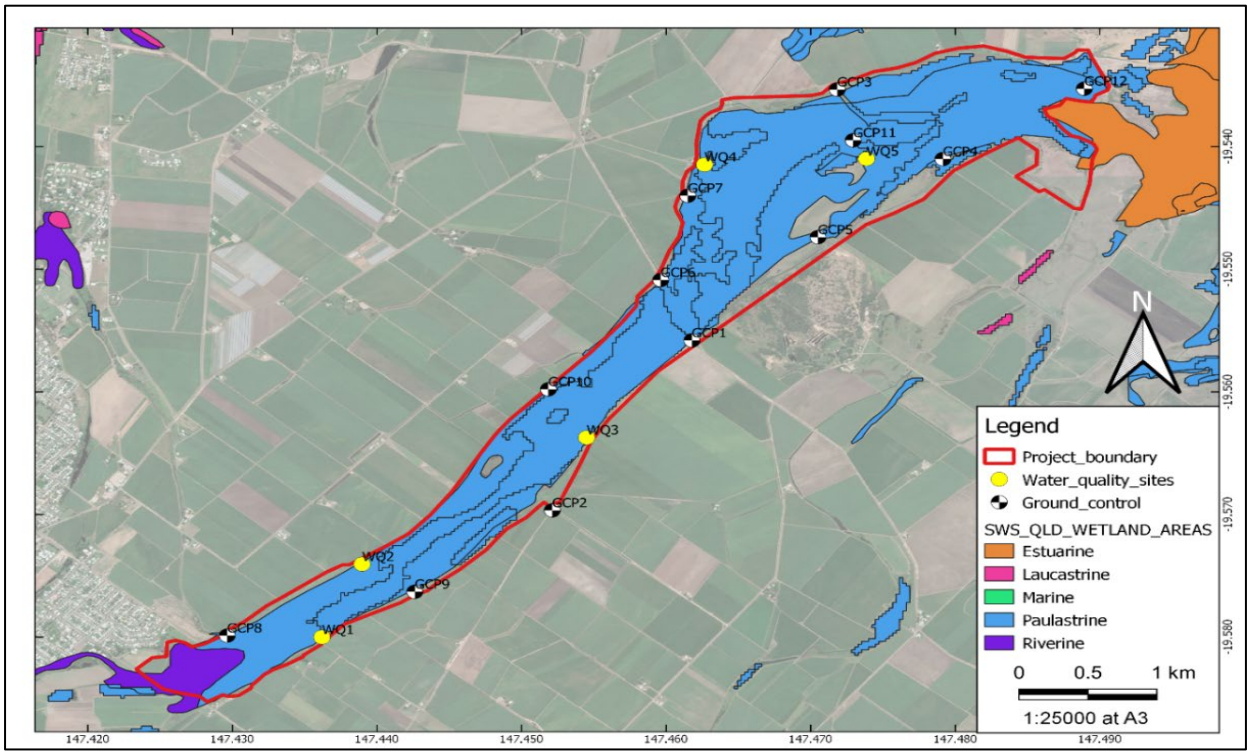

Figure A2.2. Site area map of Plantation Creek (Ayr) showing wetland types extracted from the Queensland wetland database. Layer source: State of Queensland (Department of Environment and

Science) 2019. Updated data available at http://qldspatial.information.qld.gov.au/ (taken from Waltham 2020).

General rules for site selection (wetland project areas, project sites and assessment units)

The wetland project area is where the event has occurred and/or the management intervention has had effect. The following general rules apply for project areas, project sites and assessment units:

- in most projects, the **project area** will not be homogenous in terms of the level of disturbance and wetland type. This will mean that the project area needs to be divided into a number of **project sites** of similar wetland type and level of disturbance. **Assessment units** can then be chosen within the project sites to score the indictors. The aim is to achieve an appropriate number or assessment units that are representative of the level disturbance.
- even with project areas that are largely homogenous in the level of disturbance, a replicated sampling approach should be used. The amount of replication (assessment units) within the project site can be determined in accordance with budget.
- where possible, select assessment units at each inflow and outflow point.
- where there is a lot of disturbance, where budget permits, include assessment units that assess each significant flow altering feature or item of infrastructure (hills, gullies, artificial channels, elevated roads, culverts, weirs, etc.).
- increase the number of assessment units relative to wetland size, capturing a representative sample of the range of disturbance across the wetland and wetland surrounding area. If the assessment units seem biased towards disturbed sites (for example, due to the inclusion of infrastructure), add one or more assessment units in intact areas.
- try to cover 5 to 20% combined coverage of the project site if the combined wetland and wetland support area are less than 20 ha in extent. Aim for about 5% combined coverage for areas greater than 20 ha.
- threat assessments will need to be done at both the wetland surrounding area (100m from the edge of the wetland) and the landscape (1-5 km from the edge of the wetland depending on the indicator).
- selection of project site and assessment units should be based on several factors including access, safety considerations, such as the potential presence of threats to human health (e.g., crocodiles, deep water) and/or flooding, budget, representativeness of disturbance, and responsiveness. Where possible, assessments should be undertaken within the wetland, but if this is not possible, assessment of the project site may be undertaken from bridges, causeways, high banks, or other readily accessible and safe vantage points for the wetland or based on aerial imagery and/or drone footage. The location of project sites must be justified in the CAMP.

There are generally two main options for pre-estimating the range and proportion of wetlands in various states to select project area, project site and assessment units:

- the first is to use aerial photo interpretation. Patterns of landscape and vegetation can be visually identified in aerial photographs, especially if stereoscopic photographs are available. These can be interpreted and a measuring grid-overlay (for example, in GIS packages) can be used to estimate the extent or proportion of visually obvious kinds of disturbances within the wetland, such as clearing, major weed invasion or the presence of infrastructure such as roads.

The total proportion of different kinds of disturbance, relative to undisturbed areas, can then be estimated.

- the other option is to conduct a pre-assessment wetland visit (described below). This should be done as an additional step to refine the results of the desktop site selection and can help to identify sources of disturbance to the wetland that may have been missed in the desktop estimation.

Pre-assessment visits are an important strategy for achieving a properly stratified sample of wetland sites that include critical features, such as points of inflow and outflow and flow altering infrastructure. Pre-assessment visits also streamline the assessment by ensuring that access is possible and safe, and that the assessment can be conducted in a timely manner.

A pre-assessment visit can be used to:

- assist with identifying project sites and assessment units
- confirm data identified in the desktop assessment, including areas of disturbance and points of aquatic connection (inlets, outflows)
- identify traverse routes through wetland margins and support landscapes in the wetland support area. Choose routes that allow the assessor to get an overview of the range of disturbances to landscape structures and processes, including to hydrological inflows and outflows
- confirm accessibility and usefulness of sites and traverse paths identified in the desktop study
- confirm how practical the sampling plan is
- identify the variety of process-defining features related to aquatic connections and terrain properties defining hydrological flows, including water turnover and exchange.

The final site selection may be completed before the full field assessment based on the desktop study and the pre-assessment visit. If no pre-assessment visit is possible, more candidate sites should be identified in the desktop assessment than will need to be assessed in the field to achieve adequate coverage of the wetland.

How to choose a Reference Site

Reference sites are survey sites that are normal (in good condition) for that wetland type and can, therefore, be used to help understand whether the changes in the indicators are due to natural fluctuations (e.g., climate) rather than human influences or the result of management interventions or natural recovery after an event such as a bushfire. It is, however, difficult to find normal wetlands that are also easily accessible, of the same type, and in close proximity; thus, **'best-on-offer'** sites can be used as reference sites (Eyre et al. 2011; Eyre et al. 2015). Reference sites can be used to provide further lines of evidence to demonstrate project outcomes (or lack of outcomes), where this is feasible, logistically possible, and affordable, but this is not essential.

Comparative sites are survey sites that are similar to the project site in terms of ecosystem, habitat type, hydromodification and disturbance, but are not undergoing recovery or management intervention. These sites are not essential but can be used to inform the scoring of the indicators by demonstrating the likely condition of the project site in the absence of event or management intervention.

Ideally, a potential reference site must fulfil the following criteria:

- it must be an example of the same wetland type in a normal or near- normal state
- it must be assessed at a similar time to the project sites to which it will be compared
- it must be located in the same region and be subject to comparable environmental conditions including:
    - climate
    - landscape conditions and position (e.g., soil, slope, geology, land-forming processes)
    - natural disturbance (e.g., flood, cyclone impacts or fire history).

There may be trade-offs among these requirements; for example, a reference site closer to the project area, with a more similar climate and natural disturbance history, but which falls short as a reference because of differing landscape conditions, may be preferable to a more distant reference site with very similar landscape conditions.

To address the challenge of finding undisturbed Australian wetlands, it may be necessary to choose a 'best-on-offer' site to use as a reference in the absence of one that represents the optimal natural state of a wetland of its type. This could be the best available site within the same wetland complex; for example, a site where stock has been excluded from the wetland and wetland margins.

The approach to be adopted will depend on the intended use of WetCAT scores. The best-on-offer approach is a particularly useful option when repeated assessments of the same wetland through time are anticipated, because it will ensure near-optimal comparability and will better support time series comparisons of trends in values. For example, this approach would be useful for discerning whether changes in species composition in a wetland were due to seasonal conditions or human-induced disturbance processes. On the other hand, assessing individual wetlands using reference sites within each of the wetlands compromises the ability of the data to support comparisons between wetlands, unless they are part of the same wetland complex.

The choice of reference site may also be related to the constraints of the assessment. If time or other constraints preclude travelling to a reference site, it may be necessary to accept a closer, best-on-offer site. A pragmatic approach to choosing a reference site would be to consider the consequence of using a best-on-offer site when a more pristine reference site is available at some distance. The lower the risk of adverse consequences, the more acceptable it is to choose a nearer site.

Appendix 3 – Field assessments

The following field assessment principles should be applied:

- suitable occupational health and safety (OH&S) policies are to be in observed before undertaking fieldwork
- freshwater and estuarine crocodiles may be present in Queensland wetlands. Be Crocwise in Croc Country (https://environment.des.qld.gov.au/wildlife/livingwith/crocodiles/crocodiles__be_croc_wise.html)
- for health and safety reasons, at least two people should conduct the assessment. Assessors should be familiar with, and follow, their individual organisational requirements regarding workplace health and safety, field trip planning and other applicable protocols
- assessors should have appropriate experience and training to perform field assessments
- assessors should be properly equipped with written advice from the landholder authorising entry to the property, plus other items needed to implement field methods and ensure personal comfort and safety
- the assessors can also bring information resources about the purpose and benefits of the activity to share with landholders and other interested parties
- assessments should be cross-checked, for example, through interviews with landholders and other stakeholders, and in post-assessment discussion between officers to deliver consensus on scores.

First Nations, landholders, and other stakeholders

Before conducting any assessment, contact and engage with landowners and other stakeholders, including First Nations people. It is important that First Nations people are aware of on-ground assessment and monitoring. Further information about working with First Nations people is provided in the Gurra Gurra Framework 2020-2026 (Department of Environment and Science 2020).

