

Waterbody Management Guideline

VERSION 1 SEPTEMBER 2013

waterbydesign



Water by Design is a program of Healthy Waterways Ltd

HEALTHY WATERWAYS 

Waterbody Management Guideline Overview

VERSION 1 SEPTEMBER 2013

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Healthy Waterways is a not-for-profit, non-government organisation working to protect and improve waterway health in South East Queensland (SEQ). We facilitate careful planning and coordinated efforts among a network of member organisations from government, industry, research, and the community to achieve our shared vision for healthy waterways.

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GLOSSARY OF TERMS

brackish Slightly salty water (approx 2400-8000 μ S) typical of estuarine systems.

cyanobacteria Primitive, photosynthetic bacteria occurring as a single cell or in filaments, some types can fix nitrogen and some types can produce harmful toxins.

detritus Organic waste material from decomposing dead plants or animals.

estuarine wetlands Wetlands with oceanic water sometimes diluted with freshwater runoff from the land.

eutrophication A process where an environment such as a waterbody receives excessive nutrients which leads to excessive plant growth.

fetch length The length of water over which a given wind has blown, typically the prevailing wind.

internal loading Accumulation of a pollutant in the waterbody sediment from an external source (e.g. untreated stormwater, wastewater, bird faeces).

lacustrine wetlands Wetlands that are dominated by open water and can have deep, standing or slow-moving waters.

macrophyte An aquatic plant that grows in or near water and is either emergent, submergent, or floating.

marine wetlands Include the area of ocean from the coastline or estuary, extending to the jurisdictional limits of Queensland waters (3 nautical mile limit).

palustrine wetlands Wetlands which are primarily vegetated non-channel environments of less than eight hectares. They include billabongs, swamps, bogs, springs, soaks etc., and have more than 30% emergent vegetation.

peri-urban The space that lies immediately outside the existing urban area extending in the non-urban, rural areas.

residence time The average time taken for the entire waterbody column to be displaced via waterbody inflows and outflows. Commonly referred to as Hydraulic Retention Time (HRT), waterbody detention time or waterbody retention time.

riverine wetlands All wetlands and deepwater habitats within a channel. The channels are naturally or artificially created, periodically or continuously contain moving water, or connecting two bodies of standing water.

secchi disk A disk, divided into black and white quarters, used to gauge water clarity by measuring the depth at which it is no longer visible from the surface.

stratification The separation of different layers of water due to different densities.

waterbody batter Sloped ground leading into or away from the waterbody, both above and below the water surface.

wetlands 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 six metres. 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
- the substratum is predominantly undrained soils that are saturated, flooded or ponded long enough to develop anaerobic conditions in the upper layers
- the substratum is not soil and is saturated with water, or covered by water at some time.

(Wetland definition, WetlandInfo, Department of Environment and Heritage Protection, Queensland, viewed 9 May 2013, <http://wetlandinfo.ehp.qld.gov.au/wetlands/what-are-wetlands/definitions-classification/wetland-definition.html>).

0.1 INTRODUCTION

Waterbodies are an important part of our landscape and a subset of our broader wetland assets. They are present in our urban, peri-urban and rural landscapes. Just like our broader wetland assets, waterbodies have environmental, economic and social value. However, they have specific management needs as they hold open, standing water. External pressures such as those from existing landuse (e.g. pollutant loads from stormwater and agricultural runoff) and those from changes to landuse (e.g. development or land clearing) can cause the quality of a waterbody to decline and no longer function effectively. Waterbodies need to be managed with the overall catchment in mind, as many of the impacts on and from the waterbody are tied to the broader landscape. This guideline provides guidance on all aspects of waterbody management from development assessment through maintenance to on-ground works, monitoring and communicating. This guideline provides a structured approach to how waterbodies can be managed in an integrated way as part of a broader landscape and seeks to achieve good outcomes for waterbodies, especially those with high values.

0.2 GUIDELINE SCOPE

This guideline has been designed primarily to assist in the management of artificial and highly modified fresh and brackish waterbodies but the concepts could also be applied to other waterbody and wetland types.

Based on their general characteristics, wetlands can be divided into the following broad systems; estuarine,

lacustrine, palustrine, riverine, marine (see glossary for definitions). This system classification can be useful when considering the management of waterbodies, which are often diverse with different functional needs.

Another important factor for waterbody management is to consider the waterbody formation. It is important to understand whether the waterbody:

- is natural with no modifications to its water flow
- may have been naturally present but has since had its water flows modified
- is totally artificial and was never previously present in the landscape.

These categories of waterbody formation and wetland system are consistent with Queensland state classification of wetlands (EPA, 2005). Figure 0.1 outlines the waterbodies to which this guideline applies and the relationship with wetlands in the landscape. Table 0.1 provides examples of typical waterbodies to which this guideline applies. This guideline does not apply to riverine and marine wetlands and excludes waterbodies that have natural water flows, function as treatment systems (stormwater treatment systems, contaminant removal, sewage treatment ponds etc.), are regional drinking water storages or are used for aquaculture or industrial purposes. While this guideline supports the management of the broader landscape and wetland, its primary focus is on the waterbody due to the specific management needs associated with standing water. Where possible the guideline will direct managers to other relevant sources of information for managing issues that are not dealt with in this document.

