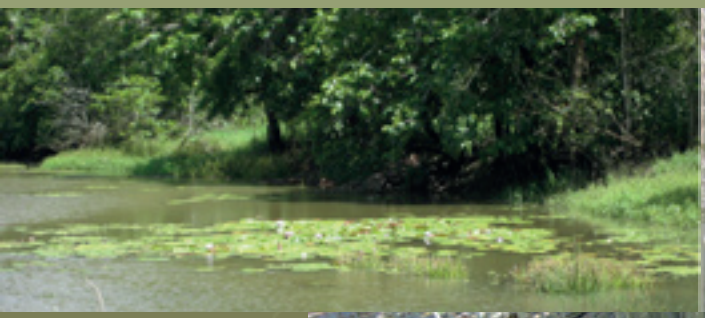
Queensland Wetland Buffer Guideline

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Queensland Wetland Buffer Planning Guideline

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Other technical contributions to the guideline include:

- Wetland Environmental Values listed on Wetland*Info* <www.derm.qld.gov.au/wetlandinfo/site/factsfigures/WetlandValues.html> — developed by the Department of Environment and Resource Management (previously the Environmental Protection Agency). This list incorporates environmental values from the Millennium Report: Ecosystems and Human Well-Being: Wetlands and Water (Millennium Ecosystem Assessment 2005) and the Environmental Protection (Water) Policy 1997 (EPP(Water)).
- Planning Guidelines: Separating Agricultural and Residential Land uses (Queensland Department of Natural Resources and Department of Local Government and Planning 1997).

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- Department of Employment, Economic Development and Innovation (previously the Queensland Department of Primary Industries and Fisheries)
- Department of Infrastructure and Planning (previously the Queensland Department of Local Government, Planning, Sport and Recreation
- Australian Government Department of Sustainability, Environment, Water, Population and Communities (previously the Department of the Environment, Water, Heritage and the Arts).

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Acronyms

ANZECC	Australian and New Zealand Environment and Conservation Council (now known as the Environment Protection and Heritage Council (EPHC))
AquaBAMM	Aquatic Biodiversity Assessment and Mapping Methodology
CAMBA	Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment, ratified 01 Sept 1988 <www.austlii.edu.au/au/other/dfat/treaties/1988/22.html>
DEEDI	Department of Employment, Economic Development and Innovation
DERM	Department of Environment and Resource Management
EPA	Environmental Protection Agency
GBR	Great Barrier Reef
GES	General Ecological Significance
HAT	Highest Astronomical Tide
HES	High Ecological Significance
JAMBA	Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in danger of Extinction and their Environment, ratified 1981 <www.austlii.edu.au/au/other/dfat/treaties/1981/6.html>
ROKAMBA	Agreement between the Government of Australia and the Government of the Republic of Korea on the Protection of Migratory Birds, ratified13 July 2007 <www.austlii.edu.au/au/other/dfat/treaties/2007/24.html>
SPP	State Planning Policy
WEV	Wetland Environmental Value

1 Introduction

This guideline has been developed to assist with the design of a wetland buffer that will maintain wetland environmental values and protect wetlands from current and future threats from adjacent land uses. The buffer design method is based on the principle that an effectively designed and managed wetland buffer not only helps maintain and protect the visible wetland, but also the suite of Wetland Environmental Values (WEVs) that are unique to that wetland.

Designing an effective wetland buffer can be a complex process which relies upon many factors, including the wetland's characteristics, the wetland type, environmental values, location, surrounding land uses, and the current and future stressors and impacts on the wetland. This guideline describes a Wetland Buffer Design Method which recognises two distinct areas — a Wetland Support Area and a Separation Area. Identifying and prioritising the unique WEVs of a target wetland is fundamental to designing the Wetland Support Area (the wetland's core). The Separation Area, which surrounds the Wetland Support Area is determined by identifying and conducting a risk assessment of the direct pressures to the WEVs (such as adjacent land uses), prioritising these pressures, and then estimating the area required to buffer the wetland and its WEVs from these pressures.

While wetland buffers should be viewed as an important part of managing wetlands, properties and catchments, not all direct pressures can be mitigated by the Wetland Support and Separation buffer areas. Therefore, it is essential to use a holistic, integrated landscape management approach, and consider a range of management strategies as potential solutions to issues affecting wetlands and the broader landscape.

How wetlands are defined

Wetlands occur at the interface between terrestrial and aquatic ecosystems. Their forms arediverse and may permanently, periodically or intermittently contain fresh or saline water. The Queensland Wetlands Program <www.environment.gov.au/water/policy-programs/wetlands/qwp.html> defines wetlands as:

> areas of permanent or periodically intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 metres. To be classified as a wetland, the area must have one or more of the following attributes:
>
> i. at least periodically, the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or
>
> ii. the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or
>
> iii. the substratum is not soil and is saturated with water, or covered by water at some time.

The Queensland Wetlands Definition and Delineation Guidelines Parts A and B (Draft) (DERM 2010a) provides further information and details on the definition (see <www.derm.qld.gov.au/wetlandinfo>).

Wetland Environmental Values (WEVs)

Wetlands are a valuable natural resource, providing a range of social, economic and environmental benefits. WEVs refer to the individual physical and biological characteristics associated with a particular wetland that provide its ecological, social and economic benefits and are sometimes referred to as ecosystem services.

Determining the WEVs associated with a particular wetland is fundamental to using this guideline. This guideline uses the suite of WEVs developed by the Queensland Wetlands Program (see Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo>). This list of environmental values incorporates values described in the Millennium Report Ecosystems and Human Well-Being: Wetlands and Water (Millennium Ecosystem Assessment 2005) and the EPP (Water).

While determining the full suite of WEVs for a wetland allows for the design of a holistic buffer, legislation may only allow for consideration of a subset of these values. Consequently, if this guideline is being used for statutory decisions, such legislative aspects must be considered when determining the range of WEVs to be used in that decision making process.

2 Purpose and scope

This guideline has been developed to support best practice in designing and managing a buffer around a particular wetland through a defined process — the Buffer Design Method, which relies on fundamental concepts and a systematic approach (Section 6). It is intended to assist those involved in wetland planning and management by providing a series of steps and considerations associated with designing a wetland buffer, its benefits and ongoing management needs. For further information about using the guideline and the expertise required to design a wetland buffer using this method refer to Section 3.

This buffer guideline can assist:

- the assessment of development applications in the vicinity of mapped wetlands
- codes and guidelines for regional plans, policies and planning schemes
- stakeholders involved in management of wetlands (including local government, state government, landholders, developers, planners, natural resource managers, rehabilitation groups
- wetland management plans (for example, as part of a farm management plan or development maintenance plan) to ensure environmental sustainability of a particular wetland
- project plans and funding applications for on-ground wetland restoration and management.

Relationship to relevant legislation, planning and management

In keeping with a holistic approach to designing an effective buffer, a range of factors which are directly or indirectly relevant to wetlands and wetland buffers need to be taken into consideration when using this guideline. This includes:

- legislation, planning, agreements and management documents relevant to the particular wetland/s
- available measures or methods for mitigating the impact of conflicting land use/s, for example stormwater treatment, contaminant management, re-vegetation, weed management or exclusion of animals
- the influence of other sources of impact in the catchment (for example other land disturbance or sewage treatment plant discharges) and activities within wetlands such as gravel or water extraction)
- future management and monitoring arrangements for the buffer and the commitment to these aspects
- social and economic constraints.

This guideline cannot over-ride legislative requirements. However, it can inform decisions required under Queensland legislation to the degree that the legislation allows for guideline consideration. Where legislation states the minimum standards that must be achieved in relation to buffers, this guideline can be used to design the appropriate buffer and its management. However, the minimum buffer distance must not be less than any other buffer requirements required under Queensland legislation and the maximum buffer distance must be guided by the capacity and willingness of the landholders to accept the requirements identified through the buffer design process, and comply with legislation. For information on using default buffer distances see the section on ‘Using a standard or default buffer width’ below.

Wetland buffers also need to be distinguished from wetland trigger areas under legislation. Trigger areas are those areas which trigger an assessment of the impacts for a development — the resulting buffer may be significantly narrower than the trigger area depending on the nature of the development.

Wetlands to which these guidelines apply

Wetland systems

Whilst this guideline has been designed primarily for the palustrine, lacustrine, estuarine and marine wetland systems, the concepts behind the Buffer Design Method could also be easily applied to riverine and artificial wetlands. These wetland systems are described fully in Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a) found on Wetland*Info* at: <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>.

Wetland significance

As the Wetland Buffer Design Method may require the compilation and evaluation of information as well as consultation with a range of wetland experts, wetlands with higher ecological significance will derive the most conservation benefit from developing a buffer based on the protection of identified WEVs — as opposed to using a standard (default) buffer distance that is not tailor-made. Nevertheless, the Buffer Design Method could also be used for other wetlands if desired.

The ecological significance of wetlands in Queensland has been assessed by many methods, for different purposes and at different scales (see <www.derm.qld.gov.au/wetlandinfo/site/SupportTools/AssessmentMethods.html>).

However, a process to map the State's ecological interests for land use planning and development assessment as areas of ecological significance (AES) is currently underway. The AES methodology combines the most accurate datasets available to identify areas of high ecological significance (HES) or general ecological significance (GES). For wetlands the method uses the results of DERM's Aquatic Biodiversity Assessment and Mapping Methodology (AquaBAMM) where available. In other areas, wetland mapping, Ramsar areas, A Directory of Important Wetlands in Australia sites and other wetlands identified as having ecological significance are combined to produce an AES layer.

Where the AES method has been applied and the mapping is available this guideline is most applicable to HES wetlands. Where the AES mapping is not available the guideline is most useful for the wetlands in Table 1.

Table 1. Wetlands for which the Buffer Design Method is recommended

Wetland	Relevant legislation / agreement
A wetland of international importance	Ramsar Convention
A wetland of national importance	Queensland chapter of *A* Directory of Important Wetlands in Australia
Significant Coastal Wetland	Regional Coastal Management Plan and State Coastal Management Plan
Area scheduled as being of High Ecological Value	Environmental Protection (Water) Policy 2009 EPP (Water)
A 'significant wetland'	Local government planning scheme
Endangered / Of-concern Regional Ecosystem	*Vegetation Management Act 1999*
Wetland within a National Park or Coordinated Conservation Area	*Nature Conservation Act 1992*
Protection and conservation zones	*Marine Parks Act 2004*
Fish Habitat Area	*Fisheries Act 1994*
A mapped wetland that contains wetland dependent wildlife (flora and fauna) listed as endangered or vulnerable.	*Nature Conservation Act 1992*
A wetland listed on the Queensland Heritage Register	*Queensland Heritage Act 1992*

This table does not override requirements of the legislation listed

Using a standard or default wetland buffer width

A standard or default buffer width may be used for non-HES wetlands or wetlands that do not have WEVs or where there is a statutory requirement and a default width is specified. In these cases undertaking the detailed design process described for the Buffer Design Method may not be justified. Current Queensland legislation or policies that specify a standard or default wetland buffer width include the following:

- State Planning Policy 4/11: Protecting Wetlands of High Ecological Significance in Great Barrier Reef Catchments. For further information see the SPP and supporting guidelines at <www.derm.qld.gov.au/wildlife-ecosystems/ecosystems/wetlands-spp.html>.
- Regional Vegetation Management Codes or Regrowth Management Code under Queensland's *Vegetation Management Act 1999*. More information about the individual Regional Vegetation Management Codes is available at <www.derm.qld.gov.au/vegetation/regional_codes.html>.
- Fisheries Queensland (part of the Department of Employment, Economic Development and Innovation (DEEDI)) has developed Fish Habitat Buffer Zone Guidelines to assist with the effective management fish habitat in fresh, estuarine and marine waters see <www.dpi.qld.gov.au/28_12907.htm>.
- Many local government planning instruments have requirements for buffers around wetlands. Contact the relevant council for more information.

3 Wetland buffer planning

Developing a wetland buffer should be considered as part of an overall adaptive planning and management framework for a wetland, as the buffer alone cannot maintain all the WEVs of a wetland, or address all threats from surrounding land uses.

Other policies and plans, such as Water Resource Plans, State Planning Policies, regional and local plans and pest management plans provide important information about a range of issues that impact wetlands such as environmental flows, connectivity, water quality, and weed and feral animal management. All of these need to be considered when designing and implementing a buffer, and managing a wetland. It is also important to recognise that buffers have only a limited ability to address connectivity. If the connectivity of a wetland has been impacted in the broader landscape and biota, nutrients, water and other processes have been interrupted, there are few opportunities to address it through a buffer, which will by its nature be limited to a specific site.

An adaptive management approach to designing the buffer is recommended as shown in Figure 1.

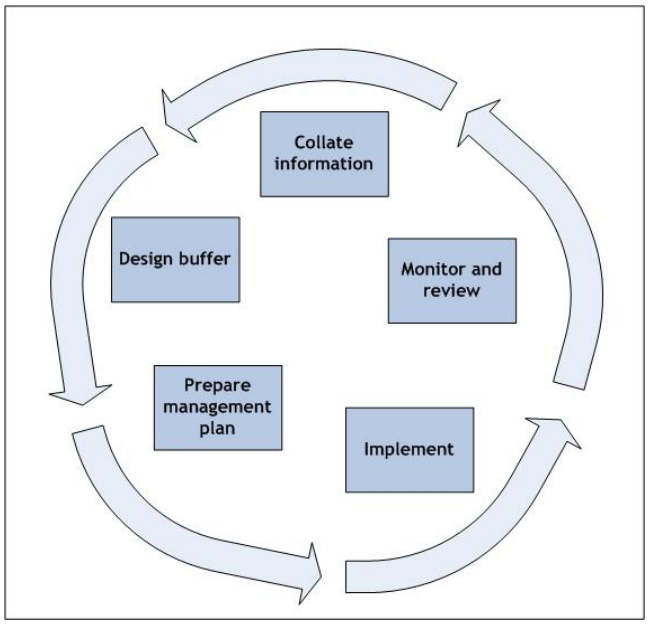

Figure 1. Adaptive management framework

By monitoring and evaluating the results of the buffer design, the values of the wetland can be better preserved. To this end it is recommended that when developing a wetland buffer and plan of management, as outlined in this guideline, that a monitoring component is also developed. By defining and reviewing indicators of buffer performance the effectiveness of the buffer can be determined over time. Monitoring also provides a sound basis for potentially altering a wetland's buffer characteristics and management so that a continual improvement or, if appropriate, maintenance of the wetland's environmental values and overall sustainability can occur.

The design process

This guideline describes a systematic and consistent method which is outlined in Figure 2. It incorporates a step-by-step approach to ensure the most significant WEVs are considered when designing the buffer, and includes six key tasks associated with determining effective and justifiable Wetland Support and Separation Area buffer distances.

Although the process is depicted as being sequential, in practice information may be compiled for a number of steps at one time, and an individual step may need to be revisited as more information becomes available.

Outputs of the Buffer Design Process are:

- a report which documents the buffer planning process and details the information and recommendations resulting from each step of the process
- wetland buffer map and specifications — detailing the Wetland Support and Separation Areas / Distances and Buffer Elements
- Wetland Buffer Implementation Plan including management actions and monitoring requirements necessary to maintain the buffer.