Stakeholder engagement should be used to:

- gain authorised access and permission for the survey
- identify important cultural heritage sites
- gain an understanding of the system from a First Nations and landholder perspective
- interpret information about the number, type, and characteristics of wetland features in the area of interest
- better understand the effect of preceding hydro-climatic conditions both on the landscape and on the assessment itself, including gaining information about whether the area can be adequately surveyed, and
- schedule travel times between assessment areas.

Field equipment

The following equipment may be required for the assessment:

- CAMP (printed and laminated)
- project map and other supporting maps
- the WetCAT data sheets in printed form (on waterproof paper if available)

- clipboard, pencils, sharpener
- data lists and reference materials (including those prepared from the desktop assessment)
- a compass, GPS, or smart phone with maps (if available)
- digital camera or smart phone with camera
- other communication devices for safety (satellite phone, walky-talky, etc.)
- knife/scissors, zip lock sample bags, and labels
- safety equipment (including a first aid kit)
- water and sun protection
- suitable clothing and footwear, including optional wet weather gear
- an appropriate vehicle
- wetland plants and animals' identification books (optional)
- a small dinghy or canoe (if required for adequate access).
- field computer or tablet for data entry (optional)
- phone with WetCAT Survey 123 App already downloaded (under development).
- dip nets
- quadrats (10 x10 m)
- measuring tape
- optional flora and fauna survey equipment.

Using drones

The following provides detailed guidance on how to acquire imagery using drones (taken from Waltham 2020). This innovative approach has the advantages of limiting the amount of field data that needs to be collected (and analysed), thereby reducing the cost and occupational risks associated with field work in Queensland wetlands (in particular, crocodiles). If successful, this approach could be important for tracking wetland condition in a consistent and credible way over time. A key benefit is having a standardised time series of quality, detailed, aerial photographs that can be re-analysed over time.

Background

Aerial photographs provide very detailed information on the structure and composition of wetlands over time. In recent time, unmanned aerial systems (UAS), often referred to as drones, have become very affordable and easy to operate. Because drones can be used at any time, they provide a unique way of acquiring robust data on wetlands without having to do laborious, and often non-representative and expensive, physical sampling. Photographs can be taken from a small personal drone or helicopter to get high-resolution aerial photographs of select sites over time. This method provides a permanent record of change and, if done correctly, is easy to convert into geo-rectified stitched images that can be further analysed using GIS software (Ross et al. 2017).

The image outputs provide a very detailed view of the wetland that can be used to monitor water extent, identify erosional features, map vegetation types, and characterise soil disturbances, such as pig damage – all key indicators of WetCAT. If aerial photographs are collected across the seasons, the results provide extremely useful information on seasonal change. In the context of feral pig impacts, this is a critical part of the potential biodiversity and water quality impact story (Ross et al. 2017).

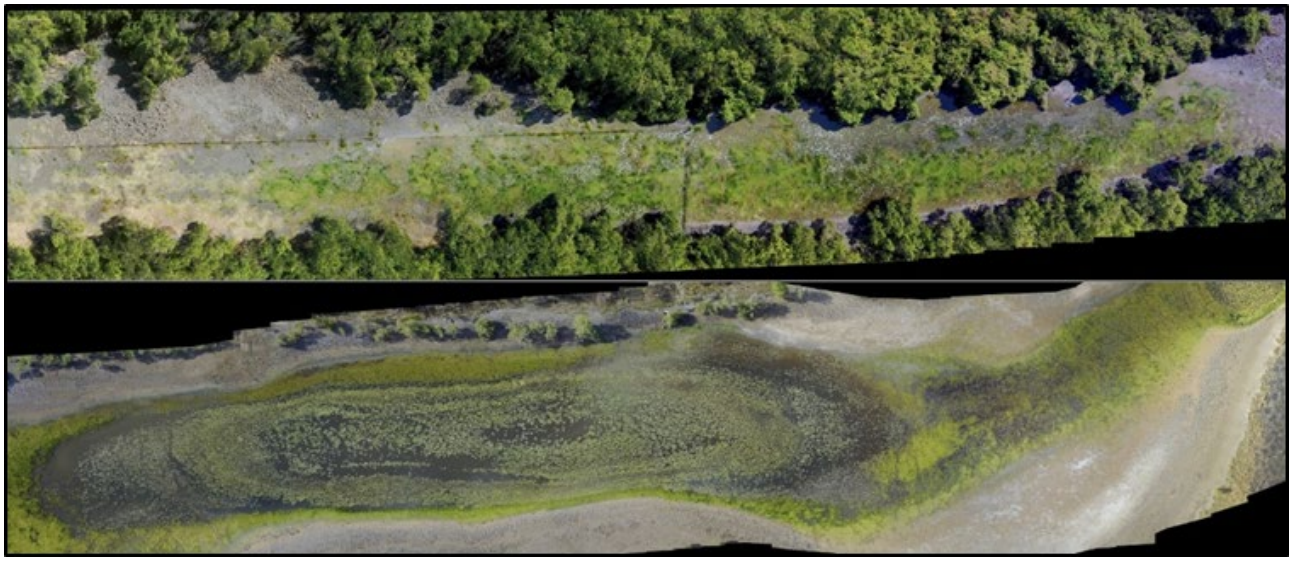

Figure A3.1. Examples of images of fenced (upper) and unfenced (lower) wetlands in Cape York. The image mosaic was captured with a drone (Taken from Ross et al. 2017).

Imagery Acquisition

Flight plans can be predetermined for each wetland site and the drone essentially navigates itself once it has been set up in the field. An example of a flight plan is shown in Figure A3.2, showing the programmed transects that the drone will fly. The application also shows how long the transects will take and how many batteries will be required. If the batteries get too low, the drone returns to the place of launch and lands and waits for a battery to be replaced. Once the battery is replaced the drone returns to the previous location and starts again. CASA regulations allow property owners to operate small drones (under 2 kg) within their property boundaries and outside of controlled airspace without requiring a licence, but appropriate training is essential before using a drone.

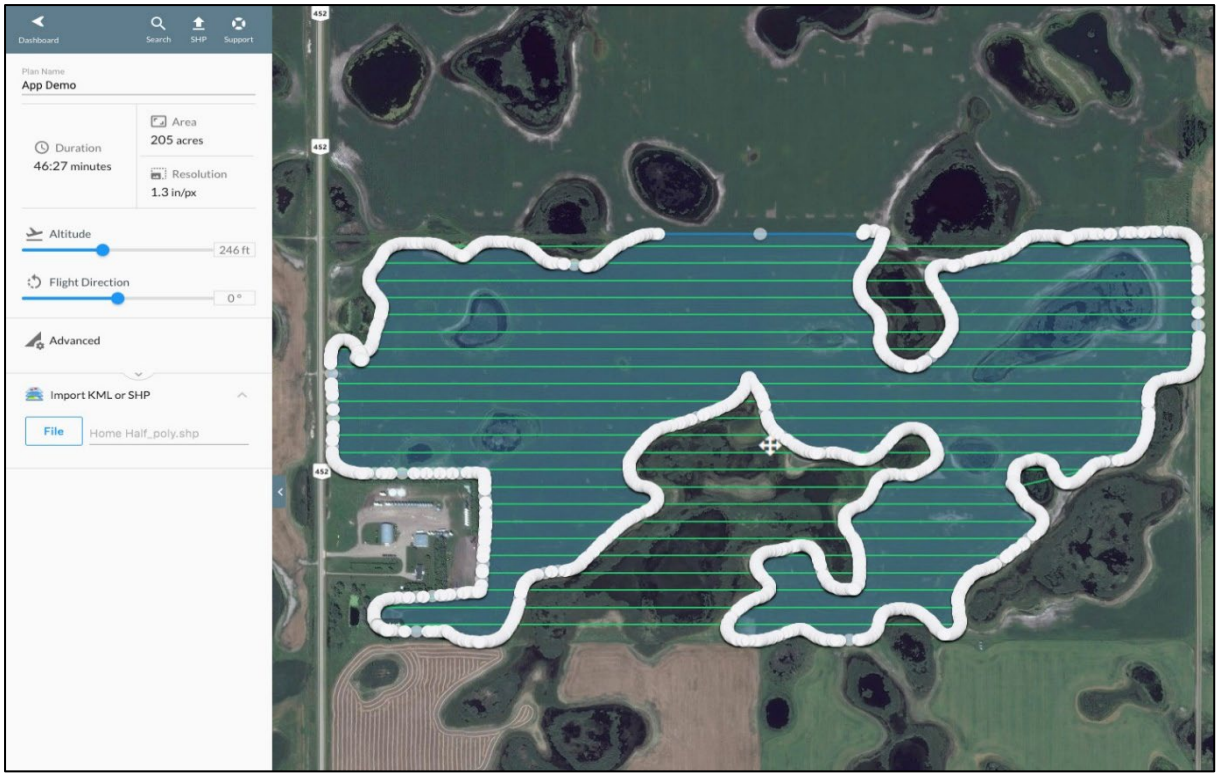

Figure A3.2. Flight plan interface example using the Drone Deploy app (Taken from Waltham 2020).

Ground control points (GCPs) are used to "tie" the imagery to known geographic coordinates (Figure A3.3). Establish one (or more) permanent ground control point(s) at each site, and several temporary GCPs. A minimum of 5 and maximum of 10 ground control points need to be positioned around the wetland project site. Space the ground control points evenly around the wetland project site and ensure they are not too close to the flight plan boundary.

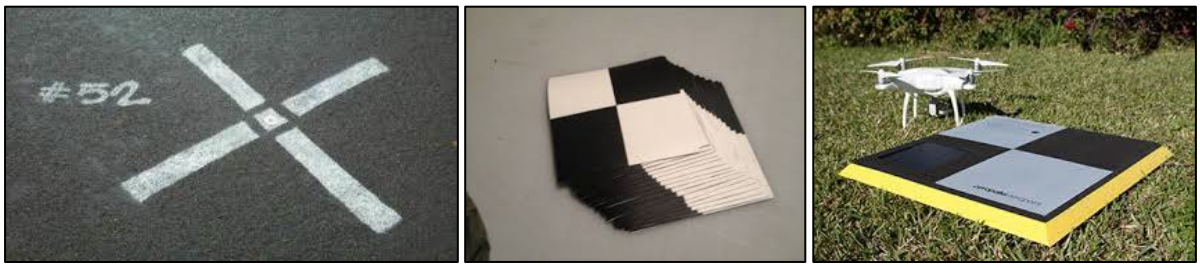

Figure A3.3. Examples of different types of ground control points. a) Permanent painted GCP with a steel rod/pin marking the centre, b) temporary GCP's made from vinyl flooring with black and white checkerboard design, c) temporary Propeller AeroPointsTM with inbuilt GPS (Taken from Waltham 2020).