Figure 0.1 Scope of The Waterbody Management Guideline

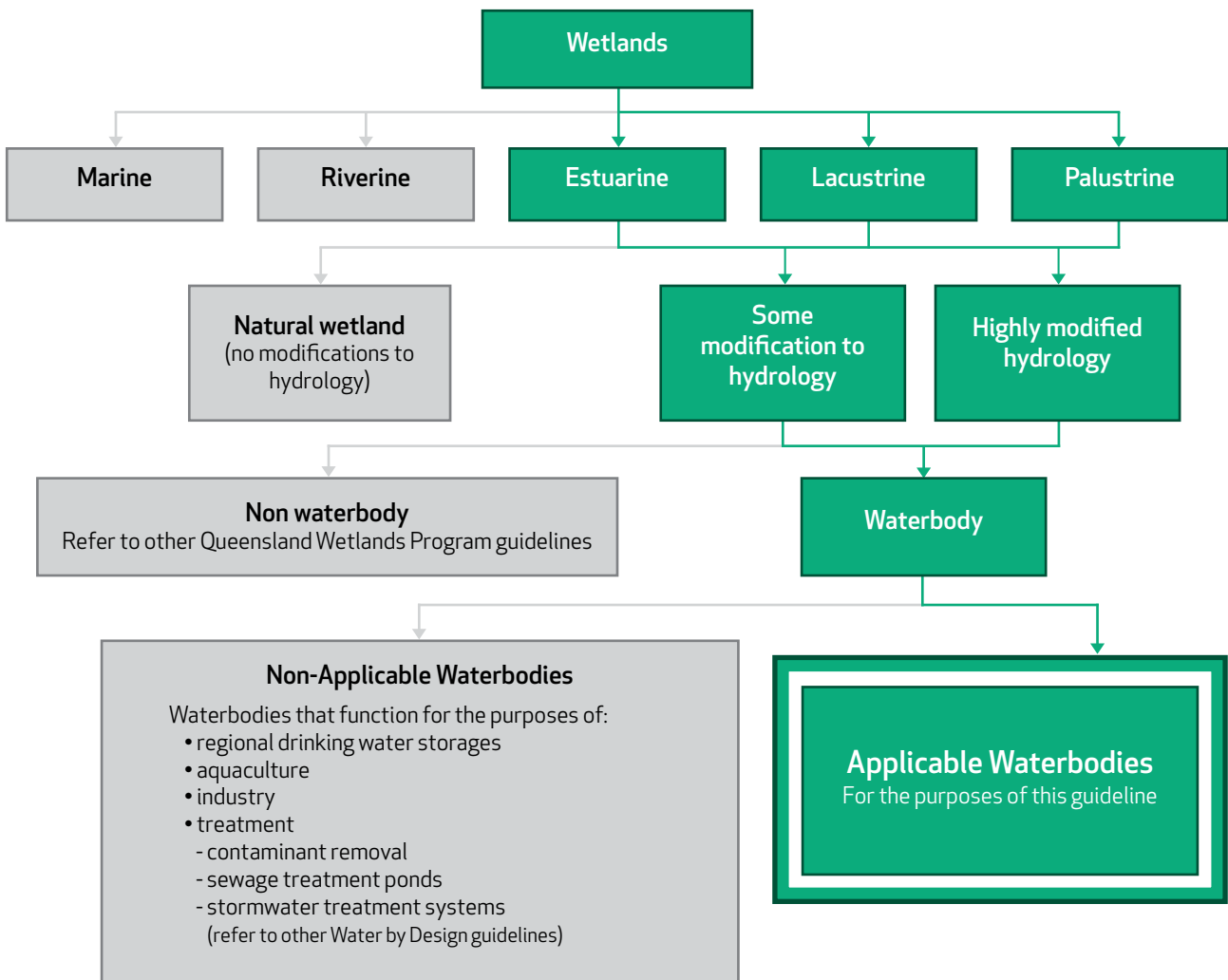


Table 0.1 Applicable waterbodies found in different landscapes

Landscapes	Applicable waterbodies	Non-applicable waterbodies	Reason why not applicable to this guideline
Urban	Artificial waterbodies Constructed urban lakes Modified existing waterbodies	Swimming pool Decorative water features Functioning stormwater treatment device	Not a wetland For information on stormwater treatment devices refer to Water by Design guidelines and resources
Peri-urban	Relic farm dams Fishing ponds Landscape features on 'lifestyle plots'	Treatment devices Aquaculture ponds Waterbodies for industry use	Outside scope of this guideline as these waterbodies usually have specific legislative requirements
Rural	Farm dams Irrigation ponds	Natural waterbodies	Outside scope of this guideline, refer to Queensland Wetlands Program tools and guidelines

For the purposes of brevity an applicable waterbody will be referred to as a waterbody throughout the rest of this guideline. A waterbody system refers to multiple waterbodies located in close proximity with connected functioning.

This guideline is provided as a best practice guideline, however, it cannot override other requirements contained in legislation. Where legislation or approvals state minimum standards must be achieved, this guideline can be used to support achieving these standards to the degree it can be incorporated.

0.3 GUIDELINE TARGET AUDIENCE

The Waterbody Management Guideline provides a management framework for managers dealing with waterbodies in all areas including development assessment, asset management, maintenance and operations as well as extension and engagement.

0.4 GOALS AND KEY PRINCIPLES OF MANAGING WATERBODIES

This guideline is directed by a set of goals and key principles.