The Buffer Design Process is described more fully in Section 6, and a checklist of the steps involved and necessary proformas are provided in Appendix B and C respectively.

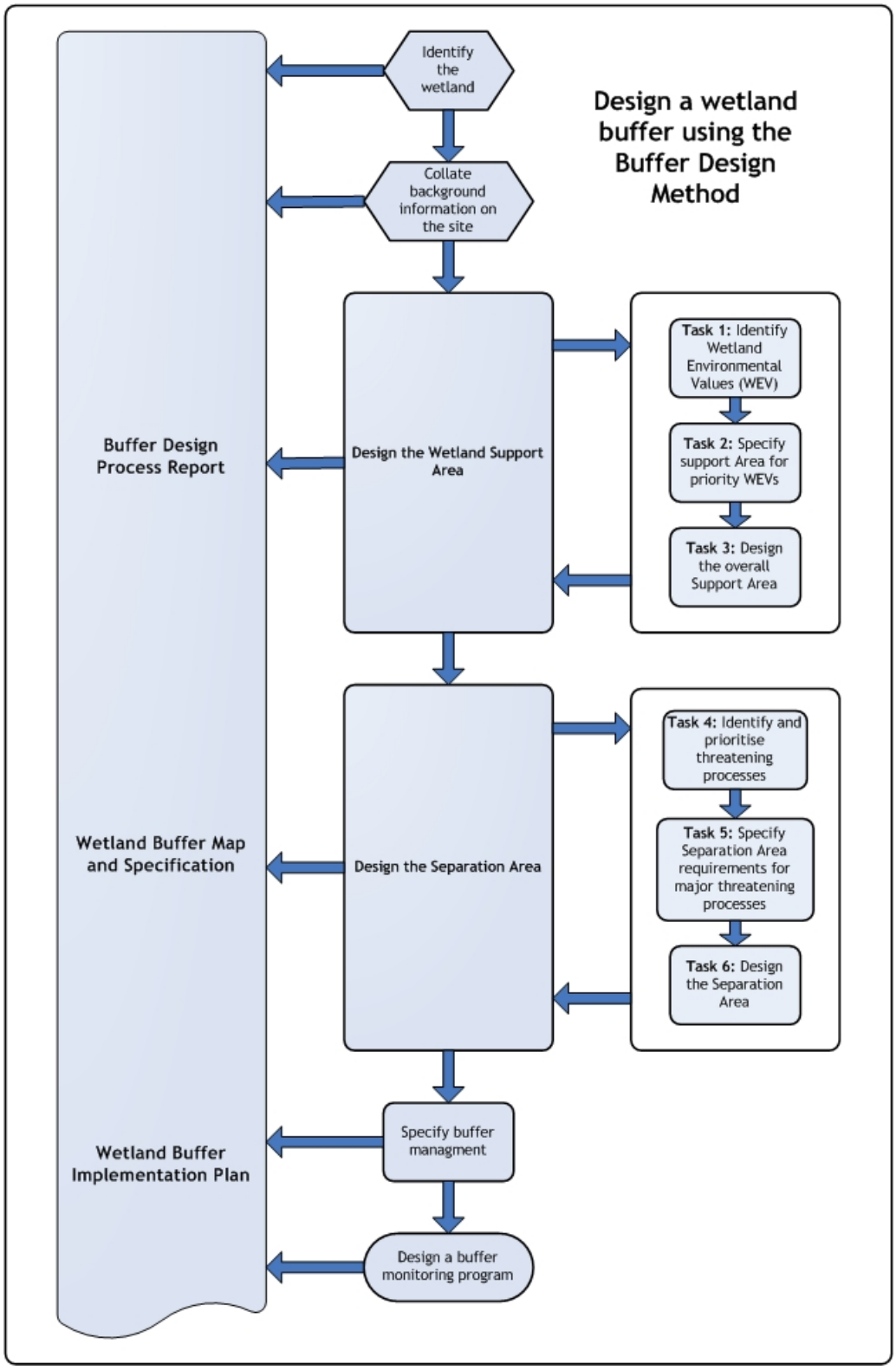

Figure 2. The wetland buffer design process

Using this guideline

Applying this guideline to large, significant or ecologically complex wetlands will require specialised desktop and field investigation skills. In these cases designing the buffer should utilise the expertise and experience of professionals from a range of disciplines related to wetland ecology, hydrology, environmental management and planning. The buffer design concepts and methodology can also be applied to smaller or less significant wetlands by those with knowledge of a particular wetland when combined with desktop and field investigation.

Designing a wetland buffer using the Buffer Design Method must always include field investigation or ground-truthing to confirm local conditions and identify characteristics that may not be evident from a desktop analysis.

The guideline is structured into six major parts:

- Wetland buffer planning (Section 3)
- Wetland buffer concepts (Section 4)
- Identifying the wetland (Section 5)
- Designing the buffer (including recommended steps and useful resources) (Section 6)
- Maintaining the wetland buffer (Section 7)
- An appendices which includes:
    - a checklist (Appendix B) to track progress through the buffer planning process
    - proforma tables (Appendix C) that provide a recommended format to complete tasks in the Buffer Design Method
    - a list of information sources about specific buffer distances for particular species, habitats, locations and situations (Appendix F).

4 Wetlands buffer concepts

This section introduces the concepts and terminology used in the wetland Buffer Design Method. It details the type of wetlands the method may be suitable for and defines the components of a wetland buffer.

Wetland buffer roles

Wetland buffers are defined as 'the transition zone between the wetland or riverine ecosystems and the surrounding land use. They help protect and support the functions and values of wetlands' (Environmental Protection Agency 2006).

A fundamental principle of the Buffer Design Method is that a wetland buffer performs two clear roles and the distance required for each is determined separately. These roles are to:

- maintain and support the WEVs within the wetland
- protect the WEVs of a wetland from both external and negative impacts.

Wetland Support Area

The Wetland Support Area (Figure 3) is the area adjacent to or connected to a wetland that helps to support the wetland and its associated WEVs. This area does not protect the wetland from external threats. It is part of the core area on which the wetland and associated WEVs depend.

Examples of how a Wetland Support Area can maintain and support wetlands and their WEVs include:

- supporting biodiversity by providing non-wetland habitat for wetland dependent species (e.g. frog species that utilise wetlands for only part of their lifecycle)
- allowing for wetland migration as a result of erosion or sea-level change
- adding to the aesthetic qualities of a wetland
- providing roost sites for waterbirds
- shading fish habitats.

A full list of Wetland Support Area roles is provided in Appendix D.

Separation Area

The Separation Area is the area adjacent to the Wetland Support Area that protects a wetland from negative impacts by providing the necessary distance and / or a barrier between the wetland and external pressures.

Wetlands are sensitive to a range of negative impacts which may result from land and water use within catchments, or as a consequence of far-reaching impacts such as climate change. Many, but not all of these can be controlled (or at least minimised) by identifying a Separation Area and implementing effective adaptive planning and management responses to maintain this Separation Area.

The Separation Area may incorporate land uses which are compatible with the wetland (for example, recreation areas or regional open space). Examples of how a Separation Area can protect a wetland and its WEVs include:

- trapping and filtering sediment from surface run-off, from land distant to the wetland
- providing a physical barrier to herbicide and pesticide spray drift from adjacent agricultural activities and mosquito control measures
- providing an attractive visual barrier from adjacent land uses.

A full list of Separation Area roles relating to key direct pressures is provided in Appendix E.

Wetland buffer areas and distances

Wetland buffer areas and distances are shown in Figure 3. The overall area within the wetland buffer area is based on both the Wetland Support Area and Separation Area.

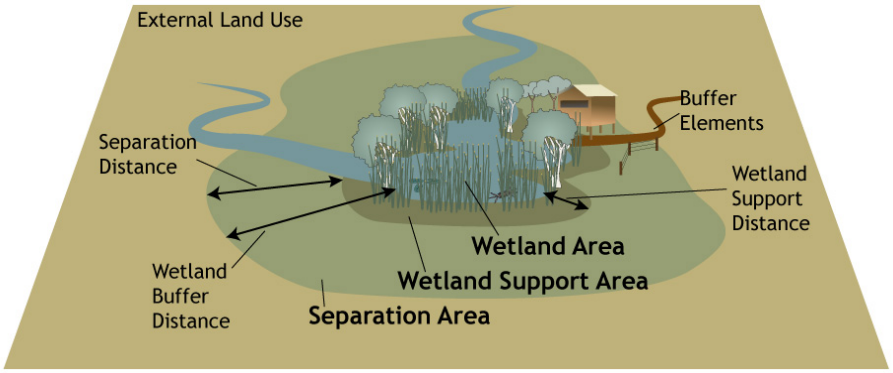

Figure 3. Wetland buffer areas

Similarly, the Wetland Buffer Distance is determined by adding the Wetland Support Distance to the Separation Distance, where the:

- Wetland Support Distance is the linear width of the Wetland Support Area, measured perpendicularly from the edge of the wetland to the boundary of the Wetland Support Area.
- Separation Distance is the linear width of the Separation Area, measured perpendicularly from the outer boundary of the Wetland Support Area to the outer boundary of the Separation Area.

The shape of a wetland buffer

The shape of a wetland buffer is not necessarily, and unlikely to be, uniform around the perimeter of a wetland. For further information about how a wetland is defined and delineated see the Queensland Wetland Definition and Delineation Guideline Parts A and B Draft (DERM 2010a)

<www.derm.qld.gov.au/wetlandinfo/site/WetlandDefinitionstart/WetlandDefinitions/definitionguide.html>.

The Wetland Support Area (and its associated distance) and / or the Separation Area (and its associated distance) may vary around the wetland, with the overall shape of the buffer being dependent on the local topography, the identified WEVs, physical barriers and the nature of pressures (negative impacts) from adjacent land uses.

Examples of why a Wetland Support Area / Distance may vary around the perimeter of a wetland include:

- presence of a rookery of waterbirds in one part of the wetland extending into the surrounding land
- variations in slope and vegetation adjacent to the wetland
- location of public access facilities for aesthetic enjoyment and recreational use on part of the wetland.

Similarly the Separation Distance can vary around a wetland, for example:

- A wetland may feature intact vegetation of sufficient width and quality on one side and intensive agriculture on the other.
- To retain the wetland's natural aesthetic appeal and values a larger Wetland Separation Distance may be necessary around the part of the wetland located adjacent to an urban development.
- The wetland may be located adjacent to a physical barrier (for example a road, rail line or other artificial barrier). This will limit how the Separation Distance can be designed.
- A wetland may need a wider Separation Distance to control an invasive pest plant spreading towards the wetland from one direction in the surrounding landscape.

Buffer Elements

Buffer Elements can be defined as natural or artificial features, or management activities within a Wetland Buffer Area that protect the wetland from direct pressures. Buffer elements are site-specific, and the effectiveness of an individual buffer element will depend on both the WEV and the type and magnitude of the pressure (for example, a stormwater mitigation device will have little impact against weed invasion). Examples of wetland Buffer Elements are provided in Appendix G.

Buffer elements can influence the shape of a wetland buffer by reducing the Separation Distance needed to protect identified WEVs. For example, a well vegetated filter strip around a wetland could reduce the Separation Distance required to maintain water quality and trap sediment and litter.

5 Identifying the wetland

The first stage in any wetland buffer design process involves confirming the location, extent, area and typology of the wetland. During this process, information is also gathered on the wetland's water regime, flora and fauna in the wetland and land uses surrounding the wetland.

Wetland mapping

Wetlands in Queensland are mapped at a scale of 1:50 000 in south-east Queensland and the Great Barrier Reef coastal catchments and 1:100,000 elsewhere. Queensland Wetland Mapping differentiates between natural and artificial wetlands, and classifies them to five broad wetland ecological systems:

- riverine (rivers and creeks)
- lacustrine (lakes and dams)
- palustrine (swamps, marshes, fens)
- estuarine (estuaries)
- marine (ocean).

The latest wetland mapping for identifying and locating a Queensland wetland is available from the Get Maps and Data section of the Wetland*Info* website <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMapsAndData.html>. This site provides access to the comprehensive and up-to-date mapping for Queensland's wetlands and includes both PDF and KML maps (that may be displayed through Google Earth and Google Maps). Frequently Asked Questions (FAQ) related to the mapping are also provided on the web pages: <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/FAQ/AnDemo.html> and <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/FAQ/FAQ2.html>.

For more information about the mapping methodology used refer to Queensland Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a) <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>.

While this mapping is the most comprehensive available for the whole of Queensland, care must be taken when using it at a property level, as the positional accuracy is dependent on the scale at which it was originally mapped. The scale of the final wetland mapping product is based on the regional ecosystem mapping scale as outlined in Neldner *et al.* (2004), which states:

- A scale of 1:100 000 delineates a minimum area for remnant vegetation of 5 ha and 75 m width limit for linear features.
- A scale of 1:50 000 delineates to a minimum area for remnant vegetation of 1 ha, and 35 m width limit for linear features.

Where further assistance is required to determine the boundary and extent of a wetland the Queensland Wetland Definition and Delineation Guideline — Parts A and B (Draft) should be consulted. These documents describe how to apply the Queensland Wetland Program Definition for wetlands and what characteristics can be used to determine whether an area is actually a wetland (for example by using hydrology, soil type, vegetation characteristics and fauna indicators).

Where a wetland has not been mapped or assistance is needed to confirm and/or classify a wetland, advice should be sought from the DERM Wetland*Info* website, a DERM regional office or other resource group.

NOTE:

1. Due to the scale of wetland mapping small wetlands less than 1 ha may not be mapped.
2. Wetland mapping is updated periodically so users should always make a record of the version number used to identify a wetland.
3. Other sources of wetland mapping information and imagery, including local mapping and aerial or satellite photography, may be available from local government or regional Natural Resource Management (NRM) groups (see <www.rgc.org.au/regions>).

Describing the wetland

The habitat attribute provided with each lacustrine or palustrine wetland in the Queensland Wetland Mapping can then be used with the relevant Wetland Management Profile to establish a generalized description of the wetland. The habitat attribute is based on the Queensland lacustrine and palustrine wetland typology that combines wetland system, climate zone, substrate, water type, geomorphology and vegetation.

Wetland Management Profiles provide information about the distribution, ecology, cultural values, conservation status, threats and management of particular wetland types, and wetland regional ecosystems (REs) within Queensland.

More detailed information relevant to the individual wetland can then be obtained from other sources e.g. see Table 2.