The permanent GCP may be marked with a steel rod driven into the ground, with a temporary marker placed over the rod when surveys are conducted. GCPs need to be large enough and contrast with the surrounding area to be visible and easily recognisable in the aerial imagery acquired. Positioning of the GCP's is best done directly on the ground

An ideal GCP will have its latitude, longitude and elevation known. This can be achieved by a survey with a differential GPS. Standard handheld GPS units measure to a horizontal accuracy of

approximately 5m, so are not accurate enough for this. Differential GPS systems can accurately measure the ground control point location to 1-3cm accuracy.

The Queensland Government maintains a database with the location of permanent survey control markers accessible via Queensland Globe (Figure A3.4). These markers are generally more abundant in built-up areas (road survey marks, property boundaries), but it is worth checking as there may be a marker close to or within the area of interest. These make excellent candidates for ground control point locations as they are easily located and do not require establishing permanent points. Information on how to access the database is available here: https://www.business.qld.gov.au/industries/building-property-development/titles-property-surveying/surveying/permanent-marks

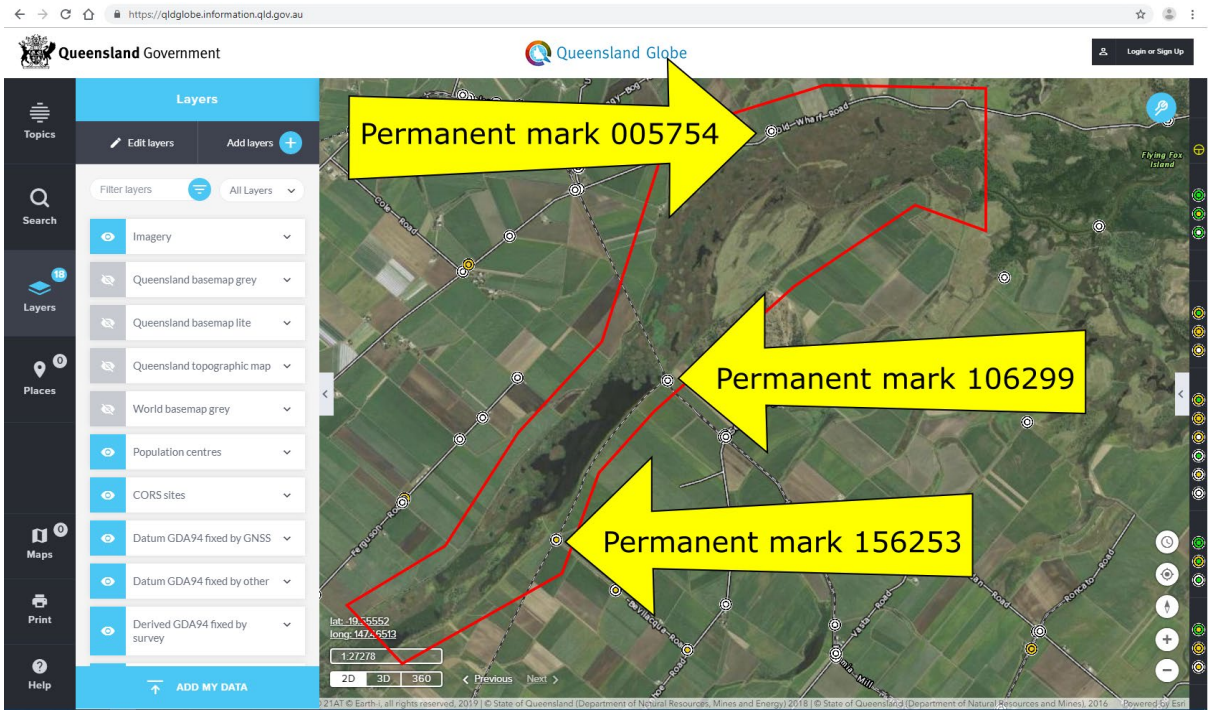

Figure A3.2. Locating permanent survey markers (yellow/white circles) in the vicinity of Plantation Creek (Ayr) using Queensland Globe. A theoretical flight plan boundary is marked in red which incorporates some of the survey marks close to the wetland (Taken from Waltham 2020).

Equipment required

To do basic aerial photography over impacted wetlands for measuring change over time, the following equipment is required:

- appropriate drone
- iPad or Android tablet to control the drone and view the images
- drone deploy application or similar for automating flights with a preprogrammed flight plan
- spare batteries (4 to 5 batteries total is ideal)
- car charging cable or inverter for charging batteries between sites.
- ground control points (5 to 10)
- high end computer with photogrammetry software (e.g., Agisoft Metashape Pro or Pix4Dmapper) or access to a research partner with the software
- GIS software for viewing and classifying output files (e.g., ArcGIS, QGIS, or MapInfo).

Quality assurance/control considerations

- Flying the drone and getting the photographs is relatively straight forward. However, high resolution photographs have very large file sizes and data management can be an issue. It is important to account for appropriate data management and processing if seriously considering using drones for monitoring.
- Important to establish ground control points (GCPs) at the wetland so that the drone imagery can be correctly georeferenced and compared between flights/visits.
- The altitude flown and image overlap need to be considered when preparing flight plan.
- Aerial surveys should be paired with a suitable ground-truthing method to give confidence in the resulting calculated changes over time.

Instructions

Operators should be trained and familiar with the drone being used.

Pre-fieldtrip

1. Create a flight plan for the site. Programs, such as Drone Deploy, can be used to plan automatic flights, with the correct amount of photograph overlap for stitching (approximately 60-70%). Within Drone Deploy, a polygon can be drawn around the perimeter of the wetland site to be captured. The height (generally 30 m) and overlap is set. Drone Deploy then calculates the time it will take to complete the survey and informs how many batteries it will take.
2. Critical step: the flight plans must be done where there is Wi-Fi or phone reception, before heading into the field (Ross et al. 2017).

In the Field

3. Establish a permanent ground control point for the site and record its precise position with a differential GPS. Mark the centre of the GCP by driving a steel rod into the earth which can be revisited on follow-up visits.
4. Position the other temporary GCPs around the site and record their precise position with a differential GPS.
5. Select and prepare a launch area for the drone.
6. Calibrate the drone before flight using the inbuilt calibration program.
7. Load the flight plan prepared for the site to the drone.
8. Check the flight time and batteries needed and set an appropriate ‘return to home’ altitude for areas with tall trees. Ensure the Micro-SD card is large enough to fit several sites worth of photos or have spares available.
9. Run the flight plan program for the site. The drone will automatically fly following the flight plan and take the photographs. The pilot and spotter must constantly watch the drone, maintaining line of site, and be prepared to take over control should anything go wrong. Watch out for birds that may be defensive and swoop at the drone and avoid disturbing animals. Note: The drone can be launched and landed manually to avoid collision with trees and shrubs.

Image analysis

The drone imagery is processed back at the office using photogrammetry software (e.g., Agisoft Metashape Pro or Pix4Dmapper), and then analysed with GIS software (i.e., ArcGIS, QGIS). As the imagery overlaps with several indicators, all indicators from the imagery will be processed at the

same time. The main activity required is to draw polygons for indicators within each indicator (Figure A3.5).

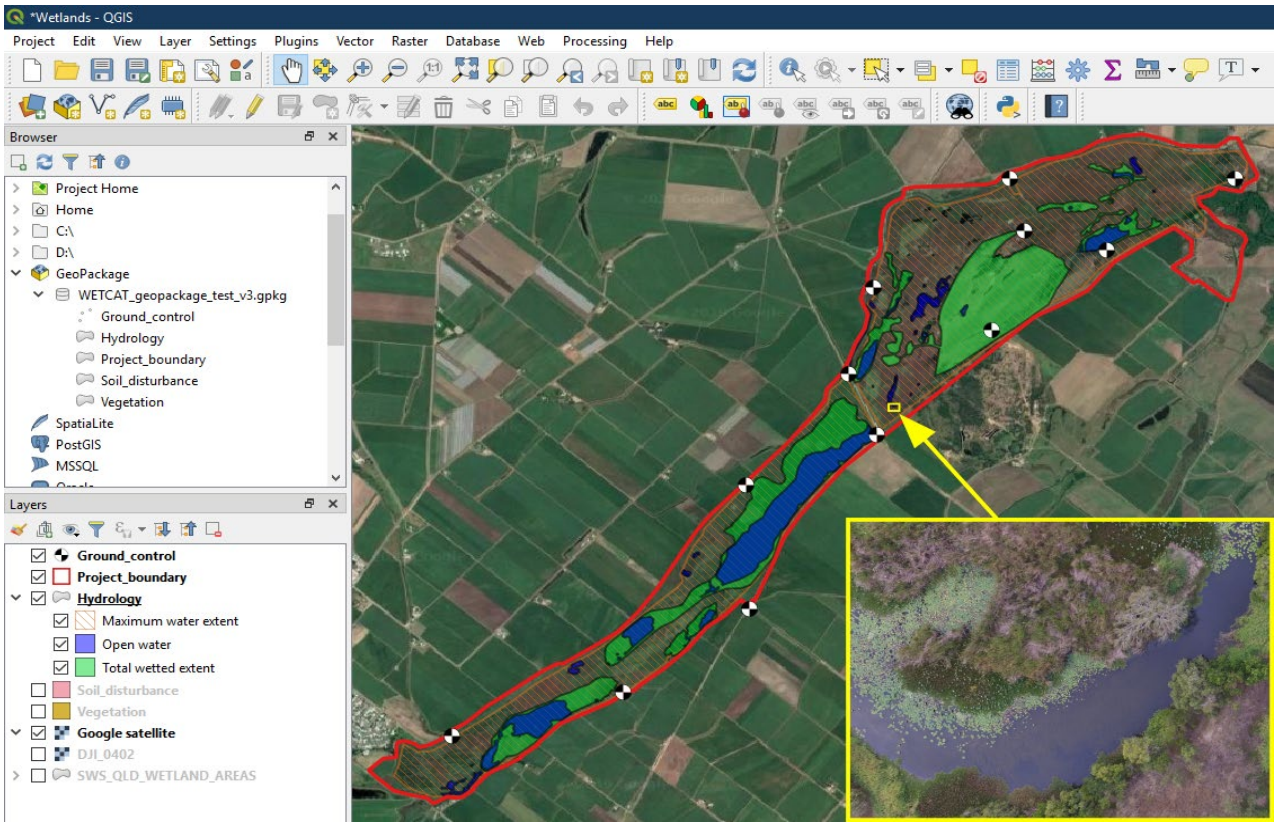

Figure A3.5. Hydrological characterisation of a wetland site at Plantation Creek (Ayr) from remotely sensed imagery (Google Earth). The project site boundary is indicated with a red line. Location of ground control points for drone image capture are shown as black/white symbols. Open water (blue), total wetted extent (green) and historic maximum water extent (orange hash) are shown. Each polygon can be calculated to determine the area and overall percentage of site identified as each class. Yellow insert: high resolution image captured from a drone (Taken from Waltham 2020).