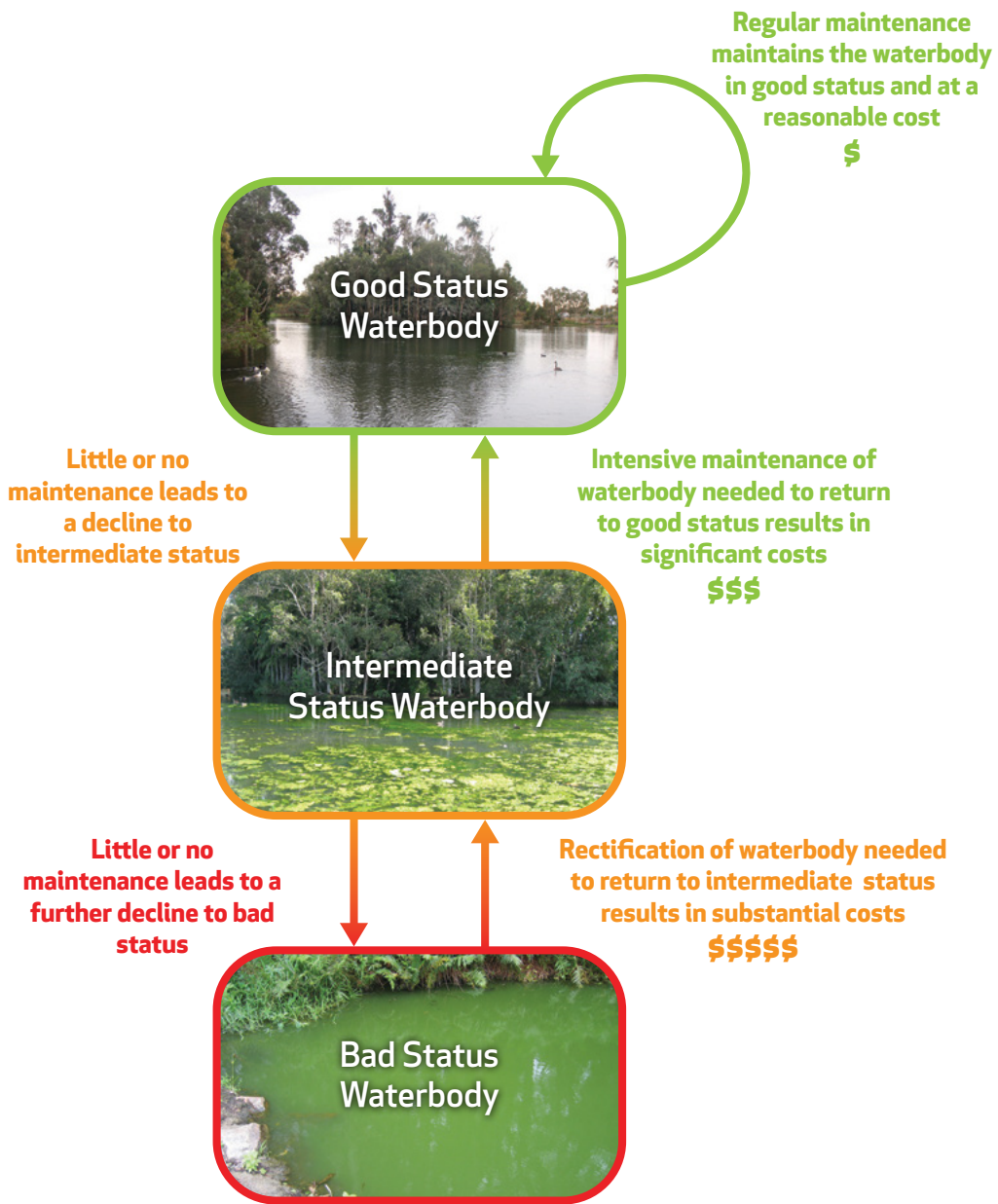
The **goals of managing waterbodies** are to:

- protect and maximise values and services provided by waterbodies
- avoid adverse downstream impacts
- build resilience into waterbodies
- reduce risk and maintenance requirements.

The **key principles of managing waterbodies** to achieve the above goals are to:

1. Avoid constructing new waterbodies and decommission waterbodies that are no longer used for the purpose for which they were designed, unless they continue to provide values.
2. Avoid using waterbodies as water treatment devices as such devices need to be properly designed.
3. Consider the connection of the waterbody to wetlands and to the broader catchment and landscape and manage them as an interconnected system in the landscape.
4. Understand how the waterbody was formed and how the presence of the waterbody impacts the natural hydrology of the catchment, use this understanding to guide appropriate management choices.
5. Prioritise waterbodies based on values and manage accordingly.
6. Ensure that actions taken to manage waterbodies are consistent with broader organisational, planning and catchment principles and activities.
7. Take a long term approach to managing waterbodies. Monitor outcomes over time, learn from successes and failures and tailor future management actions accordingly.
8. Undertake regular, proactive maintenance to prevent the status of waterbodies from declining in preference to waiting for the decline to occur before applying management actions (Figure 0.2).
9. Communicate the goals and principles to all relevant stakeholders to maximise uptake and implementation of appropriate waterbody management.