Table 2. Identify and describe the wetland

Recommended steps
Obtain wetland mapping and associated wetland attributes for the site.
Match the habitat from the wetland attributes from the wetland mapping to find the relevant wetland management profile and identify the species, soil types, ecological values, species and management requirements generally associated the habitat.
Collate specific information about site including mapped regional ecosystems, species records, status of vegetation communities and species, detailed description of water regime, water quality information, current and proposed adjacent land uses.
Useful Resources
• Queensland wetland mapping — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMapsAndData.html> • Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a) at <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html> • Queensland Wetland Definition and Delineation Guideline Parts A and *B* (DERM 2010a) at <www.derm.qld.gov.au/wetlandinfo/site/WetlandDefinitionstart/WetlandDefinitions/definitionguide.html> • Queensland Lacustrine and Palustrine Wetland Typology and Wetland Description Tool at <www.derm.qld.gov.au/wetlandinfo/site/WetlandDefinitionstart/WetlandDefinitions/Typologyintro/Typology.html> • WEV table <www.derm.qld.gov.au/wetlandinfo/site/factsfigures/WetlandValues.html> • Wetland Management Profiles (DERM 2006) at <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/Profiles.html> • Wetland conceptual models — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html> • Wetland Summary Information — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMapsAndData/SummaryInfo.jsp> • Wildlife inventory — on DERM website at <www.derm.qld.gov.au/wildlife-ecosystems/wildlife/wildlife_online/index.html> • Species profiles — on DERM website at A-Z of plants and animals (Department of Environment and Resource Management)and <www.derm.qld.gov.au/wildlife-ecosystems/conservation_management_profiles/fauna.html> • local and technical experts

6 Designing the buffer

The Buffer Design Method

This section describes the process involved in designing a wetland buffer once the wetland has been identified as described in Section 5. A checklist covering the steps involved in the Buffer Design Method (including pre-planning, management and monitoring components) is located in Appendix B.

The Buffer Design Method:

- recognises two distinct buffer components — the Wetland Support Area and the Separation Area (described in Section 4)
- focuses on identifying, prioritising, and protecting WEVs
- recognises threats to WEVs by identifying and prioritising direct pressures
- identifies and specifies Buffer Elements and their role in the buffer area.

Designing the buffer using the Buffer Design Method consists of six major tasks (Figure 2), which are described more fully below:

Task 1: Identify and prioritise WEVs

Task 2: Specify the individual Wetland Support Area required for each priority WEV

Task 3: Design the overall Wetland Support Area

Task 4: Identify and prioritise direct pressures

Task 5: Specify the individual Separation Area requirements

Task 6: Design the overall Separation Area.

It is also essential to verify the wetland's location and characteristics by conducting a site visit at one or more stages during the buffer design process.

Task 1: Identify and prioritise WEVs

Every wetland has unique WEVs and these need to be identified, described and prioritised. A proforma to assist this is located in Appendix C — Table A: Wetland Environmental Value (WEV) prioritisation.

A full suite of WEVS are provided on the Wetland*Info* website <www.derm.qld.gov.au/wetlandinfo/site/factsfigures/WetlandValues.html>. This list is a good starting point for identifying WEVs, and is broadly grouped into:

- wetland processes (for example hydrological processes, food webs, sediment trapping)
- conservation significance
- material benefits from wetland ecosystems
- material products obtained directly from wetlands
- activities (including recreation, tourism and education)
- cultural resources.

More information on the values of different wetland habitat is available from the relevant Wetland Management Profile.

While determining the full suite of WEV's for a wetland will allow for the design of a holistic buffer, legislation may only allow for consideration of a subset of these values. Consequently if this guideline is being used for statutory decisions, such legislative aspects must be considered when determining the range of WEV's to be used in that decision making process.

Some of the WEVs may be quite obvious at a particular site (for example where Aquatic Conservation Assessments (ACA) have been conducted through the AquaBAMM but determining other values may require further research and investigation, including consultation with other wetland stakeholders. These stakeholders should be identified as early as possible in the design process, and may include technical experts (for example flora, fauna, hydrology), state or local government representatives, the property owner, and / or NRM group or other interest group representatives, depending on the wetland's location and the reason for developing the buffer.

In addition to the WEVs identified for a site through the collation of information and research or through personal communications, there may also be a requirement or desire to establish or restore WEVs that have been lost or severely degraded.

The task of identifying and prioritising WEVs may take a short time (less than one day) or an extended period of time. This will depend on the size of the wetland, the level of consultation or technical expertise required, the stakeholders involved, the tenure of the wetland and the management implications required to protect the WEVs once identified.

WEVs are similar to, but more extensive than the Environmental Values (EVs) scheduled under the EPP(Water). Where EVs have been scheduled, they can be used to identify WEVs.

Table 3. Task 1: Identify and prioritise WEVs

Recommended steps
Use management profile and other data collated to list, describe and rank WEVs.
Identify the Priority WEVs.
Identify processes that support the WEVs.
If necessary, address conflicts between Priority WEVs.
Useful Resources
• WEV table — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/factsfigures/WetlandValues.html> • Wetland Buffer Planning Proforma — Table A: Wetland Environmental Value (WEV) prioritisation (Appendix C) • Wetland summary Information — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/MappingAndD/WetlandMapsAndData/SummaryInfo.jsp> • Wildlife inventory — on DERM website at <www.derm.qld.gov.au/wildlife-ecosystems/wildlife/wildlife_online/index.html> • Wetland Management Profiles (DERM 2006) <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/Profiles.html> • Species profiles — on DERM website at A-Z of plants and animals (Department of Environment and Resource Management)and <www.derm.qld.gov.au/wildlife-ecosystems/conservation_management_profiles/fauna.html> • Wetland conceptual models — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html> • Aquatic Conservation Assessments using Aquatic Biodiversity Assessment Mapping Methodology (AquaBAMM) — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/SupportTools/AssessmentMethods/AquaBAMM.html> • local and technical experts

The most significant WEVs for the wetland are regarded as the Priority WEVs around which the Wetland Support Area will be designed. The number of Priority WEVs will depend on the particular wetland. Where there is conflict between prioritising the WEVs or the WEVs themselves (for example naturalness versus recreation), it will be necessary to determine which WEVs are the primary values the site should be managed for, through this process.

The processes that support the WEV, or other requirements for the WEV, should also be identified. Conceptual models showing the components and processes for each wetland habitat type are available. Combined with the Wetland Management Profiles, they are useful for identifying processes necessary for maintaining the WEVs.

Identifying the WEVs can also assist other characterisation and management related activities associated with the wetland, beyond their use for buffer design.

Task 2: Specify the individual Wetland Support Area required for each priority WEV

The aim of this task is to specify the required Wetland Support Area (or distance) necessary to protect each of the identified Priority WEVs. This can be a complex process that may require literature reviews and research, expert knowledge, consultation with technical experts and ground-truthing if the information in this guideline is inadequate.

Some information sources describing buffer distance requirements for specific WEVs are provided in Appendix F. However, care should be taken to ensure that any references used are analysed in relation to the wetland being investigated, as each site will be unique in terms of location, WEVs and other characteristics.

For each Priority WEV identified in Task 1 use the proforma in Appendix C (Table B: Wetland Support Area requirements) to describe the role, attributes and width of the Wetland Support Area that will support and maintain the value.

For example, a particular wetland may have the following WEVs and require the associated characteristics of a Wetland Support Area:

- hydrological processes — requires critical flow paths for recharge / flushing to maintain hydrological connectivity and hydrological regimes for the wetland
- distinct species such as freshwater cod — require overhanging vegetation to shade water and reduce extremes in temperature
- mitigating wetland — requires an area the wetland can migrate to, to allow for factors such as erosion, sea-level rise, changed weather patterns and watercourse change.

Table 4. Task 2: Specify the individual Wetland Support Area required for each priority WEV

Recommended steps
Identify and document the Wetland Support Area requirements for each Priority WEV.
Useful Resources
• Wetland Buffer Planning Proforma — Table B: Wetland Support Area requirements (Appendix C) • Examples of Wetland Support Area Roles (Appendix D) • Information Sources on buffer distances (Appendix 6) • Wetland Management Profiles (DERM 2006) <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/Profiles.html> • Species profiles – on DERM website at A-Z of plants and animals (Department of Environment and Resource Management)and <www.derm.qld.gov.au/wildlife-ecosystems/conservation_management_profiles/fauna.html> • Wetland conceptual models — on Wetland*Info* at <www.derm.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html> • *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* policy statements <www.environment.gov.au/epbc/guidelines-policies.html> • journal articles and other technical documents • local and technical experts

Task 3: Design the overall Wetland Support Area

The aim of this task is to design an overall Wetland Support Area for the wetland based on the characteristics identified and the Wetland Support Areas estimated for each Priority WEV — as determined in Tasks 1 and 2.

The overall Wetland Support Area for the wetland is determined by overlaying the individual Wetland Support Area for each Priority WEV and identifying the furthest extent needed to protect all the WEVs. This is depicted for three WEVs in Figure 4. Depending on the identified WEVs and their location within the wetland the overall Wetland Support Area may not be uniform in shape around the wetland.

Another complexity of buffer design is recognising and considering the impact of high flow events, which may be infrequent but are essential to the proper functioning of the wetland ecosystem. These events allow for migration of species between wetlands and provide connectivity for wetland processes.

Table 5. Task 3: Design the overall Wetland Support Area

Recommended steps
Overlay the individual features and Wetland Support Area boundaries for each of the Priority WEVs on a map or aerial photograph of the wetland. OR Use GIS to draw the Wetland Support Area boundaries around the wetland. Outline the overall Wetland Support Area.
Useful Resources
• Wetland Buffer Planning Proforma — Table B: Wetland Support Area requirements (Appendix C) • local and technical experts • Wetland Migration (Appendix H)

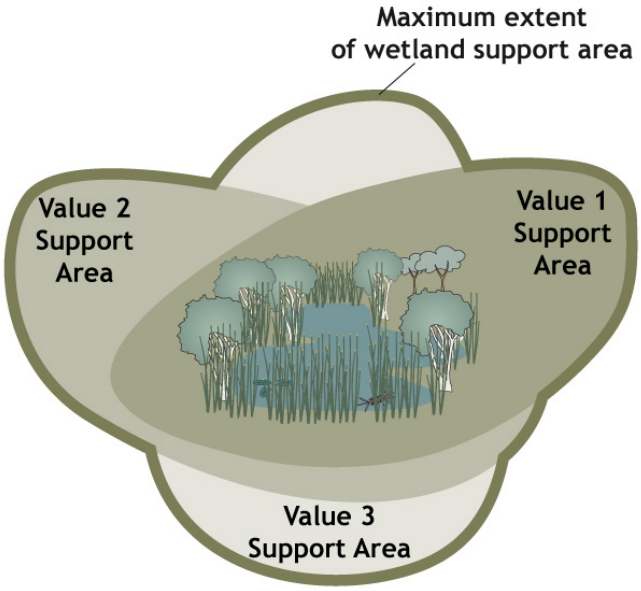

Figure 4. Designing the overall Wetland Support Area

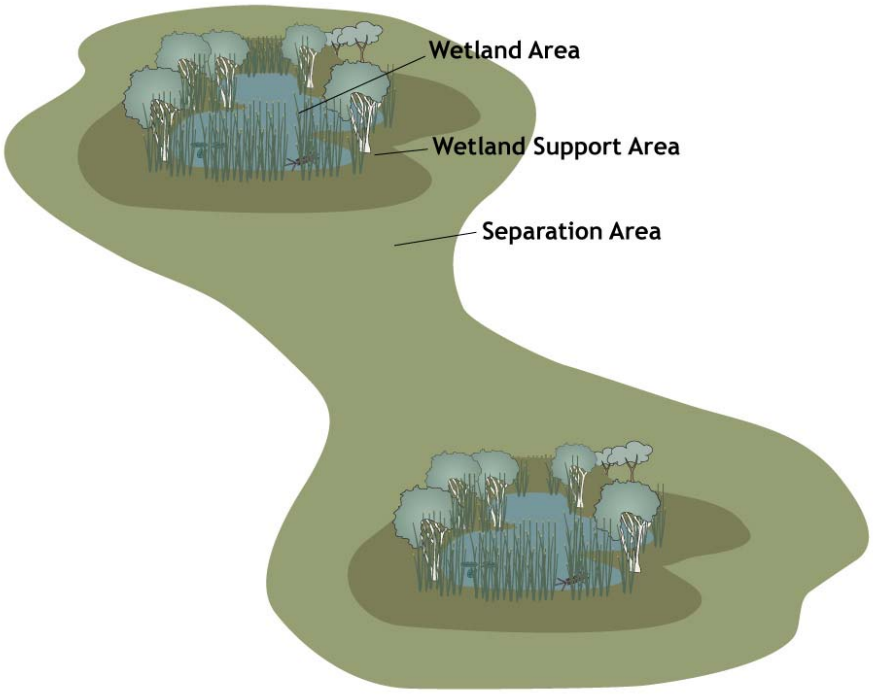

Figure 5. Designing a buffer for wetlands in close proximity to each other

Task 4: Identify and prioritise stressors and impacts

The fourth major task in designing the wetland buffer is to conduct a risk assessment, which identifies the stressors and pressures impacting, or having the potential to impact, on the wetland. Knowledge of the wetland obtained from previous steps may allow for the vulnerability to be adjusted.

Stressors have been defined as components of the environment that when changed by human or other activities can affect the condition of the ecosystem. These can be natural components such as some nutrients or components related to humans such as litter (rubbish). Some stressors may have both natural and anthropogenic aspects.

Stressor models are used to show how human activities interact with the natural processes occurring in a wetland (i.e. process conceptual models) and impact the ecosystem. Stressor models for lacustrine and palustine wetlands are available on Wetland*Info* <www.derm.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html>.

In Queensland, the major stressors in lacustrine and palustrine ecosystems are:

- aquatic sediments
- bacteria / pathogens
- biota removal / disturbance
- conductivity
- connectivity
- habitat removal
- hydrology
- litter (rubbish)
- nutrients
- organic matter
- pest (animal, plant) species
- ph
- toxicants.