Instructions

Preparing the drone imagery

1. Transfer images from the drone to the computer and maintain a backup copy of raw image files.
2. Stitch the images together to form an image mosaic with photogrammetry software.
3. Tie ground control points in the image mosaic to their known coordinates to produce an orthomosaic.
4. Create a digital terrain model (DTM) (optional - for topography and bathymetry indicator).

Assessing the orthomosaic

The attributes to collect are detailed under each indicator's specific sections. As numerous indicators capture attributes from the drone imagery, it makes sense to sit down and process all the indicators in one sitting. The following is an overview of the workflow.

Figure A3.6. Example GeoPackage structure in QGIS. The geodatabase structure in ArcGIS is similar (Taken from Waltham 2020).

1. Import the orthomosaic in GIS software
2. Setup a geopackage (.gpkg) or file geodatabase (.gdb) which contains a polygon layer for each indicator (Figure A3.6).

It is important to note that digital imagery may be good for capturing some parts of the wetland at a specific point in time, but photographs and other digital imagery cannot capture all aspects of a wetland (e.g., presence of weeds that are not located in within the photo frame, the hydrological cycle). Additionally, noting the stage of the hydrological cycle and/or seasonality when the imagery was captured is essential to ensure that interpretations of the photo are accurate (e.g., a photo taken during the natural dry cycle of the wetland does not necessarily signify poor condition of that wetland) (Figures A3.7 and A3.8).

Figure A3.7. An example of seasonal changes to hydrology and vegetation at Plantation Creek (Ayr). The site area boundary is marked in red. Note the change in position and shape of open water and vegetation extent. The high suspended sediment load can be clearly seen in the February flood image. Image sources: Google Earth (taken from Waltham 2020).

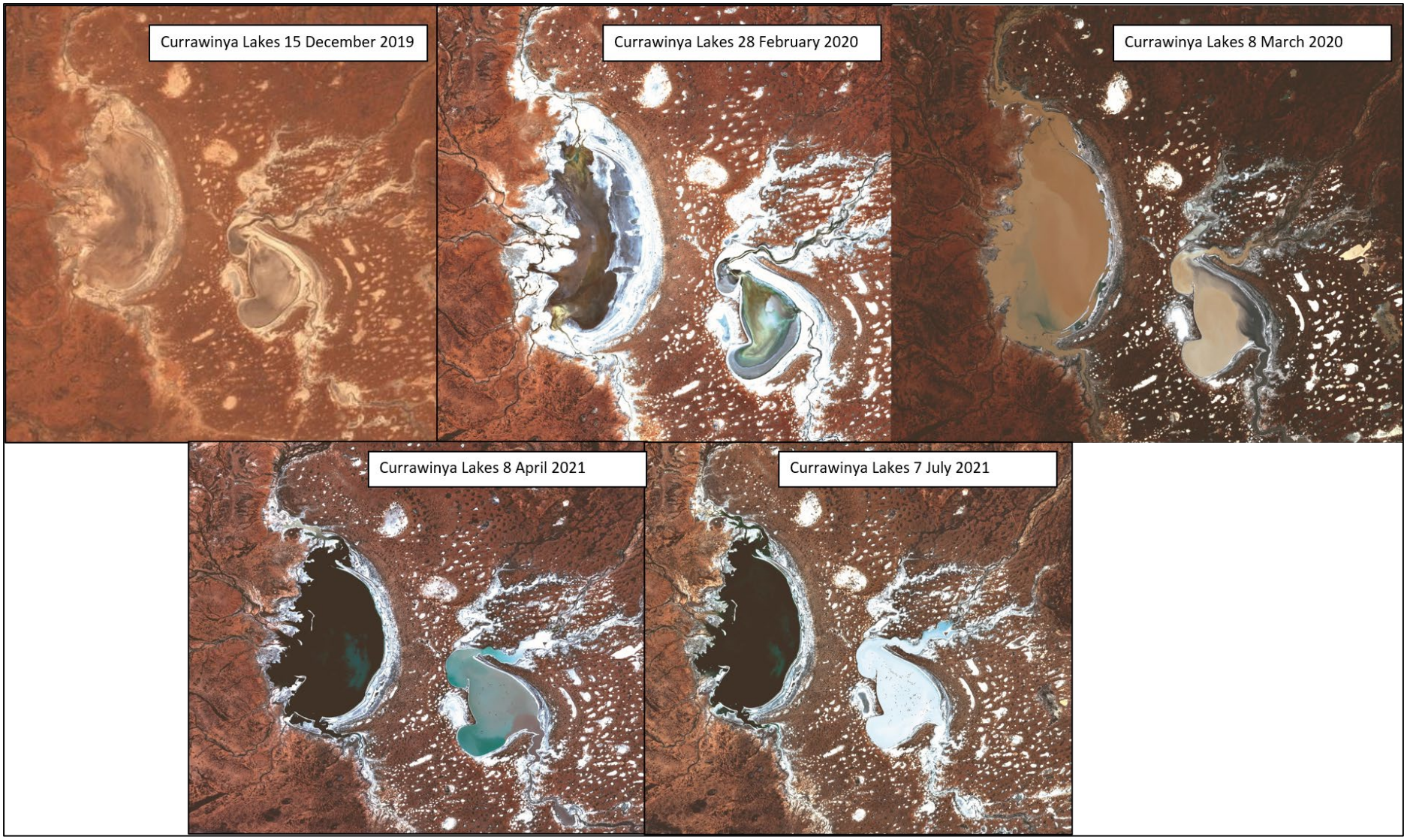

Figure A3.8. An example of seasonal changes to hydrology in an arid wetland. Image Sources: Christine Crafter

Appendix 4 – Optional indicators

Optional indicators that can be collected to provide information on more specialised assessments (not included in this version)

Appendix 5 – Data sheets

WetCAT
Wetland condition data sheet

Condition to be scored in the field for each site. It is important to define the project site/assessment unit (e.g., can use 10mx10m quadrat or 100m transect) and score indicators in that area only. Record observations outside the project site/assessment unit on the second page of this data sheet to provide context for the assessment.

Date:	**Time:**	**Assessed by:**
Project name:		
Project site/assessment unit name:		**Project site/assessment unit GPS coordinate/datum:**
Wetland system (circle): Palustrine Lacustrine Other		
Hydromodifier:	**Habitat type from wetland mapping[44]:**	
Photo point numbers: **North** **South** **East** **West**		
Define area of site: **(e.g. 10mx10m quadrat or 100m transect)**		
Area history/comments: **(e.g., fire, drought, cyclone)**		

Indicator	Rating (0-5)	Confidence Rating (A-E)[45]	Evidence, including justification for confidence rating
C1 Water regime			

[44] When out in the field, note if the habitat type differs from Wetlands mapping available online and inform the Queensland Herbarium if it does.

[45] Confidence ratings: A (known); B (High confidence); C (Moderate confidence); D (Low confidence); E (Unknown confidence). Note- Confidence rating applies to the confidence you have in the score.

Indicator	**Rating (0-5)**	**Confidence Rating (A-E)**	**Evidence, including justification for confidence rating**
C2 Water quality			
C3 Soil surface destabilisation, erosion, or deposition			
C4 Soil disturbance or compaction by humans (foot or vehicle) or hooved animals			
C5 Vegetation cover			
C6 Exotic wetland vegetation cover			
C7 Wetland macroinvertebrate abundance and diversity			
C8 Native aquatic fauna diversity			
C9 Litter and illegal dumping			
C10 Appropriate connections for biodiversity **Circle: C10-A or C10-B**			
C11 Physical habitat requirements for			

fish and other vertebrates			
Indicator	Rating (0-5)	Confidence Rating (A-E)	Evidence, including justification for confidence rating
C12 Fire impacts			
Overall impression of the condition of the wetland surrounding area[46] (i.e., G = good; GC = good with some concern; SC = significant concern; C = critical; NA = not applicable.			
Wetland surrounding area (e.g., Regional Ecosystem) and observations on condition or other activities (e.g., revegetation, fending, or litter clean up):			
Observations outside the defined site, such as weeds, exotic fauna (e.g., toads). The indicator scores above are based on observations for the defined site only (e.g., 10mx10m quadrat or 100m transect):			
Where more than one assessment unit/sampling site per project site (e.g., replicated transects or quadrats), what is the proportional area (%) of wetland that this unit represents?			

[46] Melzer, R, 2019, Natural Values Health Checks. A guide to undertaking Health Checks for key natural values. Version 1.6, July 2019. Ecological Assessment Unit, Queensland Parks and Wildlife Service & Partnerships, Department of Environment and Science, Queensland Government.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Water theme		
C1 Water regime	5) The water regime is normal for that wetland type[47] (considering seasonal change). 4) Very small to small difference to water regime for that wetland type (e.g., up to 25% change from the **end type** area/volume/level, frequency, depth, as described in the CAMP). 3) Moderate difference to water regime for that wetland type (e.g., 26-50% change). 2) Large difference to the water regime for that wetland type (e.g., 51-75% change). 1) Very large difference to the water regime for that wetland type (e.g., >76% change). 0) Complete Change to the water regime for the wetland type.	• Evidence for normal needs to be established, i.e., record the estimated upper and lower limits of inundation (typically based on wetland delineation, wetland mapping, long-term data or experience from other wetland types). ***O*** • Evidence of water regime for that wetland type needs to consider the hydrological modification of the wetland not the original type. ***O*** • Need to consider **stormwater**, that is water flow following rainfall. It can be overland or piped, both of which can alter water regimes, concentrate flows, scour soils/sediments, and introduce contaminants. Alternatively, they may divert water away from wetlands. ***F*** • Wetland delineation mapping showing changes over time. ***O*** • Observations based on satellite imagery or stacked plot of hydrological and vegetation change for wetlands in Queensland where available, see Wetland*Maps*. ***O*** • Observation of changes to water levels at the site based on vegetation (or sediment), supported by photographic evidence of aquatic and terrestrial plants and watermarks. **O&F** • Observations or records of extraction of groundwater or surface water using bores or pumps. ***O&F*** • Observations can be informed by field data (e.g., loggers) and/or records of anecdotal evidence of inundation extent***. F*** • No quadrat/transect required

[47] Further information on wetland ecosystem type, habitat type, and hydromodifiers is available on Wetland*Info*. This should refer to the 'end' wetland type where an intervention is designed to change the waterregime , e.g. excluding pigs, removing bund walls or altering irrigation flows.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Water theme		
C2 Water quality *Where more than one water quality parameter (e.g., pH, turbidity and DO) is important to the assessment, there is the option to record a score for each parameter for tracking over time. However, where more than one parameter is assessed, the score for this indicator should be based on a* ***general impression***[48] *of water quality at the site, rather than an average of all the parameters and may have an emphasis on one parameter which may be relatively more important for condition.*	5) The **water quality** is normal for that wetland type[49]. 4) Very small to small negative difference(s) to water quality for that wetland type (e.g., up to 25% change from the recorded normal range for that wetland type). 3) Moderate negative difference(s) to water quality for that wetland type (e.g., 26-50% change). 2) Large negative difference(s) to water quality for that wetland type (e.g., 51-75% change). 1) Very large negative difference(s) to water quality for wetland type (e.g., >76% change). 0) Complete change to the water quality for that wetland type.	• Evidence for normal needs to be established (typically based on long-term data or experience from other wetland types). ***O*** • Evidence for negative/positive change needs to be established. ***F*** • Direct measures of water quality parameters (where project-relevant and possible) such as turbidity, dissolved oxygen (DO), salinity/electrical conductivity (EC), pH, temperature, hydrocarbons, metals, ash and other contaminants (for more information see Monitoring and Sampling Manual: Environmental Protection (Water) Policy (DES 2018) or the Queensland Environmental Values (EVs) and Water Quality Objectives (WQOs) for basin-specific WQOs). ***F*** • Observations of water quality, where direct measurements are not possible, such as water clarity for turbidity, salt deposits or vegetation types for salinity/EC, dead or guilds of animals for DO, pH and/or temperature, slicks for hydrocarbons, algae for nutrients, odour for low DO and **anaerobic sediments**, burnt vegetation/ash as surrogate for fire, presence/absence of environmental values (EVs) based on historical use of wetlands[50]. ***F*** • Observations of direct contaminant inputs such as stormwater drains or point source inputs (e.g., drain outlet). ***F***

[48] General impression in QPWS&P Natural Values Health Checks (Melzer 2019), and a similar approach is also used for some indicators in Land Condition Assessment Tool (LCAT) (Hassett).