Figure 0.2 Proactive waterbody maintenance compared with reactive waterbody maintenance



Photos: Julian Wakefield, Sunshine Coast Council

0.5 GUIDELINE STRUCTURE

This guideline is comprised of five modules. Figure 0.3 outlines the structure and target audience for each module. A multidisciplinary approach should be adopted when managing waterbodies. Communication channels between the managers of waterbodies from different areas should be established and continually strengthened.

Figure 0.3 Structure of The Waterbody Management Guideline

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Introduction	0.1	Goals and Key Principles of Managing Waterbodies	0.3
Guideline Scope	0.1	Guideline Structure	0.5
Guideline Target Audience	0.3	References	0.6
Module 1: Waterbodies in Our Landscape - All			
Introduction	1.1	How a Waterbody Works	1.5
Context of Waterbodies	1.2	References	1.18
Value of Waterbodies	1.4		
Module 2: Development Assessment	Module 3: Asset Management	Module 4: Maintenance & Operations	Module 5: Extension & Engagement
Development assessment officers	Asset management professionals	Maintenance officers and asset managers	Extention officers
Introduction	2.1	Introduction	3.1
Background to Waterbodies and Development Assessment	2.2	Getting Started	3.2
The Development Assessment Process for Waterbodies	2.3	Identify Roles, Responsibilities and Resources	3.3
Producing a Development Code for Waterbodies	2.16	Identify and Assess Waterbodies	3.11
Worked Example	2.19	Manage Finances	3.17
References	2.28	Prioritise Waterbodies	3.19
		Review and Revise	3.24
		Worked Example	3.25
		References	3.34
		Introduction	4.1
		Scheduling Inspections and Maintenance	4.2
		Identifying Issues and Selecting Actions	4.3
		Management Actions	4.39
		Worked Example	4.51
		References	4.55
		Introduction	5.1
		Local Government Extension Programs	5.2
		Secure Participation	5.5
		Site Assessment	5.8
		Identify the Issues and Actions	5.9
		Set Priority Issues and Actions	5.27
		Implement Waterbody Plan	5.28
		Worked Example	5.29
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0.6 REFERENCES

Environmental Protection Agency (2005) *Wetland Mapping and Classification Methodology – Overall Framework – A Method to Provide Baseline Mapping and Classification for Wetlands in Queensland*, Version 1.2, Queensland Government, Brisbane.

Queensland Wetlands Program (2003-2013) suite of integrated tools across the wetland management spectrum <http://wetlandinfo.ehp.qld.gov.au>

Water by Design (2006-2013) *Guidelines for managing vegetated stormwater assets*. <http://www.waterbydesign.com.au/guidelines>

Waterbody Management Guideline

Module 1

Waterbodies in Our Landscape

VERSION 1 SEPTEMBER 2013

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1.1 INTRODUCTION

1.1.1 Purpose of module 1

This purpose of this module, '*Waterbodies in Our Landscape*', is to provide easy and accessible information about how a waterbody functions and where the waterbody sits within the landscape. A waterbody's values are usually linked to the broader catchment and hence understanding this information is essential for choosing and implementing an appropriate management strategy.

1.1.2 How to use module 1

Module 1 is divided into three key sections. Figure 1.1 describes how to use each section.

Figure 1.1 How to use module 1

Section 1.2	
Context of Waterbodies	This section sets the context of waterbodies in the landscape and the pressures they face.
Section 1.3	
Value of Waterbodies	This section identifies and describes the values that a waterbody can have.
Section 1.4	
How a Waterbody Works	This section presents the different components of a waterbody and describes how these components work and interact. This includes outlining impacting factor, the subsequent implications and introducing possible management concepts.

1.2 CONTEXT OF WATERBODIES

Waterbodies are a common feature of the landscape and can be either wetlands in themselves or part of a broader wetland and range from rural farm dams to artificial urban lakes. For example, in the Redlands Catchment of South East Queensland, an area of 537 sq km, there are 108 sq km of wetlands including approximately 2000 waterbodies. Many of the waterbodies in South East Queensland are in poor condition and have adverse downstream impacts (LimnoLogic, 2011). The condition of these waterbodies is set to worsen as the pressures of a growing population, landuse change and climate change take effect. These pressures increase the challenges faced by managers.

Population growth and landuse change

Australia's population is estimated to increase from its current size of 23 million to 35.5 million by the year 2056 (Australian Bureau of Statistics, 2006). According to the *South East Queensland Regional Plan 2009-2031*, from 2006 to 2031, 754,000 additional dwellings will be required to cater for population growth in South East Queensland. This will result in expansion of current urban areas and conversion of rural and peri-urban areas into urban areas. This will lead to an increase in direct and indirect pressures exerted on waterbodies (Table 1.1).

1.2.1 Pressures on waterbodies

Pressures affecting waterbodies may be located a long way from the waterbody itself, e.g. land clearing occurring upstream of the waterbody. Although the focus of this guideline is on managing the waterbody itself, it is important to adopt a whole of catchment perspective to help ensure pressures are appropriately addressed.