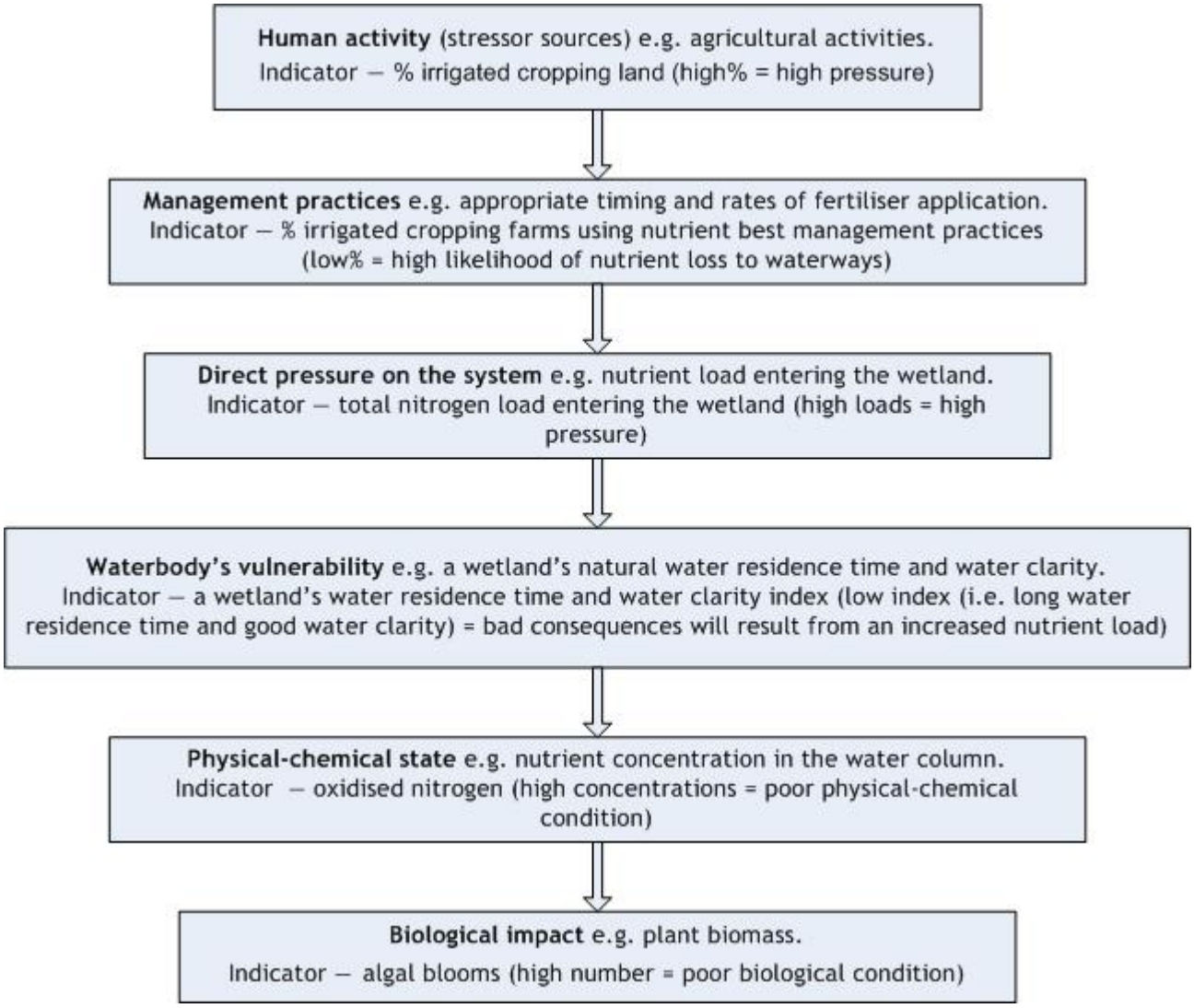

Figure 6. Assessment Framework for stressor 'nutrients' (adapted from Wetland*Info*)

To complete this task, sources of change to stressors which have, or may have, a negative impact on each Priority WEV need to be identified and documented. A proforma in Appendix C (Table C: Direct pressure prioritisation) is provided to assist this process. Only those direct impacts that can be managed through a wetland buffer should be included in this table. It is likely that one or more direct impacts will apply to each WEV, and that a single direct impact could apply to more than one WEV.

The resulting responses can then be prioritised according to the vulnerability of the wetland to the direct pressure and the likelihood of it occurring. This will provide an overall risk score for an individual pressure. The overall risk score is determined by multiplying the habitat vulnerability score (with range of one to five) by the likelihood score (with range of one to three). By undertaking this risk assessment the direct pressures which pose the highest risk to the Priority WEVs can be determined. Generally, a pressure with an overall risk score above ten would be considered a Major Direct Pressure. These are the pressures that will need to be considered when designing the Separation Area for the wetland buffer.

Table 6. Task 4: Identify major direct pressures to WEVs

Recommended steps
For each WEV, identify and document possible sources of change to each stressor due to proposed development or activity, taking into account wetland type and vulnerability where appropriate.
Identify whether Separation Area is useful to manage pressure and impact.
Identify direct pressures and probable changes to physical-chemical and biological state.
Identify impacts and score vulnerability of WEV to impacts.
Combine vulnerability and likelihood in a risk assessment to identify Major Direct Pressures to WEVs.
Useful Resources
• Wetland Buffer Planning Proforma — Table C: Direct pressure prioritisation (Appendix C) • DERM Wetland*Info* website including: • Wetland Management Profiles (DERM 2006) <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/Profiles.html> • Non-urban (rural) land management <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/LandManagment.html> • Wetlands and urban land management <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/BuildingManagment.html> • Rehabilitation and construction <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/BuildingManagment.html> • Wetland conceptual models <www.derm.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html> • Wetland stressor models • <www.derm.qld.gov.au/wetlandinfo/site/SupportTools/MonitoringExtentAndCondition/Stressormodeloverview.html> • *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act*) policy statements • <www.environment.gov.au/epbc/guidelines-policies.html> • journal articles and other technical documents • local and technical experts

Task 5: Specify the individual Separation Area requirements

The aim of this task is to determine, document and delineate individual Separation Areas for each of the Major Direct Pressures identified in Task 4. For a particular wetland this may result in the delineation of several overlapping Separation Areas. A proforma to assist in this task is provided in Appendix C (Table D: Separation Area requirements).

The Separation Area / Distance is the area / distance required to protect a wetland, and its associated WEVs from a Major Direct Pressure. Estimating and justifying the Separation Area / Distance for each Major Direct Pressure may be a complex process that will require an evaluation of existing literature and technical information, the advice of scientific and technical experts and ground-truthing. Some information sources are also provided in the Bibliography and Appendix F. Any literature and technical information used for this task should be carefully evaluated, considering the situation for which they were developed, the scientific rigor used in their development and how applicable the information is to the wetland for which the buffer is being designed.

The Separation Area requirements for each Major Direct Pressure may include:

- a Separation Distance — this may vary in width around the perimeter of the wetland
- Buffer Elements — which protect the wetland from direct pressures (described in Section 4, examples provided in Appendix G).

A description of buffer elements, their location within or around the wetland, and any management actions required to maintain the Separation Areas / Distance should be included in the proforma (Appendix C — Table D: Separation Area requirements). An example of how Buffer Elements can reduce the distance required to protect a wetland from adjacent land uses is shown diagrammatically in Figure 7.

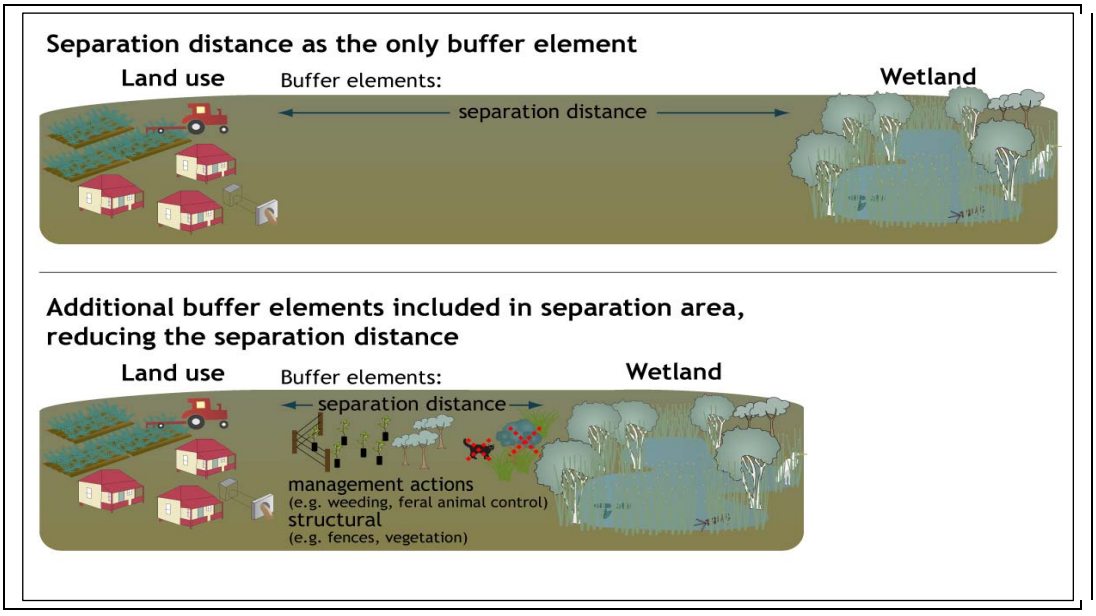

Figure 7. How Buffer Elements reduce Separation Area requirements

Table 7. Task 5: Specify the individual Separation Area requirements

Recommended steps
Identify and document the Separation Area requirements for each Major Direct Impact.
Document the required (or existing) Buffer Elements for each Major Direct Impact.
Useful Resources
• Wetland Buffer Planning Proforma — Table D: Separation Area requirements (Appendix C) • Separation Area roles (Appendix E) • Bibliography • information Sources on buffer distances (Appendix F) • Buffer Elements (Appendix G) • *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)* policy statements • <www.environment.gov.au/epbc/guidelines-policies.html> • journal articles and other technical documents • local and technical experts

Task 6: Design the overall Separation Area

The aim of this task is to design the overall Separation Area for the wetland based on the Separation Area information gathered for each Major Direct Pressure (Task 5).

It includes further consideration of Buffer Elements contained within or in close proximity to the wetland, and how existing or additional Buffer Elements may reduce the overall Separation Area required.

The overall Separation Area is determined by overlaying the individual Separation Areas / Distances for each Major Direct Pressure, and identifying the furthest extent needed to mitigate all the pressures. This is shown diagrammatically for three Separation Areas in Figure 8. Depending on where pressures and buffer elements are located the Overall Separation Area may not be uniform in shape around the wetland.

Where possible, further consideration should be given to the introduction of Buffer Elements that will reduce the threat, maintain or benefit the Priority WEV, and in doing so reduce the overall Separation Area required. If new Buffer Elements are introduced to the wetland this will need to be included and fully documented in any buffer management and implementation planning process for the wetland.

Additional Buffer Elements, whether to the wetland itself or in the surrounding area may be subject to additional legislative requirements or approvals.

When designing the overall Separation Area, consideration should also be given to any additional area that may be required to provide access to the wetland to implement management actions (for example the ability to access areas for replanting, fire control or weed removal).

Table 8. Task 6: Designing the Overall Separation Area

Recommended steps
Overlay the individual Separation Area boundaries for each Major Direct pressure on the map or aerial photograph showing the overall Wetland Support Area (produced as part of Task 3).
Identify Buffer Elements including their location, and record how their presence reduces the Separation Distance required and impacts on other factors such as management.
Consider how the introduction of additional Buffer Elements may reduce the Separation Area requirements.
Review the Separation Areas / Distances based on the Buffer Elements chosen.
Outline the maximum extent of the overall Separation Area.
Useful Resources
• Wetland Buffer Planning Proformas — Tables A–D (Appendix C) • information Sources on buffer distances (Appendix F) • Buffer Elements (Appendix G) • journal articles and other technical documents • local and technical experts • Water by Design (2010) Deemed to Comply Solutions — Stormwater Quality Management (South East Queensland), South East Queensland Healthy Waterways Partnership, Brisbane <http://waterbydesign.com.au/>

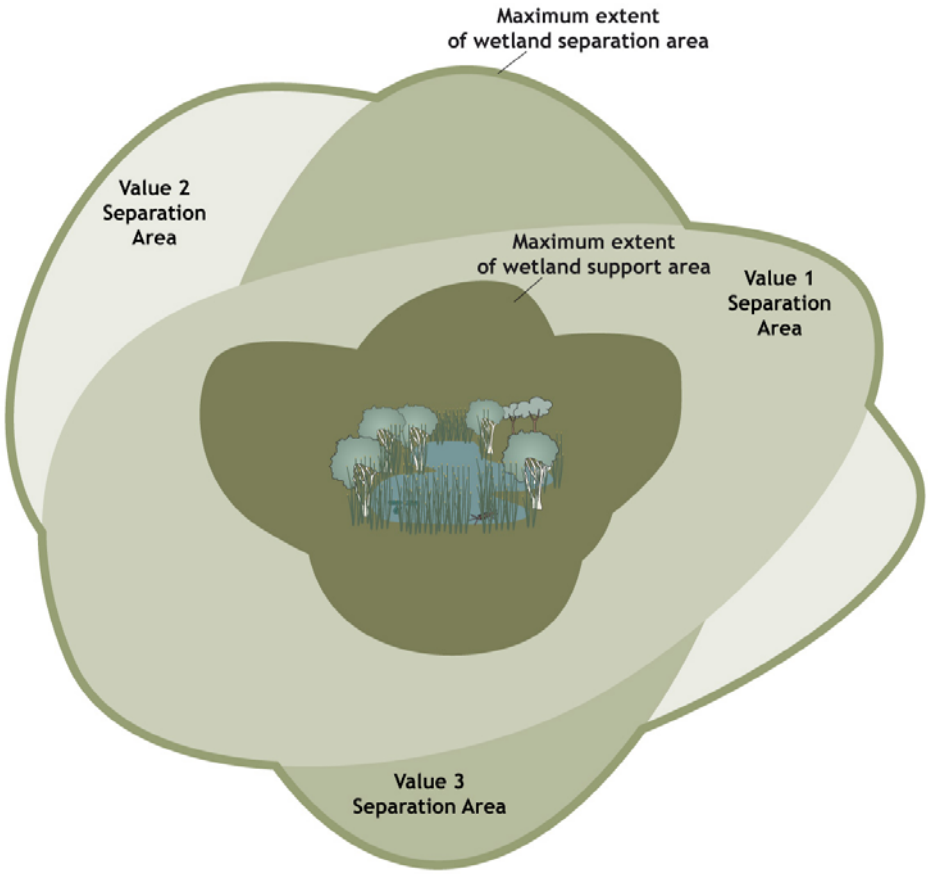

Figure 8. Designing the Overall Separation Area

7 Maintaining the wetland buffer

Determining buffer management requirements

Once the Overall Support and Separation Areas for the wetland buffer and its Buffer Elements are specified it is necessary to prepare a Wetland Buffer Implementation Plan — an overall plan of management for the wetland. This plan should incorporate maintenance requirements including weed and pest management and monitoring. This will ensure the buffer remains effective in protecting the WEVs over time.

The ownership of the buffer area and wetland should be clearly defined as ownership effects who will maintain and monitor the buffer. A buffer on private land should be maintained by the private owner or body corporate. A buffer on public land, such as a reserve or parkland, may be maintained by the local authority. Where there is a mix of ownership, the responsibilities may be shared but need to be clearly documented.

The intent of this step is to ensure that the wetland buffer specifications developed and management actions identified as part of the Buffer Design Method are fully documented, and that management actions required to maintain or enhance WEVs and reduce direct pressures are identified and implemented. In most cases this will take the form of a stand-alone Wetland Buffer Implementation Plan for a particular site. However, in some cases buffer specifications and actions may be incorporated with other management plans or management related documents, for example:

- Weed management for a wetland buffer area may be incorporated into an overall weed management strategy for a property.
- Application of pesticides impacting on a buffer area may be incorporated into the standard operating procedures for pesticide management, or an Integrated Pest Management (IPM) program for a property.
- Construction and maintenance of protective fencing could be included in an annual capital works program.

An example of buffer management activities and their impact on a wetland are illustrated in Figure 9. In this particular example the wetland is protected from the impacts of adjacent land uses, and ecosystems are supported when a wetland buffer is re-vegetated, stock is excluded and pests are managed. Therefore, in this simple case the Wetland Buffer Implementation Plan would include detailed ongoing management actions required to maintain re-vegetation and fencing, and control pests, thereby maintaining the effectiveness of the wetland buffer.

An integral part of developing a Wetland Buffer Implementation Plan is defining the management objectives. This will include outlining the:

- Priority WEVs to be protected by the Wetland Support Area
- Major Direct Pressures to be managed in the Separation Area
- minimum standards required by legislation in relation to the wetland and buffer area.