[49] It is important to consider the normal water type of the wetland, for example, not all turbid waters are an indication of poor water quality. Many inland rivers are naturally turbid and the animals and plants that grow in them have adapted to these conditions. For management purposes, it is important to know what the normal water type should be.

[50] For example, a lacustrine wetland that used to be used for swimming but is no longer used for that purpose could be an indication of degraded water quality within that wetland.

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
		• Observations of non-wetland animals (e.g., cow pat). ***F*** • Observations informed by field data (e.g., water quality probe, laboratory samples, loggers). ***F*** • Litter can impact water quality but should not be included here as it has a separate indicator. • No quadrat or transect required.
Soil/sediment theme		
C3 Soil surface destabilisation, erosion, or deposition	5) No evidence of **soil/sediment surface destabilisation**, **soil/sediment erosion** or **soil/sediment erosion/deposition or excavation/removal.** 4) Evidence of destabilisation/erosion/deposition across very small to small parts of the assessment unit (e.g., up to 25% change from the recorded normal rate for that wetland type). 3) Evidence of destabilisation/erosion/deposition across several small parts or a larger part of the assessment unit (e.g., 26-50% change). 2) Evidence of destabilisation/erosion/deposition across much (e.g., 51-75% change) of the assessment unit. 1) Evidence of destabilisation/erosion/deposition across most (>76% change) of the assessment unit with evidence of impacts to condition. 0) Extensive destabilisation/erosion/deposition.	• Destabilisation, erosion, or deposition can be related to hydrological processes (e.g., soil eroded or deposited by water movement), other natural processes (e.g., heavy rainfall associated with a cyclone or sediment burnt or ash deposits due to bushfire), or rehabilitation activities (e.g., removal of sediment with vegetation, often aquatic weeds). ***F*** • Observations of erosion and scouring can appear as receding and/or slumping banks, beds, or bars. ***F*** • Observations of excavation and in-filling. ***F*** • Observations of deposition, accretion, and/or sedimentation can appear as fine or coarse sediments (soft muds, sands), buried plants, and/or anoxic conditions. ***F*** • Observations of **sediment mobilisation** can be used to inform how sediment was destabilised (e.g., large or small event); that is, at a dry site, large particle sizes indicate high water velocities have moved those sediments, whereas fine particle sizes indicate low velocities have moved sediment areas. ***F*** • Increased sediment availability or transport can be associated with vegetation removal, particularly following aquatic weed mat removal or after fire (e.g., *salvinia*, typha, *hymenachne*). ***F*** • Time series of aerial photography or, if funding allows coring of sediments. ***F*** • Can use quadrat or transect

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Soil/sediment theme		
C4 Soil disturbance or compaction by humans (foot or vehicle) or hooved animals	5) No evidence of **soil disturbance** and/or **soil compaction** by humans or hooved animals. 4) Very small area(s) of soil disturbance and/or compaction in the assessment unit (e.g., up to <5% disturbance by humans or hooved animals). 3) Small area(s) of soil disturbance and/or compaction in the assessment unit (e.g., 6-15% disturbance). 2) Moderate to large area(s) of soil disturbance and/or compaction in the assessment unit (e.g., 16-35% disturbance). 1) Much of the wetland is disturbed and/or compacted in the assessment unit (e.g., 36-65% disturbance). 0) Most of the wetland is disturbed and/or compacted in the assessment unit (e.g., >66% disturbance).	• Observation of disturbance such as pugging, **trampling**[51], digging and/or wallowing by hooved animals (e.g., cattle, pigs, goats, horses, camels, donkeys), or compaction of sediments by humans (e.g., popular fishing or swimming areas, bicycles, vehicles) or compacted hard surfaces (e.g., roads or paths). ***F*** • May be referenced to aerial photography or drone imagery where visual evidence of soil disturbance has been mapped. ***F&O*** • Information on water points and paddock boundaries can be useful context, noting they may not influence the result. ***O*** • Small, moderate, and large to be quantified for a wetland type wetland (e.g., 25% of a shallow wetland may be more impacted than 25% of a deeper wetland). ***F*** • Can use quadrat or transect
Plant theme[52]		
C5 Vegetation cover	5) The vegetation **cover is normal** for that wetland type (includes **native** and **exotic** species).	• Includes all vegetation growing in the wetland (includes native and exotic vegetation), and vegetation considered to be aquatic (submerged, emergent, floating) and terrestrial (NB this

[51] Trampling is defined as visible disturbance to the soil surface caused by hooved animals traversing the area in dry conditions (Burrows and Scott 2020).
O – information collected in office; ***F*** – information collected in the field.
[52] BioCAT (Burrows and Scott 2020; Eyre et al. 2015) can be used for a more detailed assessment of wetland vegetation, such as surrounding area vegetation.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	4) Evidence of very small to small change(s) (e.g., up to 25% change from the recorded normal coverage for that wetland type) to the cover of vegetation for that wetland end type[53]. 3) Evidence of moderate change(s) (e.g., 26-50% change) to the cover of vegetation for that wetland type. 2) Much (e.g., 51-75% change) of the vegetation has been changed for that wetland type. 1) Most of the vegetation has been changed (e.g., >76% change) for that wetland type. 0) Complete change to the vegetation for that wetland type.	indicator is related to the **total** cover of vegetation in the wetland, and the following indicator provides for an assessment of the nature of that cover in terms of being native or exotic or non-preferred). ***F*** • Evidence for normal needs to be established (typically based on satellite imagery, wetland mapping, regional ecosystem descriptions, BioCondition benchmarks, other long-term data, or experience from other wetlands of that type). ***O*** • Observations based on satellite imagery or stacked plot of hydrological and vegetation change for wetlands in Queensland where available, see Wetland*Maps*. ***O*** • Ensure comparison during same season. • Small, moderate, and large (much/most) changes should be quantified for a wetland type. Can use quadrat or transect
Plant theme[54]		
C6 Exotic wetland vegetation cover	5) Exotic or non-preferred species are not evident in the wetland, including aquatic and terrestrial species. 4) Exotic or non-preferred species are evident in small area(s) (e.g., up to 5% coverage) of the wetland. 3) Exotic or non-preferred species are evident in larger area(s) (e.g., 6-33% coverage) of the wetland.	• Exotic plants can include floating weeds (e.g., *salvinia*, water hyacinth, water lettuce, exotic typha, alligator weed), emerging (e.g., pasture grasses, Singapore daisy, *hymenachne*) or terrestrial (cat's claw creeper, willow, prickly *acacia*, Noogoora burr), including **invasive plants**[55]. ***F*** • Observations of site-specific, **non-preferred vegetation**, which may be native, exotic, terrestrial, or aquatic.

[53] Further information on wetland ecosystem type, habitat type and hydromodifiers is available on Wetland*Info*. This should refer to the 'end' wetland type where an intervention is designed to change the waterregime, e.g., reducing cover of wetland vegetation such as weeds, or increasing cover of vegetation on the water's edge through replanting.

[54] BioCAT (Burrows and Scott 2020; Eyre et al. 2015) can be used for a more detailed assessment of wetland vegetation such as surrounding area vegetation.

[55] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/weeds-diseases/invasive-plants.

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) Exotic or non-preferred species cover much (e.g., 34-66% coverage) of the wetland. 1) Exotic or non-preferred species cover most (>67% coverage) of the wetland. 0) Exotic or non-preferred species cover the wetland.	For example, phragmites and most typha are native, but can be non-preferred where they dominate a system and influence ecology (e.g., reduce dissolved oxygen levels, alter hydrology, encourage sediment deposition, and prevent fish passage). ***F*** • Mapping from quality aerial imagery or drone footage. ***F*** • Observations can be supported by advice from and discussions with state and local government departments. • Pestinfo. ***O*** • WildNet. ***O*** • Can use quadrat or transect.
Animal theme		
C7 Wetland macroinvertebrate[56] diversity and abundance[57]	5) Evidence of normal[58] **macroinvertebrate** communities in **abundance** and **diversity.** 4) Evidence of macroinvertebrates but slightly altered abundance OR diversity compared to normal[59]. 3) Evidence of macroinvertebrates, but altered abundance OR diversity (e.g., dominated by one type) compared to normal.	• Macroinvertebrate types do not need to be taxonomically identified to species, but simply identified as different types based on **morphological[60]** features and ecological preferences[61] (e.g., high tolerance to low DO). • Normal to be determined based on historic sampling of the wetland or that wetland type in the literature. ***O*** • Aquatic macroinvertebrates can be sampled using a dip net or bucket from

[56] Aquatic and freshwater invertebrates are sometimes categorised as microinvertebrates or macroinvertebrates. Macroinvertebrates are invertebrates that are large enough to be seen with the naked eye (DES 2018). Some common macroinvertebrates found in wetlands include dragonfly nymph, worms, snails, beetles, leeches, mayflies, caddisflies, small crustaceans (excluding macrocrustaceans included in indicator C8, such as macrobrachium, other prawns, crayfish, and freshwater crabs), and other insects. See WetlandInfo for further information.

[57] Macroinvertebrates can be found in the water column, on the surface of the substrate, or within the sediment. In the case of dry wetlands, note if the sampled invertebrates are terrestrial. Be clear about where within the wetland macroinvertebrates are being assessed.