Table 1.1 Common pressures that development exerts upon a waterbody

	Pressure	Description
Indirect pressure	Catchment disturbance	Development results in landuse change, including vegetation clearing, which can result in erosion and sediment loading to the waterbody.
	Impacts on the fringing zone	Developing land adjacent to waterbodies creates edge effects such as weed ingress, degrading the waterbody.
	Loss of connectivity of the waterbody to the overall landscape	Developing land can cause fragmentation between habitats.
	Hydrological disturbances	Developing land alters hydrology by modifying catchment characteristics, typically increasing impervious land cover. This increases the magnitude and frequency of runoff events resulting in changes to waterbody inflows and waterbody detention time. This can cause erosion and alter ecological communities by changing the inundation or drying periods for vegetation and animals that live in the waterbody.
Direct pressure	Impacts on waterbody soils	Development can directly cause mechanical disturbance of waterbody soils which can lead to exposure and activation of acid sulfate soils (low pH and metal mobilisation).
	Impacts on waterbody flora and fauna	Development can directly remove habitat and encourage the introduction of pest flora and fauna.
	Impacts on water quality	Development increases stormwater pollution delivered to waterbodies, impacting water quality.

Climate change

Climate change will impact waterbodies via more frequent and intense rainfall events, extended periods of high temperature, more intense drought, rising sea level and higher storm tides. It is critical to consider climate change when planning the future management of catchments and waterbodies. This is particularly true of waterbodies located along the coast owing to sea level rise. The National Climate Change Adaptation Research Facility provides useful tools and resources for adapting to climate change (<http://www.nccarf.edu.au/>). Understanding the impact that climate change will have on a specific waterbody requires careful, case-by-case consideration of the waterbody, its processes and the pressures it faces. *WetlandInfo* outlines a step by step guide to understanding how climate change will impact a waterbody. For more information on this guide visit: <http://wetlandinfo.ehp.qld.gov.au/wetlands/management/climate-change/climate-variability.html>

1.3 VALUE OF WATERBODIES

Waterbodies have economic, social and environmental values. A high value waterbody can provide:

- a water source for uses such as irrigation, drinking water, stock watering and farm water supply
- biodiversity such as connectivity, habitat provision and drought refuge
- activities such as recreation, tourism, cultural and heritage as well as education
- flood mitigation such as water flow attenuation.

These waterbody values are further described in Table 1.2. These values are referred to throughout the rest of this guideline and are derived from the ecological values in the National Water Quality Management Strategy and Guidelines, Millennium Ecosystem Assessment, 2005, and South East Queensland Ecosystem Services Framework.

Healthy waterbodies can provide opportunities for recreation and tourism. Recreational activities such as fishing can generate considerable income. In Australia it is estimated that over five million Australians take part in recreational fishing as a leisure activity. It is estimated that international tourists spend over \$200 million

on fishing in Australia each year (Australian Bureau of Statistics, 2002). Our communities receive social and health benefits from interaction and connection with waterways and the environment. One study showed a positive correlation between environmental infrastructure (such as trails, recreation facilities and enjoyable scenery) and physical activity (Brownson *et al.*, 2001). These connections help improve individual health and help strengthen social bonds between families and communities. Community engagement with waterbodies can be enhanced by providing opportunities for people to interact with the ecosystem through the provision of trails, viewing platforms, signage etc. This also creates opportunities to engage the community to protect waterbodies, prevent trampling and pollution, and foster environmental custodianship of waterbodies.

It is important for the community to understand the range of values placed on waterbodies and the beneficial functions performed by a waterbody. Getting the balance right between values of waterbodies and aligning the most appropriate functions are important determining factors for long term management of waterbodies. This understanding will also help communication between local governments and the community about waterbody management and build relationships for working together to maintain and improve waterbody health.

Table 1.2 Waterbody values

Category	Waterbody value	Description
Water use	Drinking water	Waterbody provides suitable raw drinking water for personal supply
	Farm water supply	Waterbody provides a source of water suitable for domestic farm water supply for example for use for laundry and produce preparation
	Irrigation	Waterbody provides a source of water suitable for irrigation
	Stock watering	Waterbody provides a suitable source of water for livestock
Biodiversity	Habitat provision	Waterbody provides habitat that supports diverse ecological communities and species, including biological control of pest species
	Connectivity	Waterbody provides connectivity between important ecological communities including genetic, species and ecosystem connectivity
	Drought refuge	Waterbody provides refuge for species during drought
Activities	Recreation	Waterbody provides recreation including primary (e.g. swimming), secondary (e.g. kayaking, fishing, yabbies) and visual (e.g. walking trails, amenity)
	Cultural and heritage	Waterbody provides historical, cultural or spiritual relevance
	Tourism	Waterbody provides economic benefit through encouraging tourism
	Education	Waterbody provides areas for learning about ecology or conducting research
Flood mitigation	Flood mitigation	Waterbody reduces risk of erosion and flooding by attenuating water flows

1.4 HOW A WATERBODY WORKS

To manage a waterbody, it is important to understand what components are present and how these various components work and interact (the processes). This helps to identify, plan for and manage all those aspects of a waterbody that enables it to deliver values. The components that comprise a waterbody include things such as water type, plants, animals, soil and geology. The processes relate to the interactions between the components.

The health of a waterbody is dependent on the condition and functioning of different components of the system and landscape. This section discusses each of these components and their interacting processes in detail including information on impacting factors, the resulting implications and also introduces some management concepts.

1.4.1 Components

Geology and topography

Geology refers to the structure and composition of the earth and to the material (substrate) comprising a landscape. The topography (shape of an area) and geology influences the location and shape of waterbody and directly influences other components (e.g. water quality, fauna, flora).