Once the objectives are defined, the management actions needed to achieve these objectives can be determined and implemented. These management actions will have become evident while designing the Overall Support and Separation Areas for the wetland. The Wetland Buffer Implementation Plan will need to list the management actions required to maintain the buffer, including any existing or proposed Buffer Elements, describing how and who will carry out the activities. This will include aspects such as who is responsible for undertaking and managing the activities from a cost, on-ground and long-term perspective, and the timeframe over which these activities will occur.

A Wetland Buffer Implementation Plan will be site-specific and dependent on a range of factors including location, wetland type, surrounding land use, the identified WEVs and direct pressures, and the ownership or tenure of the land. Where management activities are likely to impact on adjacent landowners or other stakeholders, additional consultation about the wetland's management will need to occur.

Designing a buffer monitoring program

It has been demonstrated that without adequate management and monitoring, wetland buffers can diminish in size and lose their effectiveness over time (Cooke 1992). Therefore, to maintain the effectiveness of a wetland buffer the development of an ongoing monitoring program is recommended — so that a systematic evaluation of the wetland buffer can be made.

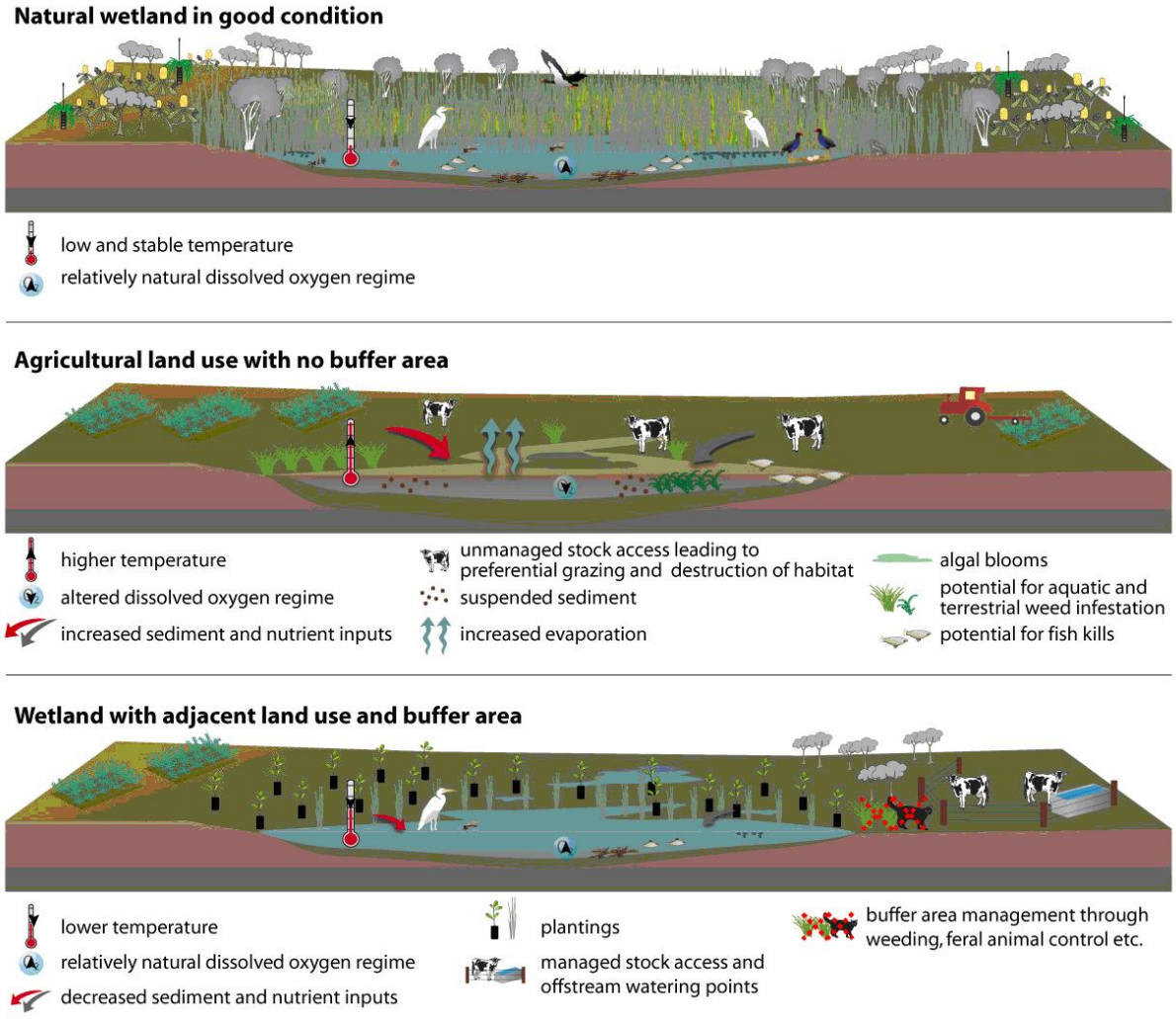

Figure 9. The importance of buffers in wetland management

The following questions should be asked when considering a monitoring program for a wetland:

1. What is the agreed baseline for the Priority WEVs, and what indicators will be used to ascertain whether values are changing?
2. Are the WEVs declining, steady, or improving, and can this be attributed to the wetland buffer?
3. Was the original buffer design and specifications appropriate or should they be reviewed?
4. Have buffer management activities been implemented and sustained. Are they suitable and effective?
5. Have there been any changes to the direct pressures impacting on the wetland?
6. Is the buffer effective in protecting the WEVs?

By adopting a monitoring program, wetland managers can adapt to changing conditions and incorporate new information about wetland buffers and their management as it becomes available. This will be particularly the case for wetlands where research or other industry-based projects are being conducted.

The monitoring program should include:

- monitoring objectives — a rationale / logic for monitoring
- indicators — the variables that need to be monitored
- methods and standards — designed for the particular wetland, its WEVs and direct pressures
- monitoring schedule — defining the frequency of monitoring
- reporting and evaluation schedule.

Table 9. Wetland buffer management and monitoring

Recommended steps — Wetland Management
Review available literature and technical information related to buffer management and monitoring, and seek expert advice on how to manage Major Direct Pressures identified for the wetland.
Define management objectives for the buffer.
Develop a Wetland Buffer Implementation Plan (or integrate this into existing management plans for the wetland or property)
Implement management actions outlined in the Buffer Implementation Plan.
Recommended steps — Wetland Monitoring
Determine monitoring objectives. Identify indicators of buffer effectiveness (i.e. the ability to protect WEVs and manage direct pressures).
Review literature and seek advice on monitoring and how to interpret indicators.
Design the monitoring program — timing, methods, and standards.
Implement the monitoring program.
Collect, report and evaluate monitoring results.
Useful Resources
• completed Wetland Buffer Planning Proformas (Appendix C) • local and technical experts • Bibliography and information sources on buffer distances (Appendix F) • journal articles and other technical documents • Wetland*Info* website including: • Wetland Management Profiles (DERM 2006) — provide specific recommendations relevant to 14 types of Queensland wetlands <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/Profiles.html> • Non-urban (rural) land management <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/LandManagment.html> • Wetlands and urban land management <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/BuildingManagment.html> • Rehabilitation and construction <www.derm.qld.gov.au/wetlandinfo/site/ManagementTools/Guidelines/BuildingManagment.html> • Wetland conceptual models <www.derm.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html> • Wetland stressor models • <www.derm.qld.gov.au/wetlandinfo/site/SupportTools/MonitoringExtentAndCondition/Stressormodeloverview.html> • Land Manager's Monitoring Guide. • <www.derm.qld.gov.au/monitoring_guide/index.html> • Weed and pest management fact sheets • <www.derm.qld.gov.au/vegetation/information_sheets.html>

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ANZECC — see Australian and New Zealand Environment and Conservation Council

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Appendix A Definitions

Best practice (environmental management)

The management of an activity to achieve a continuing minimisation of the activity's environmental harm, through cost-effective measures, assessed against the measures currently used nationally and internationally for the activity (s21 *Environmental Protection Act 1994*).

Biodiversity

The natural diversity of native wildlife, together with the environmental conditions necessary for survival. Includes regional diversity, that is, the diversity of the landscape components (landforms, soils, water, climate, wildlife and land uses) of a region and the functional relationships that affect environmental conditions within ecosystems; ecosystem diversity, that is, the diversity of the different types of communities formed by living organisms and the relations between them; species diversity, that is, the diversity of species; and genetic diversity, that is, the diversity of genes within each species (s10 *Nature Conservation Act 1992*).

Bioregion

An area of land that is dominated by similar broad landscape patterns that reflect major structural geologies and climate, as well as major floristic and faunal assemblages (adapted from Sattler and Williams 1999).

Biota

The sum total of the living organisms of any designated area.

<www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality>

Coast

All areas within or neighbouring the foreshore (s10 *Coastal Protection and Management Act 1995*).

Coastal processes

Natural processes of the coast including: sediment transport; fluctuations in the location and form of the foreshore, dune systems and associated ecosystems; tides; changes in sea-level and coastal hazards (for example, cyclones and storm tide surge); ecological processes (for example, migration of plant and animal species) and the natural water cycle (for example, a coastal wetlands' role in nutrient filtration and flood mitigation) (Environmental Protection Agency 2006).

Coastal wetlands

Tidal wetlands, estuaries, salt marshes, melaleuca swamps (and other coastal swamps), mangrove areas, marshes, lakes or minor coastal streams regardless of whether they are of a saline, freshwater or brackish nature (s14 *Coastal Protection and Management Act 1995*).

Contaminant

Under s11 *Environmental Protection Act 1994*

- a gas, liquid or solid
- an odour
- an organism (whether alive or dead), including a virus
- energy, including noise, heat, radioactivity and electromagnetic radiation, or
- a combination of contaminants.

Cultural resources

Places or objects that have anthropological, archaeological, historical, scientific, spiritual, visual or sociological significance or value, including such significance or value under Aboriginal tradition or Torres Strait Island custom, within the coastal zone (schedule of the *Coastal Protection and Management Act 1995*).

Direct Pressure

The actual factor directly related to the stressor that is changing. For example, the actual nutrient load entering the wetlands (Scheltinga *et al.* unpublished).

Ecosystem

Dynamic complex of plant, animal and microorganism communities and their non-living environment that interacts as a functional unit.

<www.environment.gov.au/soe/2006/publications/report/index.html>

Endangered regional ecosystem

An endangered regional ecosystem as defined by the *Vegetation Management Act 1999*.

Erosion prone areas

Those areas shown on the erosion prone area maps prepared under the now repealed *Beach Protection Act 1968*, but continued by the *Coastal Protection and Management Act 1995* to accommodate physical coastal processes.

Estuarine (wetland ecosystem)

See definition in Appendix B: Definitions and Abbreviations of the Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a). <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>

HES

High Ecological Significance (HES) wetlands comprise wetlands that have been identified as having high ecological significance by combining available datasets of areas of ecological significance in accordance with criteria set out in the draft Method for Mapping Ecological State Interests for Land Use Planning and Development Assessment (DERM unpublished).

Lacustrine (wetland ecosystem)

See definition in Appendix B: Definitions and Abbreviations of the Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a). <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>

Marine (wetland ecosystem)

See definition in Appendix B: Definitions and Abbreviations of the Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a). <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>

Nature

All aspects of nature, including but not limited to:

a. ecosystems and their constituent parts

b. all natural and physical resources

c. natural dynamic processes, and

d. the characteristics of places, however large or small, that contribute to their biological diversity and integrity, or their intrinsic or scientific value (s8 *Nature Conservation Act 1992*).

Palustrine (wetland ecosystem)

See definition in Appendix B: Definitions and Abbreviations of the Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a). <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>

Protected Area

Areas that have been protected under the *Nature Conservation Act 1992*.

Protected wildlife

Presumed extinct, endangered, vulnerable, rare or common wildlife, as defined in the *Nature Conservation Act 1992*.

Queensland Heritage Register

As defined in the *Queensland Heritage Act 1992*, the Queensland Heritage Register is a record of:

a. registered places and heritage agreements relating to registered places, and

b. protected areas, and

c. orders or permits made or granted under the Act.

Referable wetland

An area shown as a wetland on Map of Referable Wetlands, a document approved by the chief executive (environment) under the Sustainable Planning Regulation 2009. <www.derm.qld.gov.au/wildlife-ecosystems/ecosystems/referable-wetlands-maps.html>

Regional Coastal Management Plan

A regional coastal management plan approved under the *Coastal Protection and Management Act 1995*. <www.derm.qld.gov.au/environmental_management/coast_and_oceans/coastal_management/regional_coastal_management_plans/index.html>.

Regional ecosystems

Means vegetation communities in a bioregion that are consistently associated with a particular combination of geology, landform and soil.

<www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/regional_ecosystems/introduction_and_status/index.html>

Riparian

Pertaining to the river bank (e.g. riparian vegetation is vegetation along a river).

'Of or relating to or located on the banks of a river or stream; "riparian land"' (Princeton University 2003). <http://wordnet.princeton.edu/>

Riverine (wetland ecosystem)

See definition in Appendix B: Definitions and Abbreviations of the Wetland Mapping and Classification Methodology (Environmental Protection Agency 2005a). <www.derm.qld.gov.au/wetlandinfo/site/MappingFandD/WetlandMandDBackground.html>

Significant coastal wetland

A significant coastal wetland that is listed or mapped in a regional coastal plan or, in the absence of a regional coastal plan, an area that has the following characteristics:

a. it is listed as a wetland of international importance under the Ramsar Convention; or

b. it is listed as a wetland of importance within the Queensland chapter of A Directory of Important Wetlands in Australia (Environment Australia 2001); or

c. it is an area of permanent or periodic inundation, whether natural or artificial, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres, that meets one or more of the following criteria:

d. it is a good example of a wetland type occurring within a bioregion in Queensland;

e. it plays an important ecological or hydrological role in the natural functioning of a major wetland system;

f. it is important as a habitat for animal taxa at a vulnerable stage in their life cycles, or provides a refuge when adverse conditions such as drought prevail;

g. it supports a significant number of the bioregional populations of any native plant or animal taxa;

h. it supports native plant or animal taxa or communities that are considered endangered or vulnerable at the bioregional level; or

i. it is of historical or cultural significance. (State Coastal Management Plan – Queensland's Coastal Policy 2001).

<www.derm.qld.gov.au/environmental_management/coast_and_oceans/coastal_management/state_coastal_management_plan/>

Stressor

Stressors are defined as components of the environment that when changed can affect the condition of the ecosystem. These can be natural components such as nutrients or entirely anthropogenic components such as rubbish or biota removal / disturbance. <www.derm.qld.gov.au/wetlandinfo/site/SupportTools/MonitoringExtentAndCondition/Stressormodeloverview.html>

Toxicant

A chemical capable of producing an adverse response (effect) in a biological system at concentrations that might be encountered in the environment, seriously injuring structure or function or producing death. Examples include pesticides, heavy metals and biotoxins (i.e. domoic acid, ciguatoxin and saxitoxins).

<www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality>

Water quality

The status of an aquatic ecosystem (including surface, soil and groundwater), including its physical, chemical, biological and aesthetic characteristics (Lee *et al*. 2001).

Waterway

Includes a river, creek, stream, watercourse or inlet of the sea (*Fisheries Act 1994*).