[58] Normal macroinvertebrate abundance and diversity is influenced by the biophysical features of a wetland. For example, the hydrology of non-permanent wetlands will influence what invertebrates there are at any time. Just filled – no time to colonise, on verge of emptying – environmental conditions of wetland may become intolerable and so minimal macroinvertebrates may be present

[59] If there is not enough information and/or the assessor has limited experience with identifying macroinvertebrates, scores 5, 3, and 1 should be used and justification for those scores should be recorded.

[60] Morphological features of invertebrates refers to the physical features of an organism to a group level. See Waterwatch Murray and Government of South Australia (no date) for a key to identifying aquatic macroinvertebrates.

[61] Sensitivity ratings (based on SIGNAL2 system) for groups of macroinvertebrates can be found in Waterwatch Murray and Government of South Australia (no date) and Chessman (2003) for sensitivity ratings for families of macroinvertebrates.

O – information collected in office; ***F*** – information collected in the field.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	2) Evidence of macroinvertebrates, but altered abundance AND diversity compared to normal. 1) Evidence of macroinvertebrates, but very altered abundance AND diversity compared to normal (e.g., one individual macroinvertebrate). 0) Lack of macroinvertebrates in the wet (i.e., aquatic macroinvertebrates) or dry (i.e., terrestrial macroinvertebrates) wetland.	the water's edge or a safe vantage point (DES 2018). ***F*** • Dry wetlands can also be assessed by sampling terrestrial invertebrates, such as ants, beetles, and spiders, using pit fall traps (Stewart et al. 2018). ***F*** • Diversity and abundance observations of live aquatic macroinvertebrates. ***F*** • iNaturalist. ***O*** • Assessments at night greatly increase the species richness and abundance detected for invertebrates. ***F*** • No quadrat or transect required.
Animal theme		

C8 Native aquatic fauna diversity
This indicator is to be assessed at the project area level given the highly mobile nature of these species.
	5) Evidence of normal abundance and diversity of native aquatic vertebrate communities and typically no exotic fauna (e.g., toads, gambusia or tilapia) or non-preferred fauna (e.g., translocated native fish or crayfish). Exotic birds may be present if they do not have an adverse ecological impact.
	
	4) Evidence of native aquatic fauna, but slightly altered abundance OR diversity compared to normal.
	
	3) Evidence of native aquatic fauna, but altered abundance OR diversity (e.g., dominated by one or few types) compared to normal.
	
	2) Evidence of native aquatic fauna but altered abundance AND diversity compared to normal.
	
	1) Evidence of native aquatic fauna, but very altered abundance AND diversity compared to normal
	
	0) Lack of native aquatic fauna
	0) Lack of native aquatic fauna
		• Normal to be determined based on historic sampling of the wetland for that wetland type in the literature. ***O***
		• It is important to note some wetland types do not support diverse fauna due to natural factors, such as connectivity or habitat.
		• NB native fauna, excluding aquatic macroinvertebrates included in indicator C7, such as:
		  ○ macrocrustaceans (*macrobrachium*, other prawns, crayfish, such as yabbies and red claw, and freshwater crabs)
		  ○ freshwater mussels
		  ○ fishes
		  ○ birds
		  ○ frogs
		  ○ turtles
		  ○ other wetland-associated reptiles (e.g., crocodiles, goannas, water dragons).
		• Observations of site-specific, non-preferred fauna, which may be native, exotic, terrestrial, or aquatic. For example, native translocated fish or crayfish. ***F***
		• WildNet. Ground-truthing where possible. ***O***
		• Assessments at night greatly increase the species richness and abundance detected for frogs. ***F***
		• No quadrat or transect required.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Other		
C9 Litter and illegal dumping[62]	5) No evidence of **litter**[63] or **illegal dumping**[64]**.** 4) Very minor litter (e.g., 1-2 items per quadrat), with no accumulation and no evidence of **toxic** or **dangerous** materials. 3) Minor litter or dumping, with minor accumulation and/or some evidence of toxic or dangerous materials (but impact may be unclear). 2) Obvious litter, but not extensive, with moderate accumulation and/or evidence of toxic or dangerous materials (but impact may be unclear). 1) Litter or dumping (> 200 litres in volume) is obvious, but not extensive, and includes toxic or dangerous materials, with evidence of physical impacts, such as altered water or sediment/soil quality. 0) Litter or dumping is extensive, with major accumulation and includes toxic or dangerous materials, with evidence of impacts to ecosystems, such as vegetation dieback, entanglement/dead fauna.	• Evidence of **toxic**[65] materials can include details or labels from containers indicating poison (e.g., skull and crossbones), oil slicks or slurries, hydrocarbon slicks or 'shimmering' on sediments, yellowing/dying vegetation, or dead animals. ***F*** • Evidence of **dangerous**[66] materials can include discarded fishing equipment (traps, nets, hooks, fishing line), plastic, cigarette butts, broken bottles or glass, metal, barbed wire, toilet tissue or asbestos. ***F*** • Aquatic biodiversity can be impacted by litter through ingestion of litter (e.g. birds, turtles, fish and other aquatic fauna), entanglement from discarded fishing equipment (particularly birds and turtles), toxicity associated with microplastics, nanoplastics, heavy metals, etc., fire associated with cigarette butts, habitat destruction (e.g. smothering, introduction of pest animals and plants), injury associated with sharp and broken materials, littered food, contaminated water, or other debris. ***F*** • The Litter and Illegal Dumping Management Framework (LIDMF) provides further details on assessing and monitoring litter. It is underpinned by an attribute-based classification scheme and LIDPrograms@des.qld.gov.au should

[62] For more information on litter and illegal dumping see https://www.qld.gov.au/environment/pollution/management/waste/litter-illegal-dumping. Indicator informed by QPWS&P Natural Values Health Checks (Melzer 2019) and Scottish Executive Environment Group (2006).

[63] Littering is the unlawful deposit of any type of waste material that is less than 200 litres in volume (about the volume of a wheelie bin) (Department of Environment and Science 2018a).

[64] Illegal dumping is the unlawful deposit of any type of waste material that is 200 litres or more in volume (about the volume of a wheelie bin) (Department of Environment and Science 2018b).

[65] Toxic refers to any substance that may have a negative biochemical effect on flora, fauna, or the wetland environment (Heads of EPA Australia and New Zealand 2020).
O – information collected in office; ***F*** – information collected in the field.

[66] Dangerous refers to any material that is harmful to and may entangle, injure, or destroy flora, fauna, or the wetland environment.

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
		be contacted for further information on data collection.[67] ***O*** • Can use quadrat or transect.
Other		
C10-A Appropriate connections for biodiversity *C10 indicator scores have been split into A and B; only score A* ***or*** *B.* *Suffix A (C10-A), indicates systems that require connections, and involves most systems in Queensland.* Quadrats and transects not required	5-A) Movement of flora and fauna is **appropriate** to maintain connections of populations. 4-A) Barrier(s) to movement of flora and fauna are likely to be appropriate, but evidence is not clear (e.g., a barrier with a fishway that has not been assessed for efficiency). 3-A) Barrier(s) to movement of flora and fauna are not likely to be appropriate, but evidence is not clear (e.g., chemical barriers, such as poor water quality, have not been sampled). 2-A) Barrier(s) to movement of flora and fauna are likely to negatively influence fauna movement. 1-A) Barrier(s) to movement of flora and fauna are negatively influencing fauna movement. 0-A) Movement of flora and fauna is not appropriate to maintain populations due to barriers.	• Evidence for appropriate needs to be established, that is flora and fauna can move appropriately to maintain populations and should consider different stages of a life cycle such as breeding, spawning, nursery, grow out, etc.[68].***O&F*** • Lack of connectivity due to barriers can be used as a surrogate for flora and fauna movement (biodiversity/condition). • Observations of barriers at the wetland (e.g., roads, railways, fences, bunds, poorly designed culverts, weed chokes, or poor water quality), which can inhibit the movement of water, aquatic flora, and aquatic fauna, such as fish and turtles (noting fences can be major barriers to turtles). ***F*** • Aerial imagery and mapping. ***O*** • Water use (e.g., farm dams and bunds) and linear infrastructure (e.g., roads, railways, and pipelines). ***O&F*** • Survey data. ***F*** • Observations of fish passage structures, such as fishways or fish-friendly culverts. ***F*** • NB effectiveness of fish passage would need to be assessed by a suitably qualified fish biologist; further information on barriers to fish passage is provided on Wetland*Info*[69].
Other		

[67] The Litter and Illegal Dumping Compliance Operations team can be contacted for advice if concerning litter or dumping is found on site at illegaldumping@des.qld.gov.au

[68] See Wetland*Info* Connectivity and the Landscape for more information, including the Framework for evaluating aquatic ecosystem connectivity

[69] https://wetlandinfo.des.qld.gov.au/resources/static/pdf/resources/fact-sheets/fs-aewrr-20200715-final.pdf

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
C10-B Appropriate connections for biodiversity Quadrats and transects not required *C10 indicator scores have been split into A and B; only score A **or** B.* *Suffix B (C10-B) indicates systems that need fewer connections or disconnections from other systems. This could include species such as threatened or endemic species that require isolation. For example, honey blue eye, Oxleyan pygmy perch, freshwater crabs, colour morphs of rainbowfish, or spring or lake systems which are naturally isolated and protected from predatory exotic fish, such as mosquitofish.*	5-B) Movement of flora and fauna is appropriate to maintain populations. 4-B) Natural barrier(s) to movement of fauna are likely to be appropriate, but evidence is not clear (e.g., natural disconnections/barriers in place but populations have not been sampled). 3-B) Natural barrier(s) to movement of fauna are likely to be inappropriate or modified, but evidence is not clear (e.g., natural disconnections/barriers have been altered but populations have not been sampled). 2-B) Modified natural barrier(s) to movement of fauna are likely to be influence fauna movement (e.g., fish are likely to be entering a pool that would not naturally be accessible due to a rock bar or similar natural barrier). 1-B) Modified natural barrier(s) to movement of fauna are influencing fauna movement (e.g., fish are entering a pool that would not naturally be accessible). 0-B) Movement of flora and fauna is not appropriate to maintain populations due to modified natural barriers.	• Evidence for appropriate needs to be established, that is flora and fauna can move appropriately to maintain populations[70]. **O&*F*** • Observations of barriers at the wetland (e.g., roads, railways, fences, bunds, poorly designed culverts, weed chokes, or poor water quality), which can inhibit the movement of water, aquatic flora, and aquatic fauna, such as fish and turtles (noting fences can be major barriers to turtles). ***O&F*** • Aerial imagery and mapping. ***O*** • Water use (e.g., farm dams and **bunds**) and linear infrastructure (e.g., roads, railways, and pipelines). ***O&F*** • Survey data. ***F*** • Observations of fish passage structures such as fishways or fish-friendly culverts. ***F*** • NB effectiveness of fish passage would need to be assessed by a suitably qualified fish biologist; further information on barriers to fish passage is provided on Wetland*Info*[71].
Other		
C11 Physical habitat requirements for fish and other vertebrates	5) Evidence of normal physical **habitat** (structure) for fish and other vertebrates is present, noting some wetland types do not necessarily support diverse or abundant fauna due to natural factors such as connectivity or habitat (e.g., some	• Normal to be determined based on historic sampling of the wetland or that wetland type or in the literature. ***O&F*** • Observations of habitat types such as **refugia**, feeding or breeding habitat for fish or other vertebrates, such as frogs, turtles, crocodiles, goannas, and water

[72] Aligns with QPWS&P Natural Values Health Checks (Melzer 2019).
[72] Aligns with QPWS&P Natural Values Health Checks (Melzer 2019).