Table 1.3 Impacts, implications and management concepts: Geology and topography

Impacts	Implications	Management concepts
Major development, earth works and extractive industries can alter the geology and topography.	Major alterations to geology and topography will impact the shape and functionality of the waterbody by effecting processes such as connectivity and water movement.	It is important to thoughtfully plan any development or earth works to ensure it has minimal negative impacts to the geology and topography.

Soils and acid sulfate soils

Soils directly influence other components (e.g. water quality, fauna, flora) and can be a reflection of the physical processes occurring in the waterbody e.g. water movement, nutrient and carbon cycles. Acid sulfate soils contain highly acidic soil horizons or oxidated iron

sulfides. Acid sulfate soils are found predominantly in coastal waterbodies which are rich in organic matter and have available sulfate ions, iron and sulfate reducing bacteria.

Table 1.4 Impacts, implications and management concepts: Soils and acid sulfate soils

Impacts	Implications	Management concepts
Mechanical disturbance can mobilise sediment and can also result in acid sulfate soils.	Mobilised sediment can cause high turbidity in the waterbody. When exposed to air due to drainage or disturbance acid sulfate soils produce sulfuric acid, often releasing toxic quantities of iron, aluminum and heavy metals.	See Table 1.15 for management concepts for high turbidity. The presence of acid sulfate soils within a waterbody requires specific management, particularly if the waterbody is prone to disturbance. Refer to the Queensland Acid Sulfate Soil Technical manual for further information or contact the Queensland Acid Sulfate Soils Investigation Team for advice.

Water depth and bathymetry

The bathymetry of a waterbody refers to the profile of the waterbody's base. In other words bathymetry is the underwater equivalent of topography.

Table 1.5 Impacts, implications and management concepts: Water depth and bathymetry

Impacts	Implications	Management concepts
<p>The design and construction of a waterbody will determine its bathymetry and depth. In the rural landscape, waterbodies that are primarily constructed for water supply vary in depth, but usually slope continuously to the deepest point in the waterbody. In the urban landscape, waterbodies may be as shallow as 2 m, but in some cases deeper than 6-7 m. These urban waterbodies will often have steeply sloping edges (1:2 to 1:4), which grade to a completely flat base.</p>	<p>Waterbodies with depths greater than 3 m and steep edges are vulnerable to stratification and weed infestation. Steep edges also increase safety risks. Shallow waterbodies (<3 m) with gradually sloping edges provide ideal habitat for submerged and emergent vegetation to grow. Shallow systems tend to be more resilient and stable compared with deep systems.</p>	<ul style="list-style-type: none"> • Infilling backwater • Reconfiguring inlet and outlet structures • Targeted planting • Dredging. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Water type – salinity

Water salinity can be expressed in parts per million (ppm) but most commonly it is measured as electrical conductivity (EC) and expressed in micro Siemens (μ S). EC is the ability of water to conduct an electrical charge, which is primarily dependent upon the concentrations of

ions in the water. Those ions are commonly associated with mineral salts, so EC is closely related to salinity. Table 1.6 outlines the typical μ S and ppm values for a range of water types. Waterbodies can be freshwater, marginal, brackish or saline.

Table 1.6 Typical salinity measurements

	Rainwater	Freshwater	Marginal	Brackish	Saline	Seawater
Micro Siemens (μ S)	15	< 800	800-2400	2400-8000	> 8000	~ 54,000
Parts per million (ppm)	10	< 520	520-1550	1550-5200	> 1550	~ 35,000

Table 1.7 Impacts, implications and management concepts: Water type – salinity

Impacts	Implications	Management concepts
Freshwater ecosystems are confronted with increasing salinity on a worldwide scale, due to a variety of different processes, including long term droughts, rising seawater levels, agricultural practices or specific water management strategies (Williams, 2001, Nielsen <i>et al.</i> , 2003)	Rising salt concentrations are known to affect numerous freshwater plants and animals (Hart <i>et al.</i> , 1991, 2003), and may change the composition of ecological communities. Salinity can affect both the community structure and function of freshwater waterbodies. High salinity can influence nutrient cycling, rates of primary production and respiration, and the survival of riparian vegetation and aquatic fauna. Cyanobacteria are found across a wide range of different salinities, including hypersaline waters. Studies have shown that certain freshwater species of cyanobacteria (e.g. <i>Microcystis aeruginosa</i>) have high salt tolerance and will have a competitive advantage over species vulnerable to changes in salinity (Tonk <i>et al.</i> , 2007).	<ul style="list-style-type: none"> • Backflow preventing device on the outlet pipe • Trenching along the waterbody batter and placing a clay barrier across the groundwater intrusion site • Raising bund levels to prevent tidal backwatering • Replanting the waterbody with saline or brackish tolerant species. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Water type – pH

The term pH is an abbreviation of potential hydrogen. It is a measure of the concentration of free hydrogen ions which indicate the acidity of water. The pH scale is a measure of hydrogen ions and ranges from 1.0 (highly acidic) through to 7.0 (neutral) to 14 (highly alkaline). Water with a pH of 5.0 has ten times the concentration of free hydrogen ions as water with a pH of 6.0, and

100 times the concentration of water with a neutral pH (7.0). The pH of waterbodies usually varies naturally between catchments due primarily to catchment geology and vegetation. The pH of waterbodies in South East Queensland generally ranges from about 4.5 in the tannin-stained waterbodies near coastal 'wallum' heath to near 9.0 in waterbodies located near headwaters of catchments.