Wetlands — Queensland Wetland Definition

Areas of permanent or periodic / intermittent inundation, with water that is static or flowing fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed 6m.

To be a wetland the area must have one or more of the following attributes:

- at least periodically the land supports plants or animals that are adapted to and dependent on living in wet conditions for at least part of their life cycle, or
- the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers, or
- the substratum is not soil and is saturated with water, or covered by water at some time.

<www.derm.qld.gov.au/wetlandinfo/site/WetlandDefinitionstart/WetlandDefinitions.html>

Appendix B Checklist — Wetland buffer design method

Stage	Steps		Completed (Y/N)
Preparation	1	Review relevant planning documents, processes and legislation and consider their consequence when designing the wetland buffer.	
	2	Acquire a map of the wetland and its catchment.	
	3	Acquire an aerial photograph of the wetland.	
	4	Collect general information about the wetland (such as the history of the site, tenure, land owners, land use, current and past management, stakeholders, general issues and goals.	
Identify the wetland	5	Map the location and extent of the wetland, and / or source this from *Queensland Wetland Mapping* (Environmental Protection Agency 2005a). Verify this by site inspection.	
	6	Delineate the boundary of the wetland on the map and / or aerial photo.	
	7	Identify wetland habitat type from *Queensland Wetland Mapping* (Environmental Protection Agency 2005a) attributes and obtain relevant wetland conceptual model from Wetland*Info*.	
	8	Identify typical species, water regime, soils, ecological values and management requirements associated with the wetland type using the relevant Wetland Management Profile.	
	9	Collect specific biological data relevant to the wetland (such as regional ecosystems present, plants and animal records, water quality data, water regime, ACA results).	
Determine guideline suitability	10	Determine whether the Buffer Design Method is suitable for the wetland (i.e. Is it a HES wetland or a wetland listed in Table 1?).	
Design the wetland buffer	Task 1: Identify and prioritise Wetland Environmental Values (WEVs) (Table A Appendix 3)		
	11	List, describe and rank WEVs.	
	12	Identify the Priority WEVs.	
	13	If necessary, address conflicts between Priority WEVs.	
	Task 2: Specify the individual Wetland Support Area required for each Priority WEV (Table B Appendix 3)		
	14	Identify and document the Wetland Support Area requirements for each Priority WEV.	
	Task 3: Design the overall Wetland Support Area		
	15	Overlay the individual features and Wetland Support Area boundaries for each of the Priority WEVs on a map or aerial photograph of the wetland. OR Use GIS to draw the Wetland Support Area boundaries around the wetland polygon.	
	16	Outline the overall Wetland Support Area.	

Stage	Steps		Completed (Y/N)
	Task 4: Identify risks to Priority WEVs (Table C Appendix 3)		
	17	Identify and document stressors and direct pressures for each Priority WEV.	
	18	Identify impacts for each direct pressure and the capacity to manage this pressure by a Separation Area.	
	19	Identify the Major Direct Pressures for the Priority WEVs using a risk assessment process.	
	Task 5: Specify the individual Separation Area requirements (Table D Appendix 3)		
	20	Identify and document the Separation Area requirements for each Major Direct Pressure.	
	21	Document the required (or existing) Buffer Elements for each Major Direct Pressure.	
	Task 6: Design the Separation Area		
	22	Overlay the individual Separation Area boundaries for each Major Direct Pressure on the map or aerial photograph showing the overall Wetland Support Area (produced as part of Task 3).	
	23	Identify any proposed Buffer Elements including their location, and record how their presence reduces the Separation Distance required and other factors such as on-going maintenance required.	
	24	Consider additional Buffer Elements that may reduce the Separation Area requirements and associated management required.	
	25	Review the Separation Areas / Distances based on the Buffer Elements chosen.	
	26	Outline the maximum extent of the Separation Area.	
Develop Wetland Buffer Management Plan	Determine buffer management requirements		
	27	Review available literature and technical information related to buffer management and monitoring, and seek expert advice on how to manage stressors identified for the wetland.	
	28	Define management objectives for the buffer.	
	29	Identify management actions required to maintain the buffer in line with the management objectives.	
	Design a buffer monitoring program		
	30	Determine monitoring objectives and identify indicators of buffer effectiveness (i.e. the ability to protect WEVs and manage direct pressures).	
	31	Review literature and seek advice on monitoring and how to interpret indicators.	
	32	Design the monitoring program — timing, methods, and standards.	
	Combine management requirements and monitoring program		
	33	Develop a Wetland Buffer Implementation Plan (or integrate this into existing plans of management for the wetland or the property) incorporating management actions and monitoring.	

Appendix C Wetland buffer planning proformas

Table A. Wetland Environmental Value (WEV) prioritisation

WEV Category*	WEV Characteristic*	Description of WEV	Supporting processes	WEV Rating (H/M/L)**	Priority ***	Comment
e.g. wetland processes	e.g. hydrological processes	describe the WEV in relation to the particular wetland				
e.g. material products	e.g. farm water supply					
e.g. activities	e.g. recreation					

NOTES:

* See Wetland Environmental Values (WEVs)

** H=high, M=medium, L=low

*** Priority WEVs will generally have a rating of High or High / Medium.

Table B. Wetland Support Area requirements

Priority WEV Description*	Description of Wetland Support Area Role	Wetland Support Area / Distance estimate and other attributes	Additional Comments**

NOTES:

* From Table A

** Include comments such as references, justifications and assumptions.

Table C. Direct pressure prioritisation

Priority WEV Description*	Associated stressors due to development or activity	Direct pressure on WEV	Impact	Separation Area Appropriate (Y/N)	Impact Rating (1–5)**	Likelihood (1,2,3)***	Impact Overall Risk****	Major Direct Pressure? (Y/N)*****
e.g. shorebird roost	aquatic sediments	change in size distribution of benthic sediments	loss or reduction in suitable food available to shorebirds	Y	5	2	10	Y
	habitat removal or disturbance	disturbance of shorebirds when roosting	reduction in energy resources for migrating	Y	5	2	10	Y

NOTES:

* From Table A

** 1 = minimal, 3 = moderate, 5 = serious (integrates overall impact and vulnerability of wetland)

*** 1 = unlikely, 2 = quite likely, 3 = highly likely

**** Overall risk = vulnerability score x likelihood score

***** Generally, a direct pressure with an Overall Risk score above 10 would be considered a Major Direct Pressure, although this will vary.

Table D. Separation Area requirements

Major Direct Pressure*	Response	Recommended management	Recommended Separation Area / distance	Comments**
e.g. increased suspended sediments within the water column	control increased sediment loads to wetland due to activity	eliminate drains discharging directly into wetland	calculate based on soil types, vegetation etc.	
e.g. alteration to the water regime	maintain groundwater levels	regulation of groundwater abstraction as catchment management measure	Separation Area not appropriate	
e.g. habitat removal	reduce weed infestation	maintain firebreak	50 m to inhibit weed infestation 6 m firebreak inside fence	
e.g. biota removal / disturbance	control access	fence to limit vehicle, stock access	base on feasibility of fencing and vegetation type	

NOTES:

* From Table C

** Include comments such as references, justifications, assumptions and buffer element details.

Appendix D Wetland Support Area roles

WEV characteristic	Examples of Wetland Support Area roles
Hydrological processes	• provide the setting for fundamental hydrological processes e.g. evaporation and evapotranspiration, managing aspects of hydrological connectivity with the wider groundwater system supporting the wetland • helps to maintain appropriate flood regimes by increasing interception and evapotranspiration of stormwater • achieve / maintain appropriate levels of evapotranspiration loss from the groundwater system supporting the wetland as a result of wetland / riparian vegetation or through evaporation from a water body
Food webs	• provide the setting for physiochemical and ecological processes that are necessary for functional food webs e.g. maintain organic matter sources that support wetland food webs • provide shade to lower water temperature and increase oxygen holding capability of water body
Physical habitat	• provide the physical structures (living and non-living) for the ecological and physiochemical processes that underpin all wetland processes • provide habitat for wetland plants and animals which also use non-wetland areas • moderate air and water temperatures due to the shading effect of riparian vegetation • provide shade to reduce nuisance aquatic plants and algae • provide for firebreaks to assist fire regime management (where adequate firebreaks cannot be provided in the Separation Area) • allow for the expansion and contraction of riparian plant communities in response to changing water levels • shelter wetland types vulnerable to wind damage
Nutrient cycling	• provide the setting for natural filtering and beneficial cycling and conversions of contaminants, nutrients, pesticides that occur in shoreline or riparian areas (particularly where suitably vegetated)
Sediment trapping and stabilisation	• reduce un-channelised surface water flow rates into the wetland, allowing suspended material to settle and be consolidated and not move into the wetland
Water supply	• assist natural riparian filtering purposes to assist water quality
Recreation and Tourism	• retain aesthetic qualities • provide an area for managed public access and activities • protect particular aspects of the wetland processes necessary for the recreational and tourist activities
Education	• maintenance of unique / representative character, feature or function of educational interest

Appendix E Separation Area roles

Stressor	Direct pressure	Example roles for Separation Area
Aquatic sediments	changes in the amount of suspended sediments within the water column changes to size distribution of benthic sediments	• manage or eliminate drains discharging into wetland • maintain vegetation that will trap sediments
Bacteria / pathogens	increase in the amount of bacteria, viruses, protozoans or fungi which cause disease entering the system	• management or elimination of drains discharging into wetland • restricted bush camping • restricted use of septic tanks • restrict access by feral animals likely to be carrying diseases
Biota removal / disturbance	removal or disturbance of individual plants or animals of a specific species	• manage inappropriate recreational activities. • provide an area for managed recreational access and use. • provide barrier to visual, light and noise pollution of wetland • reduce potential for increased frequency of fire in wetland • minimise weed infestation due to nearby land uses and development • minimise public access and activities in certain areas and / or wetlands (e.g. permit only unpowered or electric-powered vessels) • restrict disturbance and physical damage to wetland by animals, humans and vehicles • restrict disturbance to nesting birds, wading birds and ground dwelling fauna • restrict harvesting of wetland plants • manage stock access for example by controlling stocking periods and densities
Conductivity	changes in the amount of ions entering a wetland	• manage or eliminate drains discharging into wetland • increase interception and evapotranspiration of stormwater or saline run-off • intercept saline sediments • restrict removal of vegetation that may result in higher evaporation rates
Connectivity	altered lateral or longitudinal connectivity	• provide a native fauna corridor to the wetland / between wetlands • provide alternate or better designed and located crossings that allow for migration of aquatic organisms
Nutrients	change in the amount of nutrients entering the wetland	• manage or eliminate drains discharging into wetlands • increased interception and evapotranspiration of stormwater and other altered run-off • restrict use of septic tanks • restrict bush camping • reduce or ban use of detergents, soaps, toothpastes, shampoos, sunscreens and other chemicals • reduce chemicals such as oils, pesticides, fertilisers, septic tank seepage and heavy metals entering the wetland • managed nutrient application • managed stock access
Organic matter	change in the amount of organic matter entering the wetland	• manage or eliminate drains discharging into wetlands • increase interception and evapotranspiration of stormwater and other altered run-off • stock management (controlled grazing)
Pests	invasion by plants or animals not native to that particular region	• reduce access to the wetland by exotic terrestrial vertebrate fauna • minimise weed invasion by agricultural and urban escapees

Stressor	Direct pressure	Example roles for Separation Area
		• restrict access to sensitive wetlands
pH	acidic load	• manage or eliminate drains discharging into wetlands. • increase interception and evapotranspiration of stormwater and other altered run-off • acid sulphate soil management and rehabilitation
Toxicants	increase in amount of toxicants entering a wetland	• manage or eliminate drains discharging into wetlands • increase interception and evapotranspiration of stormwater and other altered run-off • protect from spray drift • reduce chemicals such as oils, pesticides, fertilisers, septic tank seepage and heavy metals entering the wetland
Hydrology	alteration to the water regime	Many changes to hydrology are not able to be managed by a Separation Area. • resist channelisation and velocity of stormwater inflows, decreasing erosion and buffering the rate of water flow into the wetland • allow ecological adjustments to changing water levels via the expansion and contraction of plant communities • increase groundwater recharge areas • moderate storm water run-off through increased interception and evapotranspiration of stormwater
Rubbish	increase in human produced waste	• prevent dumping of rubbish within wetland • collect wind blown and water carried rubbish
Habitat removal	removal or modification of areas of wetland	Generally not managed by a Separation Area.

NOTE: Some Separation Area roles may relate to more than one stressor.

Appendix F Information sources — buffer distances required for specific Wetland Environmental Values and stressors

NOTE: Blue text indicates that the buffer distance comes from an international source.

Role	Buffer distance	Reference
Hydrological Connectivity		
Protection of groundwater	2 km (in direction of groundwater flow)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia.
Biodiversity, Food Webs and Nutrient Cycling		
Fisheries species diversity and distribution	5-106 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Protection of ecological buffer (structure, productivity)	5-100 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
To maintain ecological processes and major food webs	20-50 m (measured from the outer edge of open water)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia.
Protection of coastal biological processes	20-100 m (dependent on specific biophysical circumstances)	Kinhill Cameron McNamara (1994) *Coastal Protection Strategy: Preparation of guidelines for assessing buffer zone widths*, Queensland Department of Environment and Heritage, Brisbane.
Wildlife corridors	80-100 m buffer strip for the long term retention of most birds and mammals	Riding T and Carter R (1992) *The Importance of the Riparian Zone in Water Resource Management: A Literature Review,* NSW Department of Water Resources, Parramatta.
Bird community richness / species diversity	100 m minimum streamside forest buffer	Shirley SM and Smith JNM (2005) 'Bird community structure across riparian buffer strips of varying width in a coastal temperate forest', *Biological Conservation*, 125: 475-489.
Protection of wetlands and streams	15 m (minimum), actual buffer width of 3 m to 200 m depending on site-specific conditions	Castelle AJ, Johnson AW and Conolly C (1994), 'Wetland and stream buffer size requirements – a review', *Journal of Environmental Quality*, 23: 878-882.
Prevent water temperature increase / fluctuation	30 m minimum	Chagrin River Watershed Partners Inc (2001) *Riparian setbacks: why that width*?, Chagrin River Watershed Partners Inc, Ohio, USA.
Maintain healthy riparian community	37 m minimum	Chagrin River Watershed Partners Inc (2001) *Riparian setbacks: why that width*?, Chagrin River Watershed Partners Inc, Ohio, USA.
Maintenance of species diversity	15 m minimum in rural areas; 30 m minimum in urban areas	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA.
Encourage detrital input	3-10 m	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Maintain riparian habitat	30-500 m	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated*