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	wetlands are naturally low in nutrients). 4) Evidence of normal habitat for fish and other vertebrates; however, the condition of that habitat may be impacted (e.g., overhanging banks that are eroding or **slumping**, sand banks with minor accumulation of sediments). 3) Evidence of normal habitat for fish and other vertebrates; however, the condition of that habitat is degraded. 2) Habitat requirements for fish and other vertebrates are likely (e.g., turbid water, but woody debris has been seen at lower water levels). 1) Habitat requirements for fish and other vertebrates are not likely. 0) Normal habitat requirements for fish and other vertebrates are not evident.	dragons (e.g., woody debris, instream vegetation, overhanging banks, sand banks and the water itself (e.g., water holes). ***F*** • Species habitat mapping and information about habitat requirements, including species recovery plans***. O*** • No quadrat or transect required for fish. • Can use quadrat or transect for other vertebrates.
Other		
C12 Fire impacts[72] Quadrat or transect	5) There may be evidence of fire, however the **fire regime** appears appropriate and the wetland plants and wetland soil/sediment/peat[73] are normal for that wetland type. If peat is burnt a lower score should be assigned.	• NB If fire is being assessed, then the timing within the fire cycle must be considered when making an assessment. When a fire initially passes through a wetland, the expectation is that the wetland will receive a low score due to the damaged vegetation and/or soil or peat, and that the score will increase

[72] Aligns with QPWS&P Natural Values Health Checks (Melzer 2019).

[73] Peat wetlands are intricately linked to water; however, peatland hydrology is often poorly understood, and fire is one of the major threats to Australian peatlands (Pemberton 2005)

O – information collected in office; ***F*** – information collected in the field. There are a wide range of peat wetland in Queensland, including temperate coastal peatlands (e.g. coastal wallum from the New South Wales border to K'gari (Fraser Island)), montane swamps (e.g. Byfield), inland spring mounds (Great Artesian Basin, e.g. near Boulia), tropical peatlands of Northern Australia including floodplains (e.g. Russell – Mulgrave, Moresby, Murray and Tully River systems), mountain swamps and lakes (e.g. Atherton Tablelands), inter-dune swales (e.g. Whitsunday Island, Cape Flattery, and Olive River), and mangrove peat (e.g. Bowling Green Bay and Orpheus Island) (Whinam and Hope 2005)

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	4) Very minor evidence of fire impacts to wetland plants and/or wetland soil/sediment/peat. The fire regime is appropriate, and the wetland is highly likely to return to the normal state (e.g., mapped regional ecosystem) in terms of components and processes. 3) Minor evidence of fire, such as impacts on the abundance and/or coverage of wetland plants (e.g., canopy and subcanopy un-scorched, shrubs may be scorched, fire-sensitive low shrubs may be dead), and/or wetland soil/sediment/peat. The fire regime is appropriate, and the wetland is likely to return to the normal state. 2) Moderate evidence of fire, such as impacts on the abundance and/or coverage of wetland plants (e.g., partial canopy scorched, subcanopy partially or completely scorched, and/or fire-sensitive tall shrub or small tree layer mostly dead), and/or peat and peat-generating plants. The fire regime is unlikely to be appropriate and the wetland is unlikely to return to the normal state. 1) Evidence of severe fire in terms of the abundance and/or coverage of wetland plants (e.g., full canopy scorch to partial canopy consumed, subcanopy fully scorched or consumed), and/or loss of peat across <15% of the site and/or peat-generating plants. The fire regime is inappropriate, and the wetland is highly unlikely to return to the normal state. 0) Evidence of extreme fire in terms of the abundance and/or coverage of wetland plants (e.g., full canopy, subcanopy and understorey	as the wetland recovers over time. However, if the wetland does not recover as expected (e.g., subsequent and/or excessive burning or a shift in the normal vegetation for that wetland type from native to exotic, or peat beds are damaged or receding, or peat-generating vegetation does not return), then the score will remain low. ***F*** • NB peat can be burnt on the surface; however, fire can also pass through the peat, under the surface, and this can appear as collapsed surfaces, including large cracks and crevices and changes in colour from dark brown fibrous appearance to red, orange, yellow, grey, white or black [74]. ***F*** • Peat-generating plants can include *Astelia alpina, Baeckia gunnii, Brachycome* spp.*, Callistemon sieberii, Calythrix tetragona, Carex* spp.*, Celmisia* spp., *Chionogentiana* spp.*, Cyperus gymnocaulos, Drosera* spp., *Eleocharis sphacelata, Empodisma minus, Epacris breviflora, Epacris paludosa, Eucalyptus* spp. *(E. robusta and E. ovata), Gahnia* spp., *Isolepis aucklandicus, Juncus* spp. *(J. kraussi), Leptospermum juniperinum, Leptospermum lanigerum, Melaleuca* spp. *(M. quinquenervia, M. ericifolia, M. squarrosa, M. argentea), Oreobolus pumilio, Pandanus* spp.*, Phragmites australis, Richea continentis, Sphagnum* spp. moss*, Sprengelia incarnata, Typha angustifolia, Typha domingensis.* ***F***

[74] Lavinia State Reserve, King Island Post-fire Geomorphology and Vegetation Assessment (Corbett 2010) Detailed assessments of fire impacts to peat wetlands have not been undertake in Queensland, and these scores are based on studies in temperate systems (Corbett 2010, Flanagan et al. 2020, Fryirs et al 2021) together with Melzer (2019).

Condition indicator	Condition rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	consumed), and/or loss of peat across >15% of the site with loss of peat-generating plants. The fire regime is completely inappropriate, and the wetland is not expected to return to the normal state (e.g., mapped regional ecosystem).	

Confidence ratings for WetCAT indicator scoring are:

- known (A): According to expert knowledge **AND** supporting evidence based on an accepted, published method (e.g., AusRIVAS; qualified hydrologist has done survey of water movement)
- derived - High confidence (B): According to expert knowledge **OR** an accepted method (but no expert has verified score). This confidence rating could be used when an assessment method that would normally generate a "known" confidence rating was used, but with caveats
- derived - Moderate confidence (C): Used inadequate data sources/method combined with a strong assessment method/adequate data and/or expert knowledge
- derived - Low confidence (D): Derived from inadequate sampling methods/frequencies and/or expert has low confidence in result
- unknown confidence (E): According to expert knowledge, the confidence in the assessment method and indicator score is yet to be determined.

Note- Confidence rating applies to the confidence you have in the score.

WetCAT
Wetland surrounding area scale threat data sheet - 100 m from the edge of the wetland

Threat data in the wetland surrounding area to be scored in the office (where possible). The threat scores do not contribute to the scoring of condition, rather, threat scores are used to inform broader threat interactions with the site, and to inform the outcomes of the intervention and project more broadly. Threats do not need to be scored every assessment.

Date:			**Assessed by:**
Project name:			**Catchment name:**
Indicator	**Rating (0-5)**	**Confidence Rating (A-E)[75]**	**Evidence**
T1 – S Intensive land use			
T2 – S Major hydrological modifications			
T3 – S Minor hydrological modifications			
T4 – S Inflows from modified landscapes			

[75] Confidence ratings: A (Known); B (High confidence); C (Moderate confidence); D (Low confidence); E (Unknown). Note- Confidence rating applies to confidence you have in the score.

T5 – S Septic systems			
T6 – S Extraction of groundwater or surface water			
T7 – S Soil disturbance or compaction by humans or hooved animals			
T8 – S Native vegetation clearing			
Indicator	**Rating (0-5)**	**Confidence Rating (A-E)**	**Evidence**
T9 – S Exotic wetland plants			
T10 – S Exotic wetland animals			
T11 – S Exotic predators			
T12 – S Collection and harvesting of wetland species			
Notes (e.g., indicators that need to be checked in the field):			

WetCAT
Landscape scale threat data sheet

- 1 km or 5 km depending on the wetland indicator

Threat data in the landscape to be scored in the office (where possible). The threat scores do not contribute to the scoring of condition, rather, threat scores are used to inform broader threat interactions with the site, to inform the outcomes of the intervention and project more broadly. Threats do not need to be scored every assessment.

Date:			**Assessed by:**
Project name:			**Catchment name:**
Indicator	**Rating (0-5)**	**Confidence Rating (A-E)[76]**	**Evidence**
T1 – L Intensive land use			
T2 – L Major hydrological modifications			
T3 – L Minor hydrological modifications			
T4 – L Inflows from modified landscapes	*Not applicable at landscape threat*		
T5 – L Septic systems			

[76] Confidence rating: A (Known); B (High confidence); C (Moderate confidence); D (Low confidence); E (Unknown). Note- Confidence rating applies to confidence you have in the score.

T6 – L Extraction of groundwater or surface water			
T7 – L Soil disturbance or compaction by humans or hooved animals			
T8- L Native vegetation clearing			
Indicator	**Rating (0-5)**	**Confidence rating (A-E)**	**Evidence**
T9- L Exotic wetland plants			
T10 – L Exotic wetland animals			
T11 – L Exotic predators			
T12 – L Collection and harvesting of wetland species			
Notes (e.g., indicators that need to be checked in the field):			

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Water theme		
T1 Land use	5) No intensive land use present. 4) 1- 25% intensive land use is present. 3) 26-50% intensive land use is present or road, track, building within wetland surrounding area. 2) 51-75% intensive land use is present. 1) 76%-95% intensive land use present. 0) 96-100% intensive land use is present.	• Queensland Land Use Mapping Program (QLUMP)/Australian Land Use and Management (ALUM) intensive land use (ALUM PRIMARY[77] categories 3, 4 and 5). ***O*** • GIS and/or aerial photograph interpretation. ***O*** • Score to 5 km for the landscape scale.
T2 Major hydrological modifications	5) No major hydrological modifications and no major dam(s) affecting the wetland in the catchment. 4) Major hydrological modifications are not likely and with no major dam(s) in the catchment. 3) Major hydrological modifications are likely and no major dam(s) in the catchment. 2) One major hydrological modification, but no major dam(s) in the catchment. 1) Two to three major hydrological modification, but no major dam(s) in the catchment. 0) More than three major hydrological modification, and/or major dam(s) in the catchment.	• Major hydrological modifications, such as major impoundments (dams, weirs), irrigation systems, or drainage systems, which inhibit water from moving across the landscape. ***O&F*** • Wetland hydromodifier mapping. ***O*** • Aerial photograph interpretation. ***O*** • Barriers and instream structures (Department of Environment and Science) (des.qld.gov.au). ***O&F*** • Score to 5 km for the landscape scale.
T3 Minor hydrological modifications	5) No hydrological modifications.	• Recordings and observations of modifications/barriers, such as roads, railways, fences, bunds, weed chokes, poor water quality,