Table 1.8 Impacts, implications and management concepts: Water type – pH

Impacts	Implications	Management concepts
<p>A wide variety of factors may have an effect on the pH of water, including:</p> <ul style="list-style-type: none"> • rainfall • water temperature • amount of algal or plant growth in the water (photosynthesis and respiration) • geology and soils • disturbance of acid sulfate soils due to agriculture, urban development or mining • atmospheric deposition (acid rain, dry particle deposition) • burning of fossil fuels by cars and factories • salinity. 	<p>Although small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms in the waterbody (including nutrients and metals) and may aggravate nutrient problems. For example, a lowering of pH may increase the solubility of phosphorus, making it more available for plant growth and resulting in a greater long term demand for dissolved oxygen.</p>	<ul style="list-style-type: none"> • Management of industrial discharge • Acid sulfate soil management plans • Establish and maintain riparian vegetation to buffer inflows. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Biodiversity

Biodiversity is the variety of plant, animal and microbial life within an ecosystem. Biodiversity is essential for our existence, providing the fundamental building blocks which support our economy and lifestyle. A waterbody with high biodiversity reflects a healthy ecosystem that is likely to be more resilient and stable to environmental changes such as nutrient inputs and variations in climate. High biodiversity and stable ecosystems reduce management burdens. The plants in and surrounding waterbodies are an integral part of the ecosystem health, stability and functioning. Waterbody plants can be grouped into five broad categories, namely: free floating, floating attached, submerged, emergent as well as trees and shrubs. Waterbody plants play a number of important roles in waterbody health. Submerged, emergent and riparian waterbody plants improve waterbody health by:

- reducing erosion through reduction of flow rates and stabilising banks
- improving water quality by reducing nutrient concentrations and increasing dissolved oxygen levels
- promoting biodiversity through provision of food and habitat for aquatic fauna
- improving water clarity through trapping and settling suspended sediment
- reducing water temperature through shading.

Even waterbodies which are artificially constructed, such as farm dams, can provide important habitat for native waterplants and fauna and can even provide 'stepping stones' between undisturbed and modified habitats, helping to reduce habitat fragmentation (Brainwood and Burgin, 2009).

There are useful resources on waterbody flora available to managers of waterbodies, including:

- *Waterplants in Australia* (Sainty and Jacobs, 2003) is a comprehensive field guide for identifying waterplants in Australia
- *A Census of Queensland Flora* (Bostock and Holland, 2010) also provides a comprehensive list of native vegetation
- *Mangroves to Mountains* (Leiper, *et al.*, 2009) is a full colour field guide for the plants of South-East Queensland and northern NSW
- *Planting Wetlands and Dams* (Romanowski, 2009) provides practical advice on planting in constructed dams and wetlands.

Over the last 200 years Australia has suffered the largest documented decline in biodiversity of any continent. The biodiversity of Australia is still in decline, with this decline expected to accelerate as the added threats of climate change and landuse change come into play. Australia has been invaded by multiple introduced plants and animals, some of which have become established as problematic. Allaby's (1998) definition of a weed describes a weed as 'a plant in the wrong place'. A plant that may be considered a weed or pest in one area may be a valued member of the ecological community in another area. When defining and assessing a plant or animal as a pest it is important to consider the impacts, both negative and positive, that organism has on its surrounding environment. In Queensland the *Land Protection (Pest and Stock Route Management) Act 2002* provides the legislative measures to manage pests and address their environmental impacts. This Act declares pest species under one of three classes. A list of declared pest plants and animals within the different classes in Queensland under this Act can be viewed at www.daff.qld.gov.au. Pest plants and animals should be managed in accordance with local government area pest management plans (LGAPMPs).

Table 1.9 Impacts, implications and management concepts: Biodiversity

Impacts	Implications	Management concepts
<p>A variety of factors may have an effect on biodiversity, including:</p> <ul style="list-style-type: none"> • landuse change – habitat destruction • habitat fragmentation • clearing of native vegetation • introduction of invasive alien species • climate change • overexploitation and overharvesting • pollution, in particular nutrient loading. 	<p>Pest flora and fauna can cause the following problems:</p> <ul style="list-style-type: none"> • out competing and displacing native species • establishing monocultures which lower the biodiversity and hence stability of the system • lowering the recreational, aesthetic, social and cultural value of the system • damaging the economic viability of the system. 	<p>Studies have shown that waterbodies have the highest conservation value when they have the following features (Hazell <i>et al.</i>, 2001):</p> <ul style="list-style-type: none"> • high percentage of the water’s edge providing emergent vegetation cover • low levels of bare ground in the riparian zone • high percentage of native tree cover in the surrounding 1 km area. <p>For information on the management of pest flora and fauna see Module 4 ‘Maintenance and Operations’</p>

1.4.2 Processes

Connectivity

A waterbody can rarely be considered as an individual, isolated ecosystem. Rather, waterbodies usually sit within a broader wetland and catchment and are connected to this much larger ecosystem. Connectivity looks at the connections between and within waterbodies, taking a whole of catchment approach. When managing a waterbody, it is important for the surrounding catchment to be considered as this can have a major effect on the waterbody. Therefore, always consider the upstream and downstream impacts of management actions. Similarly, when tracking the sources of waterbody issues consider the upstream features of the catchment. It is important to understand how a waterbody functions within its catchment and manage accordingly.