Role	Buffer distance	Reference
		buffer strips, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Habitat for Species		
Provision of wildlife habitat	15-45 m for wildlife corridors	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones.* Department of Primary Industries, Queensland, 37 pp.
	5-100 m for protection of remnant riparian vegetation	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones.* Department of Primary Industries, Queensland, 37 pp.
Protection of stream habitats and biota	30 m minimum to protect stream habitats from the impacts of logging	Davies PE and Nelson M (1994) 'Relationships between Riparian Buffer Widths and the Effects of Logging on Stream habitat, Invertebrate Community Compostion and Fish Abundance', *Australian Journal of Marine and Freshwater Research*, 45: 1289-305.
Black throated finch (southern) *(Poephila cincta cincta)*	• maintain all foraging habitat within 400 m of known nesting habitat, and within three kilometres of permanent water sources retain remnant woodland within one kilometre of water sources (nesting habitat) • maintain connectivity between important habitat, or areas known or likely to contain the black throated finch (southern), with corridors of at least 100 m in width	Department of the Environment, Water, Heritage and the Arts, (2009a*)* 'Significant impact guidelines for the endangered black-throated finch (southern) *(Poephila cincta cincta)'*, *EPBC Act policy statement 3.13*, Australian Government, Canberra.
Southern cassowary	Corridors should be at a 5:1 ratio (length: width), wider if possible, with a minimum width of 200 m if development abuts either side. This width is required to minimise habitat degradation by light and wind penetration as well as weed invasions. It also provides for resilience over time allowing corridors to naturally regenerate after cyclone damage.	Department of the Environment, Water, Heritage and the Arts, (2009b) 'Significant impact guidelines for the endangered southern cassowary (*Casuarius casuarius johnsonii*) Wet Tropics population', *EPBC Act policy statement 3.15*, Australian Government, Canberra.
Eastern long-necked turtles	375 m - most individuals use sites within 375 m of wetland. The species uses more than one wetland due to seasonal migration and periodic drought.	Roe JH and Georges A (2007) 'Heterogeneous wetland complexes, buffer zones, and travel corridors: Landscape management for freshwater reptiles', *Biological Conservation,* 135: 67-76.
Migratory shorebirds	165-255 m	Department of the Environment, Water, Heritage and the Arts, (2009c) 'Significant impact guidelines for 36 migratory shorebird species', *EPBC Act policy statement 3.10*, Australian Government, Canberra.
Water mouse (*Xeromys myoides)*	at least 30 m of natural vegetation around areas identified as containing or linking likely water mouse habitat	Department of the Environment, Water, Heritage and the Arts, (2009d) 'Significant impact guidelines for the vulnerable water mouse (*Xeromys myoides)'*, *EPBC Act policy statement 3.20*, Australian Government, Canberra.
Core terrestrial habitat for amphibians	159-290 m	Semlitsch RD and Bodie JR (2003) 'Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles', *Conservation Biology*,

Role	Buffer distance	Reference
		17(5): 1219-1228.
Core terrestrial habitat for reptiles	127-289 m	Semlitsch RD and Bodie JR (2003) 'Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles', *Conservation Biology*, 17(5): 1219-1228.
Freshwater turtles	275 m to protect all of the nest and hibernation sites 73 m to protect 90% of the nest and hibernation sites	Burke VJ and Gibbons JW (1999), 'Terrestrial buffer zones and wetland conservation: a case study of freshwater turtles in a Carolina Bay', *NCASI Technical Bulletin*, 781: 68.
Dragonflies	160 m to protect all dragonflies — particularly females and immature males. Mature males are more likely to be found close to the water.	Bried JT and Ervin GN (2006) 'Abundance patterns of dragonflies along a wetland buffer', *Wetlands*, 26(3): 878-883.
Wildlife habitat and corridor protection	30 m minimum for unthreatened species 60-90 m for rare, threatened or endangered species	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA.
Vegetation	30 m minimum to capture 90% of vascular plant species	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Habitat	45 m minimum to maintain an unaltered microclimatic gradient	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Reptiles and Amphibians	30 m minimum buffer of mature trees for amphibians and reptiles 165 m minimum for salamanders 135 m minimum for aquatic turtles	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Mammals	50 m minimum for gray squirrels	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Invertebrates	30 m minimum to maintain background levels of benthic invertebrates in streams adjacent to logging activity	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Fish	30 m minimum to allow normal development of salmon eggs	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.

Role	Buffer distance	Reference
Birds	50 m minimum for forest-dwelling birds 100 m minimum strips for Neotropical migrant birds area sensitive forest birds and red-shouldered hawks California yellow-billed cuckoo 150 m minimum to include 90% of bird species; to reduce edge-related nest predation 500 m minimum to maintain the complete avian community	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Wildlife habitat	30-90 m buffer for a suitable travel corridor or transition zone	Iowa State University Extension Service (1997) *Stewards of our Streams: buffer strip design, establishment and maintenance PM 1626b*, Iowa, USA.
Plant species	30 m minimum to capture 90% of vascular plant species	Spackman S and Hughes J (1994) 'Assessment of minimum stream corridor width for biological conservation: species richness and distribution along mid-order stream in Vermont, USA', *Biological Conservation*, 71: 325-332.
Bird species	150 m minimum to include 90% of bird species	Spackman S and Hughes J (1994) 'Assessment of minimum stream corridor width for biological conservation: species richness and distribution along mid-order stream in Vermont, USA', *Biological Conservation*, 71: 325-332.
Birds	15 m minimum bird habitat preservation 250 m — blue winged teal 50-100 m — great blue herons 200 m — blackbirds (for foraging sites) 50 m — gadwalls (average distance for nest sites) 10 m minimum — lesser scaups (most nesting habitat within 50 m of wetlands) 90 m minimum — wood duck (most nests within 180 m of water) 50 m minimum — pileated wood peckers (to preserve nesting sites) 23 m — pheasant, quail, mourning dove	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc, Washington.
Mammals	100-180 m — beaver (to preserve feeding sites); 100 m minimum (dense forested cover) — mink; 60 m minimum — marten; 23 m — deer	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc, Washington.
Brook and rainbow trout	30 m minimum for temperature moderation	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc, Washington.
Stream invertebrates	10-30 m	Riding T and Carter R (1992) *The Importance of the Riparian Zone in Water Resource Management: A Literature Review*, NSW Department of Water Resources, NSW Government.
Maintain aquatic habitat	10-30 m native forest	Wenger S (1999) *A review of the scientific literature on riparian buffer width, extent and vegetation*, Institute of Ecology, University of Georgia, Georgia USA.
Protect diverse terrestrial	100 m minimum	Wenger S (1999) *A review of the scientific literature on*

Role	Buffer distance	Reference
riparian wildlife communities		*riparian buffer width, extent and vegetation*, Institute of Ecology, University of Georgia, Georgia USA.
Wildlife protection	30-90 m	McElfish JM, Kihslinger RL and Nichols SS (2008) *Planner's Guide to Wetland Buffers for Local Governments*, Environmental Law Institute, Washington DC.
Sediment trapping, water quality and storm / erosion protection		
Filtration of nutrients / pesticides / heavy metals	9-61 m for sediment bound particles; 5-262 m for soluble particles	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Sediment filter / control	30-90 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Stormwater run-off filter / control	30-90 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Provision of shading effects	15-30 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Stabilisation of bank erosion	15-125 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Controlling water pollution	30 m minimum (in most cases)	Karssies LE and Prosser IP (1999) *Guidelines for Riparian Filter Strips for Queensland Irrigators*, CSIRO Land and Water, Canberra.
Trapping soil and nutrients	6 m minimum grass filter strip 10 m minimum vegetation filter strip	Lovett S, Price P and Lovett J (2003) *Managing Riparian Lands in the Cotton Industry*, Cotton Research and Development Corporation.
Stabilising banks	5-10 m riparian buffer along the top of bank	Lovett, S, Price, P and Lovett, J (2003) *Managing Riparian Lands in the Cotton Industry*, Cotton Research and Development Corporation.
Prevent spraydrift to waterways	20 m minimum native vegetation buffer which must include trees	Lovett S, Price P and Lovett J (2003) *Managing Riparian Lands in the Cotton Industry*, Cotton Research and Development Corporation.
Healthy riparian vegetation	5-10 m riparian buffer along the top of bank	Lovett S, Price P and Lovett J (2003) *Managing Riparian Lands in the Cotton Industry*, Cotton Research and Development Corporation.
In-stream health	5-10 m riparian buffer along the top of bank	Lovett S, Price P and Lovett J (2003) *Managing Riparian Lands in the Cotton Industry*, Cotton Research and Development Corporation.
Managing stock	5-10 m riparian buffer along the top of bank	Lovett S, Price P and Lovett J (2003) *Managing Riparian Lands in the Cotton Industry*, Cotton Research and Development Corporation.
Filtering out sediments and nutrients	10 m minimum forest buffer on low gradient land 5 m dense grass buffer on steeper riparian land for narrow (<3 m) streamlines the grass buffer should be at least 10 m	Prosser I, Karssies L, Ogden R and Hairsine P (2002) Using buffers to reduce sediment and nutrient delivery to streams, *Riparian Land Management Technical Guidelines Volume 2* [online], Land and Water Australia, Canberra.

Role	Buffer distance	Reference
Erosion protection	80-115 m for pocket beaches 90-130 m for beach compartments 95-140 m buffer zone for open beaches 150 m buffer zone for open coast 30 m buffer zone for rocky coasts	Kinhill Cameron McNamara (1994) *Coastal Protection Strategy: Preparation of guidelines for assessing buffer zone widths*, Queensland Department of Environment and Heritage, Brisbane.
Prevent silt entering rivers	40 m minimum	Riding T and Carter R (1992) *The Importance of the Riparian Zone in Water Resource Management: A Literature Review,* NSW Department of Water Resources, Parramatta.
Maintaining water quality	20 m minimum	Riding T and Carter R (1992) *The Importance of the Riparian Zone in Water Resource Management: A Literature Review,* NSW Department of Water Resources, Parramatta.
Reduce nutrient inputs	200 m (measured from the boundary of wetland dependent vegetation)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia .
Pollution protection	100-200 m (measured from the boundary of wetland dependent vegetation)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia.
Protection from rising salinity	250 m (measured from the boundary of wetland dependent vegetation)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia.
Minimise sedimentation	100 m (measured from the outer edge of seasonally inundated zone)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia.
Limit streambank erosion	20 m minimum to be windfirm 45 m minimum to accommodate the natural meandering of streams	Chagrin River Watershed Partners Inc (2001) *Riparian setbacks: why that width*?, Chagrin River Watershed Partners Inc, Ohio, USA.
Filter out pollutants	45 m minimum on a 3% slope reduces sediment transport by 90% 15 m minimum to remove nitrate from agricultural drainage waters 45 m minimum to protect water quality from sedimentation and pollutants	Chagrin River Watershed Partners Inc (2001) *Riparian setbacks: why that width*?, Chagrin River Watershed Partners Inc, Ohio, USA.
Sediment reduction	15 m minimum for shallow slopes 30 m for steep slopes	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA.
Phosphorous reduction	15 m minimum for shallow slopes 30 m for steep slopes	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA.
Nitrate reduction	30 m minimum	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA.
Biological contaminant / pesticide reduction	15 m minimum	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA.
Water quality	5-30 m depending on buffer type	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Stream Stabilisation	10-20 m	Fischer RA and Fischenich JC (2000) *Design*

Role	Buffer distance	Reference
		recommendations for riparian corridors and vegetated buffer strips, US Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Flood attenuation	20-150 m	Fischer RA and Fischenich JC (2000) *Design recommendations for riparian corridors and vegetated buffer strips*, U.S. Army Engineer Research and Development Center, Report no. EMRRP Technical Notes Collection (ERDC TN-EMRRP-SR-24), Vicksburg, Mississippi, USA.
Remove agricultural chemicals and sediment from surface run-off	20 m minimum	Iowa State University Extension Service (1997) *Stewards of our Streams: buffer strip design, establishment and maintenance PM 1626b*, Iowa, USA.
Remove sediment	15 m minimum	Iowa State University Extension Service (1997) *Stewards of our Streams: buffer strip design, establishment and maintenance PM 1626b*, Iowa, USA.
Land capability	30 m minimum	Iowa State University Extension Service (1997) *Stewards of our Streams: buffer strip design, establishment and maintenance PM 1626b*, Iowa, USA.
Water quality	60 m minimum width is generally adequate (15-80 m depending on soil, landform and vegetation type)	Phillips JD (1989) 'Nonpoint source pollution control effectiveness of riparian forests along a coastal plain river', *Journal of Hydrology*, 110: 221-237.
Sediment removal	30 m approximately	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc., Washington.
Nutrient removal	20-30 m depending on nutrients	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc., Washington.
Faecal coliform removal	30 m of a clean grass strip will reduce the concentration of faecal coliform by 60%	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc., Washington.
Temperature moderation	20-30 m	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc., Washington.
Sediment and phosphorous control	30 m minimum (larger on steep slopes)	Wenger S (1999) *A review of the scientific literature on riparian buffer width, extent and vegetation*, Institute of Ecology, University of Georgia, Georgia USA.
Nitrate Control	15-30 m	Wenger S (1999) *A review of the scientific literature on riparian buffer width, extent and vegetation*, Institute of Ecology, University of Georgia, Georgia USA.
Sediment removal	10-30 m	McElfish JM, Kihslinger RL and Nichols SS (2008) *Planner's Guide to Wetland Buffers for Local Governments*, Environmental Law Institute, Washington DC.
Phosphorous removal	10-30 m	McElfish JM, Kihslinger RL and Nichols SS (2008) *Planner's Guide to Wetland Buffers for Local Governments*, Environmental Law Institute, Washington DC.
Nitrogen removal	30-50 m	McElfish JM, Kihslinger RL and Nichols SS (2008) *Planner's Guide to Wetland Buffers for Local*

Role	Buffer distance	Reference
		Governments, Environmental Law Institute, Washington DC.
Recreation / aesthetic values		
Aesthetics	50 m minimum for category C wetlands 10-50 m for category R and M wetlands	Western Australian Planning Commission (2005) *Guideline for the Determination of Wetland Buffer Requirements for Public Comment,* Western Australian Planning Commission Perth. Category C wetlands: Attributes identified as having high importance to achievement of the aims of conservation. Category R wetlands: Attributes identified as having high importance to achieve aims of resource enhancement. Category M wetlands: Attributes identified as having high importance relative to achievement of the aims of multiple use.
Barrier	50 m minimum for category C wetlands 10-50 m buffer for category R and M wetlands	Western Australian Planning Commission (2005) *Guideline for the Determination of Wetland Buffer Requirements for Public Comment,* Western Australian Planning Commission Perth. Category C wetlands: Attributes identified as having high importance to achievement of the aims of conservation. Category R wetlands: Attributes identified as having high importance to achieve aims of resource enhancement. Category M wetlands: Attributes identified as having high importance relative to achievement of the aims of multiple use.
Pedestrian access to fisheries resources	5-10 m	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Mosquito and midge control	5 km or more - pest problems likely within 5 km of breeding sites	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones,* Department of Primary Industries, Queensland, 37 pp.
Nuisance insects	100-800 m (measured from the outer edge of open water)	Water and Rivers Commission (2000) *Wetland Buffers Water note WN4,* Water and Rivers Commission, Western Australia.
Visual amenity	30-100 m dependent on coastline type	Kinhill Cameron McNamara (1994) *Coastal Protection Strategy: Preparation of guidelines for assessing buffer zone widths*, Queensland Department of Environment and Heritage, Brisbane.
Noise from agricultural activities	60 m between agricultural land and sensitive receptor for intermittent noise and 500 m buffer for long-term noise in the day time 1000 m minimum buffer for night-time noise Aerial agricultural activity requires a 100 m separation buffer from sensitive receptors.	Department of Natural Resources and Department of Local Government and Planning (1997) *Planning Guidelines: Separating Agricultural and Residential Land Uses*, Queensland Government, Brisbane.
Noise	6 m minimum evergreen vegetated buffer	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc, Washington.
General Human Impact		