[77] https://www.agriculture.gov.au/sites/default/files/abares/aclump/documents/ALUMv8.pdf

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	4) Minor hydrological modifications are not likely (but evidence is not clear). 3) Minor hydrological modifications are likely (but evidence is not clear). 2) One minor hydrological modification is evident. 1) Two to three minor hydrological modifications are evident. 0) More than three minor hydrological modifications are evident.	infilling, or earthen farm dams, which can inhibit the movement of water, and aquatic fauna, such as fish and turtles. ***O&F*** • Wetland hydromodifier mapping. ***O*** • Aerial photograph interpretation. ***O*** • Barriers and instream structures (Department of Environment and Science) (des.qld.gov.au). ***O*** • Score to 1 km for the landscape scale.
T4 Inflows from modified landscapes	Inflows from modified landscapes are not evident. The area (i.e., 'wetland surrounding area-scale) is unmodified. 4) Inflows from modified landscapes are not likely. 3) Inflows from modified landscapes are likely. 2) <4 inflows are evident. 1) 4-18 inflows are evident. 0) More than 18 inflows are evident.	• T4 should be assessed at the wetland surrounding area only (not at the landscape scale), that is, record as 'not scored' at the landscape scale, do not assign 0 as that would suggest >18 inflows. NB the same needs to be done during subsequent threat assessments so the change in score is meaningful. • Stormwater is defined as water flow following rainfall, which can be diffuse overland or piped, both of which can alter water regimes, concentrate flows, scour soils/sediments, and introduce contaminants. • Mapping layers of point sources, such as major roads, residential areas, resource and primary production/extraction activities, stormwater drains. ***O&F*** • Licensed pollutant delivery sites (DES compliance pollution database).***O*** • Aerial photograph interpretation. ***O***
T5 Septic systems[78]	5) No septic systems. 4) Septic systems are not likely (but evidence is not clear). 3) 1-2 septic systems are evident. 2) 3-4 septic systems are evident. 1) 5-8 septic systems are evident 0) >8 septic systems are evident.	• There is a need to understand the local aquifers to understand the extent of influence associated with septic tanks, noting groundwater systems can be very complicated (e.g., springs and fractured metamorphic geologies, and sand systems with indurated layers) and different geology have different porosity and nutrient treating potential (e.g., sand is typically poor at capturing and/or treating septic tank inputs). • T5 should be assessed at a wetland surrounding area only (not at landscape scale). Record as 'not scored' at the landscape scale, but do not assign 0 as that indicates >8 septic tanks. NB the same needs to be done during subsequent threat assessments so the change in score is meaningful. • Local government area (LGA) information about the extent of sewered residential areas. ***O***

[78] Adapted from the draft Wetland Field Assessment Tool (Department of Environment and Heritage Protection 2014) and *Wetland Tracker: Field methods guide and workbook* (Department of Environment and Science 2022)

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
		• Aerial photo interpretation. ***O***
T6 Extraction of groundwater or surface water[79]	5) No extraction. 4) Extraction is not likely (but evidence is not clear). 3) Extraction is likely (but evidence is not clear). 2) 1 extractive groundwater bore is evident. 1) 2-5 extractive groundwater bores are evident. 0) >5 extractive groundwater bores are evident	• There is a need to understand the local aquifers to understand the extent of influence associated with groundwater extraction, noting groundwater systems can be very complicated (e.g., localised aquifers in fractured metamorphic geologies, layered aquifers in sand systems with **indurated layers**, and large regional aquifers such as the Great Artesian Basin). • T6 should be assessed at the wetland surrounding area only (not at the landscape scale). Record as 'not scored' at the landscape scale, do not assign 0 as that would suggest >5 extractive groundwater bores. The same needs to be done during subsequent threat assessments so the change in score is meaningful. • Groundwater bore mapping on Queensland Globe (filtered for extractive and active bores). ***O*** • Recordings and observations of groundwater or surface water pumps based on mapping or information from landholders, water utilities, water boards, industry, etc., or other extraction. ***O&F*** • The volume of groundwater or surface water extracted can be used where available, instead of the number of bores/pumps. ***O***
Soil/sediment theme		
T7 Soil disturbance or compaction by humans or hooved animals	5) No evidence of soil disturbance and/or soil compaction by humans (e.g., foot, bicycle, vehicle) or hooved animals (e.g., livestock, pigs, goats, horses). 4) Very small area(s) of soil disturbance and/or compaction (e.g., <5%). 3) Small area(s) of soil disturbance and/or compaction (e.g., 6-15%). 2) Moderate to large area(s) of soil disturbance and/or compaction (e.g., 16-35%). 1) Much of the area (e.g., 36-65%) has soil disturbance and/or compaction. 0) Most (e.g., >66%) of the area is disturbed by hooved animals.	• LGA and NRM plant/animal pest advice. ***O*** • Aerial photo interpretation. ***O*** • Score to 1 km for the landscape scale.

[79] Adapted from the draft Wetland Field Assessment Tool (Department of Environment and Heritage Protection 2014)

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
Plant theme		
T8 Native vegetation clearing	5) Native vegetation clearing is not evident (other than natural seasonal change). 4) Very small area(s) of native vegetation clearing is evident (e.g., <5%). 3) Small area(s) of native vegetation clearing is evident (e.g., 5-25%). 2) Moderate area(s) of native vegetation clearing is evident (e.g., 25-50%). 1) Much of the area is clear of native vegetation (e.g., 50-75%). 0) Most of the area is clear of native vegetation (e.g., >75%).	• Clearing of native vegetation where it previously existed, as indicated by **pre-clear vegetation** mapping (i.e., current **remnant vegetation** and **regrowth vegetation** layer compared to preclear layer). ***O*** • QLUMP cleared land or similar composite (e.g., Herbarium Integrated Vegetation Dataset). ***O*** • Cartographic interpretation of contemporary imagery if required ***O*** • Score to 1 km for the landscape scale. v
T9 Exotic wetland plants	5) Exotic or non-preferred species are not evident, including aquatic and terrestrial species. 4) Exotic or non-preferred species are evident, but percent cover is not clear in area of interest (wetland surrounding area- or landscape-scale). 3) Exotic or non-preferred species cover <5% of the area of interest. 2) Exotic or non-preferred species cover 5-25% of the area of interest. 1) Exotic or non-preferred species cover 26- 50% of the area of interest. 0) Exotic or non-preferred species cover >50% of the area of interest.	• Recordings or observations of exotic plants that grow in wetlands, such as *salvinia*, water hyacinth, water lettuce, Singapore daisy, *hymenachne*, exotic typha, alligator weed, cat's claw creeper, willow, prickly *Acacia*, Noogoora burr or pasture grasses, including invasive plants[80]. ***O&F*** • Recordings or observations of site-specific, non-preferred vegetation, which may be native or exotic, or terrestrial or aquatic. For example, *phragmites* and most *typha* are native, but can be non-preferred where they dominate a system and influence ecology (e.g., reduces dissolved oxygen levels and prevents fish passage). ***O&F*** • includes aquatic and terrestrial species, given terrestrial species can also influence the condition of a wetland. • DAF, NRM, LGA, QPWS advice. ***O*** • Pestinfo. ***O*** • WildNet. ***O*** • Score to 5 km for the landscape scale.
Animal theme		

[80] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/weeds-diseases/invasive-plants

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
T10 Wetland animal pests	5) Exotic or non-preferred wetland animals are not evident, such as cattle or feral pigs. 4) Exotic or non-preferred wetland animals are not likely (but evidence is not clear). 3) Exotic or non-preferred wetland animals affect <5% of the area of interest. 2). Exotic or non-preferred wetland animals affect 5-25% of the area of interest. 1). Exotic or non-preferred wetland species affect 26-50% of the area of interest. 0) Exotic or non-preferred wetland animals affect > 50% of the area of interest**.**	• Recordings and observations of exotic animals that inhabit (e.g., toads, fishes or turtles) or regularly use (e.g., feral pigs, cattle, goats, horses) wetlands, including **invasive animals**[81]**. *O&F*** • Recordings or observations of site-specific, non-preferred fauna, which may be native or exotic, or terrestrial or aquatic. For example, native predatory fish, such as spangled perch, may predate other native fish in a wetland system that was previously isolated from predators. ***O&F*** • Noxious fish are listed under Queensland legislation[82] and include several fish species, such as tilapia, carp and gambusia. • Declared animals are pests listed under Queensland legislation and include water buffalo and red-eared slider turtles. • See 'Exotic predators' indicator (T11) for non-wetland specific predators, such as feral dogs, cats, and foxes • DAF, NRM, LGA, QPWS advice. ***O*** • Pestinfo. ***O*** • WildNet ***O*** • Score to 5 km for the landscape scale.
T11 Exotic predators	5) Exotic predators, such as predatory fish, dogs, cats, and foxes, are not evident. 4) Exotic predators are not likely (but evidence is not clear). 2). Exotic predators affect <5% of the area of interest. 3). Exotic predators affect 5-25% of the area of interest. 1). Exotic predators affect 26-50% of the area of interest. 0) Exotic predators affect > 50% of the area of interest.	• Recent recordings and observations of native and exotic animals (including invasive animals) that are predators and use wetlands, such as direct observations of dead or alive feral predators, such as fish, dogs, cats or foxes, or indirect observations such as predated birds and small mammals, scats, tracks, or burrows. ***O&F*** • Local knowledge, land use mapping***. O&F*** • DAF, NRM, LGA, QPWS advice. ***O*** • Pestinfo. ***O*** • WildNet. ***O*** • Score to 5 km for the landscape scale.
T12 Collection and harvesting of wetland species	5) Collection or harvesting of wetland species is not evident. 4) Collection or harvesting of wetland species is not likely (but evidence is not clear).	• DAF advice on licenses for fisheries and wildlife collection. ***O*** • QPWS advice on wildlife collection. ***O*** • NRM advice. ***O*** Cross check with evidence of infrastructure (e.g., jetties, and signage). ***O&F*** Score to 1 km for the landscape scale.

[81] https://www.business.qld.gov.au/industries/farms-fishing-forestry/agriculture/land-management/health-pests-weeds-diseases/pests/invasive-animals

[82] https://www.qld.gov.au/environment/plants-animals/animals/pests-diseases/invasive-fish/legal-obligations

O – information collected in office; ***F*** – information collected in the field.

Threat indicator	Threat rating (0-5) and description of state	Visual cues and other information (e.g., description, clarifications)
	3) Limited collection or harvesting of wetland species is evident (e.g., limited to scientific collection). 2) Minor evidence of collection or harvesting of wetland species. 1) Moderate evidence of collection or harvesting of wetland species (e.g., fishing spot).	