Role	Buffer distance	Reference
Weed infestation	100 m minimum for category C wetlands 50 m buffer for category R and M wetlands	Western Australian Planning Commission (2005) *Guideline for the Determination of Wetland Buffer Requirements for Public Comment*, Western Australian Planning Commission Perth. Category C wetlands: Attributes identified as having high importance to achievement of the aims of conservation. Category R wetlands: Attributes identified as having high importance to achieve aims of resource enhancement. Category M wetlands: Attributes identified as having high importance relative to achievement of the aims of multiple use.
Bird habitat	100 m maximum dependent on use for category C wetlands 50 m buffer for category R and M wetlands	Western Australian Planning Commission (2005) *Guideline for the Determination of Wetland Buffer Requirements for Public Comment*, Western Australian Planning Commission Perth. Category C wetlands: Attributes identified as having high importance to achievement of the aims of conservation. Category R wetlands: Attributes identified as having high importance to achieve aims of resource enhancement. Category M wetlands: Attributes identified as having high importance relative to achievement of the aims of multiple use.
Firebreak	6-50 m firebreak for category C wetlands 6 m firebreak for category R and M wetlands	Western Australian Planning Commission (2005) *Guideline for the Determination of Wetland Buffer Requirements for Public Comment*, Western Australian Planning Commission Perth. Category C wetlands: Attributes identified as having high importance to achievement of the aims of conservation. Category R wetlands: Attributes identified as having high importance to achieve aims of resource enhancement. Category M wetlands: Attributes identified as having high importance relative to achievement of the aims of multiple use.
Edge effects	100 m minimum to reduce edge effects in category C wetlands	Western Australian Planning Commission (2005) *Guideline for the Determination of Wetland Buffer Requirements for Public Comment*, Western Australian Planning Commission Perth Category C wetlands: Attributes identified as having high importance to achievement of the aims of conservation Category R wetlands: Attributes identified as having high importance to achieve aims of resource enhancement Category M wetlands: Attributes identified as having high importance relative to achievement of the aims of multiple use
Reduce the negative impact of human pressures	15 m minimum	Emmons and Olivier Resources (2001) *Benefits of Wetland Buffers: a study of functions, values and size*, Emmons & Olivier Resources, Minnesota, USA
Human impact deterrence	15-30 m buffer from low intensity land uses 30-45 m buffer from high intensity land uses	Castelle A, Connolly C, Emers M, Metz E, Meyer S, Witter M, Mauermann S, Erickson T and Cooke S (1992) *Wetland Buffers: Use and Effectiveness*, Adolfson Associates Inc, Washington
Agricultural risk (spray drift, dust, odour)		

Role	Buffer distance	Reference
Agricultural Chemical Spray Drift	20 m no spray zone adjacent to down slope waterbodies 30 m if the wind is blowing toward the water body unless applied using a shielded sprayer	Department of Environment and Resource Management (2010b) *Sugarcane environmental risk management plan and mandatory requirements for herbicide use*, Queensland Government, Brisbane <www.reefwisefarming.qld.gov.au/>
Filtration of nutrients / pesticides	5 m effective vegetated treated area (EVTA)	Department of Environment and Resource Management (2010b) *Sugarcane environmental risk management plan and mandatory requirements for herbicide use,* Queensland Government, Brisbane <www.reefwisefarming.qld.gov.au/>
Filtration of nutrients / pesticides	Tebuthiuron cannot be applied on any drain or within 20 m of a sink hole or well.	Department of Environment and Resource Management (2010b) *New Chemical Controls*, Queensland Government, Brisbane. <www.reefwisefarming.qld.gov.au/>
Agricultural Chemical Spray Drift	300 m minimum open ground buffer from agricultural land to sensitive area or a minimum of a 40 m vegetated buffer of suitable height and density, with access strips on either side and a suitable watering system	Department of Natural Resources and Department of Local Government and Planning (1997) *Planning Guidelines: Separating Agricultural and Residential Land Uses*, Queensland Government, Brisbane
Dust, Smoke and Ash	150m minimum open ground buffer from agricultural land to sensitive receptor or a minimum of a 40 m vegetated buffer of suitable height and density, with access strips on either side and a suitable watering system	Department of Natural Resources and Department of Local Government and Planning (1997) *Planning Guidelines: Separating Agricultural and Residential Land Uses*, Queensland Government, Brisbane
Odour	500 m minimum buffer from agricultural land to sensitive receptor if odour affects receptor more than 1% of the time (88 hours/year)	Department of Natural Resources and Department of Local Government and Planning (1997) *Planning Guidelines: Separating Agricultural and Residential Land Uses*, Queensland Government, Brisbane
Filtration of nutrients / pesticides / heavy metals	40-300 m buffer for spray drift	Bavins M, Couchman D and Beumer J (2000) *Fisheries Guidelines for Fish Habitat Buffer Zones.* Department of Primary Industries, Queensland, 37 pp.

NOTE: Blue text indicates that the buffer distance comes from an international source.

Appendix G Buffer elements

A buffer element is a natural or artificial feature or management action within a wetland buffer that mitigates a negative impact and may reduce the separation distance required. A buffer element may include open ground, grassed areas, natural vegetation, fencing or structures to restrict access.

Management actions such as maintenance or conservation tenure may be required to ensure the long-term effectiveness of the buffer element. Buffer elements, particularly physical barriers, are an effective way of managing many impacts from inappropriate recreational use in urban and rural areas. Fencing, regulation and signage (education) are relatively simple ways of managing these types of impacts.

Management actions

Some management actions can reduce the area needed for a Separation Area, provided they have guaranteed continuance into the future. Examples are conservation tenure and management plans that include ongoing maintenance of the buffer area.

Vegetation

Some vegetation can be considered a buffer element provided it is maintained to reduce the Separation Area required.

Photo 1. A grassed buffer area maintained to reduce speed of overland flow reducing erosion and to trap nutrients (Photo: Gay Deacon)

Typical ways vegetation can be used as a buffer element include:

- filter nutrients and other pollutants travelling to wetland from surface run-off
- reduce speed overland flow reducing erosion hazard
- trap pesticides and herbicides
- block unwanted views
- provide competition for invasive pest plants.

As vegetation is an important and common buffer element, it is worth noting that:

- As a general rule, multi-species vegetated buffer zones that contain high quality natural habitats are most successful at providing effective and multiple buffer functions.
- Vegetation buffer elements are very effective in areas where overland flow concentrates — due to their ability to slow overland flow and trap contaminant loads entering or leaving the wetland.
- Vegetation is effective in slowing or trapping surface run-off, and thereby consolidating a wetland substrate and reducing bank and bed erosion.
- Grassed areas are effective filters, but must be maintained to retain their effectiveness. Grassed areas can result in weed invasion into the wetland and additional nutrients if fertilizers are applied or clippings travel into the wetland.
- The ability of vegetation to perform these functions can vary according to the condition of the vegetation.

Photo 2. Vegetation used to intercept run-off from a road (Photo: Gay Deacon)

Water Sensitive Urban Design

Water Sensitive Urban Design (WSUD) is a multidisciplinary approach used to avoid or minimise urban development impacts on the natural water cycle and environmental values. It minimises stormwater run-off quantity and maximises stormwater quality. Used upstream of a wetland, it may reduce the separation distance required. Many of the buffer elements described in this section are incorporated in WSUD. For more information visit <http://waterbydesign.com.au>

Boardwalks, jetties and viewing platforms

Boardwalks, jetties or platforms are often built above ground level to allow access to wetlands while limiting disturbance. Their construction through or on the edge of a wetland buffer may allow reduction of the buffer distance needed for disturbance and recreational use. Benefits include:

- facilitating recreational and educational enjoyment of a wetland
- limiting negative impacts of physical disturbance by constraining users to a defined pathway
- avoiding altering hydrological regime
- allowing for fauna movement
- minimum disturbance during construction.

Jetties and small platforms also provide access to open water for viewing or fishing.

Photo 3. Boardwalk through a freshwater wetland (Photo: DERM)

Bird hides

Bird hides are often built in conjunction with boardwalks. They allow observation of birds and other wildlife at close quarters without disturbing them.

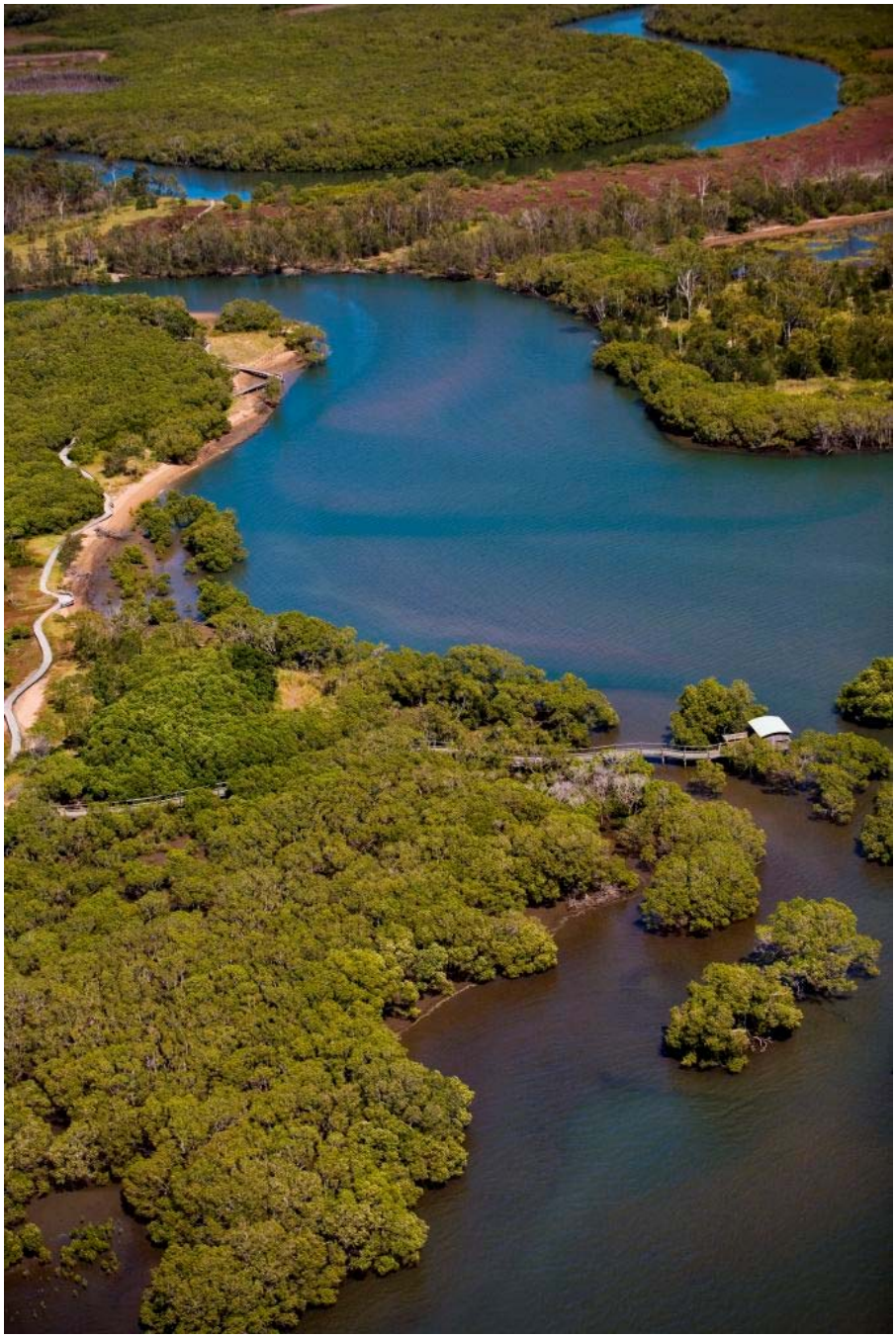

Photo 4. Bird hide at the end of a boardwalk (Photo: DERM)

Fencing

Fencing can be an effective way to manage vehicles, people and stock by excluding them from the wetland and the wetland buffer, thus reducing the buffer required. Combined with watering points, fences can be used to exclude stock and reduce trampling and improve water quality. However care should be taken that fencing does not impact adversely on wildlife.

Photo 5. Wetland fenced to prevent vehicle access (Photo: DERM)

Off-wetland watering points

Off-wetland watering points can be used to reduce stock access to wetland edges and maintain vegetation cover within the buffer. Another benefit is that providing cattle access to clean unpolluted water has been shown to improve their health, growth rates and productivity.

Photo 6. Watering point (Photo: Ian Layden)

Integrated pest plant and animal control

A program of integrated pest control that protects the native species in the wetland and wetland buffer may allow the buffer to be reduced. For information on pest management planning see <www.derm.qld.gov.au/propertyplanning/weeds.html>

Appendix H Wetland migration

Wetlands may migrate or expand over time, and while this is usually at a slow and imperceptible rate it can also occur quite quickly and needs to be considered in the Buffer Design. Recognition of this phenomenon allows the Wetland Support Area to encompass the wetland migration and retain full functionality of the wetland over a long-term (e.g. 50 years) planning period.

The processes of wetland migration are varied and include:

- erosion
- watercourse / tidal channel meandering
- coastal wetlands by storm erosion or tidal influence
- changes to the shoreline profile in response to changed weather patterns, sea-level rise
- migration of water levels up or down in response to sediment infilling.

It is envisaged that as the wetland migrates into and displaces riparian vegetation, the Wetland Support Area will accommodate this while the Separation Area should continue to buffer the wetland. In some circumstances the Migration Component will be the factor that justifies the most extensive Wetland Support Area and defines the boundary.

In estuarine and coastal areas the migration of the landward boundary is critical for successful coastal land use management. The seaward face will accrete or erode from time to time, sometimes substantially — however the main factor in landward migration of coastal and estuarine shorelines is a rise in sea-level (Environmental Protection Agency 2005b). Marine and estuarine wetlands will be expected to migrate in response to a predicted 810 mm rise in sea-level over the next one hundred years (IPCC 2007).

Wetland Support Areas for estuarine and marine wetlands should include an allowance for migration that incorporates long and short-term erosion and estimates shoreline retreat in response to sea-level rise, as described in the information sheet Coastal erosion and assessment of erosion prone area widths (Environmental Protection Agency 2005b) and the Erosion Prone Area Maps for many coastal areas in Queensland, available from Department of Environment and Resource Management.

For areas with an approved Regional or State Coastal Management Plan or Erosion Prone Area Management Plan the Migration component of the Wetland Function Area should include any:

- erosion prone area
- coastal building line, which is defined as a line fixed within a coastal management district that is declared by a regulation or notice and delineates the seaward building setback distance for development (s66 *Coastal Protection and Management Act* 1995)
- any areas where development is limited under a Priority Area for Shoreline Management Plan.

For all other areas, the migration area is defined in the information sheet Coastal erosion and assessment of erosion prone area widths (Environmental Protection Agency 2005b).