Table 1.10 Impacts, implications and management concepts: Connectivity

Impacts	Implications	Management concepts
<p>Landuse change, habitat fragmentation and changes to water movement within the catchment can all impact connectivity.</p>	<p>Low connectivity can negatively impact the biodiversity and stability of the ecosystem.</p>	<ul style="list-style-type: none"> • Provide waterbodies with buffer and support zones • Allow environmental flows • Encourage wildlife corridors <p>For further information on understanding the connectivity of waterbodies and associated management, visit http://wetlandinfo.ehp.qld.gov.au/wetlands/ecology/landscape/.</p>

Water movement

Understanding the water movement in a waterbody is key for directing appropriate management. This includes understanding the timing, frequency, duration, extent and depth as well as the variability of the water within the waterbody (Boulton and Brock, 1999). The hydrology and hydraulics of a waterbody are interrelated and influence the functionality of a waterbody.

The hydraulics of a waterbody describes the physical mechanisms by which water moves into, out of and

through a waterbody. This includes consideration of the conveyance of water through pipes and channels. These factors influence the amount of time that water spends in the waterbody (known as hydraulic residence time). Inlet and outlet pits, pipes and weirs are common hydraulic features of waterbodies.

The hydrology of a waterbody describes how a waterbody interacts with the surrounding environment, particularly the sources and distribution of a waterbody's water.

Water inflows:	Water outflows:
<ul style="list-style-type: none"> • catchment runoff e.g. stormwater • rainfall onto surface of waterbody • groundwater • flood water • water pumped in for storage • tidal water (in the case of coastal waterbodies). 	<ul style="list-style-type: none"> • evaporation of surface water • evapotranspiration by plants • discharge through hydraulic structures (e.g. pipes, weirs, channels, swales) • seepage to groundwater • water drawn for irrigation, water supply or animal watering.

Table 1.11 Impacts, implications and management concepts: Water movement

Impacts	Implications	Management concepts
<p>The waterbody's location within the catchment, the landuse of the catchment, the amount of water drawn for irrigation, water supply or animal watering as well as the configuration of the hydraulic structures are all factors that influence and impact a waterbody's hydrology.</p>	<p>A waterbody with persistent low flows and high hydraulic residence time is more likely to develop cyanobacterial blooms. Non flowing water allows the cyanobacterial population to grow and develop a bloom. Warm weather coupled with non flowing water causes stratification. Stratification causes low oxygen conditions on the bottom of a waterbody which can result in substantial release of phosphorus from the sediment. Cyanobacteria have competitive advantages over other species, allowing them to become dominant and cause management burdens. The main competitive advantage of cyanobacteria is that they can regulate their buoyancy and move from the upper, light part of the water column during the day, to the deeper, phosphorus-rich layers at night.</p>	<ul style="list-style-type: none"> • Reconfiguring hydraulic structures such as inlet and outlet pipes • Configuring waterbody to receive flushing flows • Altering water level by diverting catchment runoff into or around the waterbody • Mechanical aeration and recirculation systems. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Nitrogen cycle

Nitrogen is an essential nutrient to flora and fauna in waterbodies. Nitrogen is present in waters in both dissolved and particulate forms. Particulate forms include those bound up in organisms, chiefly as proteins in plant and animal tissues, and those bound to suspended particulate matter such as sediment. Dissolved nitrogen may be either inorganic or organic. Water quality reporting often refers to Dissolved

Inorganic Nitrogen (DIN), which represents the total amount of nitrogen present as ammonium, nitrate and nitrite. Nitrogen is also present as soluble, carbon-containing molecules such as urea and amino acids, collectively known as Dissolved Organic Nitrogen (DON). Finally, nitrogen is found in particulate organic form such as phytoplankton and organic detritus known as Particulate Organic Nitrogen (PON). The total nitrogen concentration in water (TN) includes all these forms. Figure 1.2 summarises the different forms of nitrogen.

Figure 1.2 The different forms of nitrogen present in a waterbody

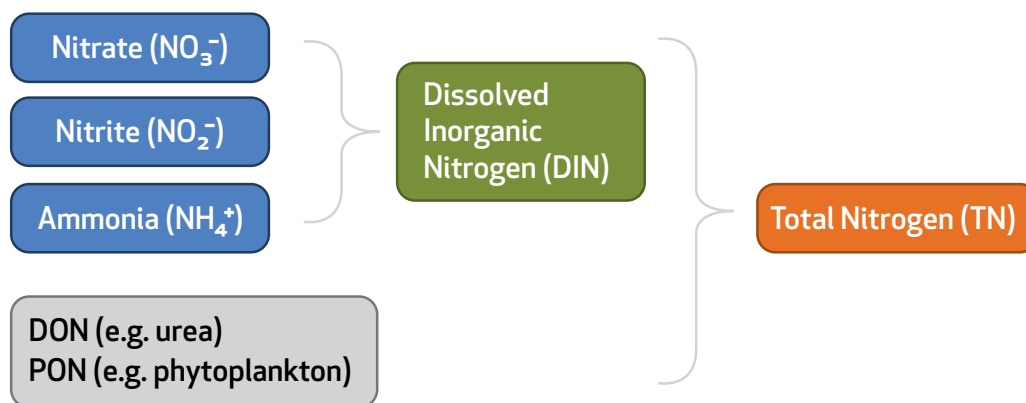
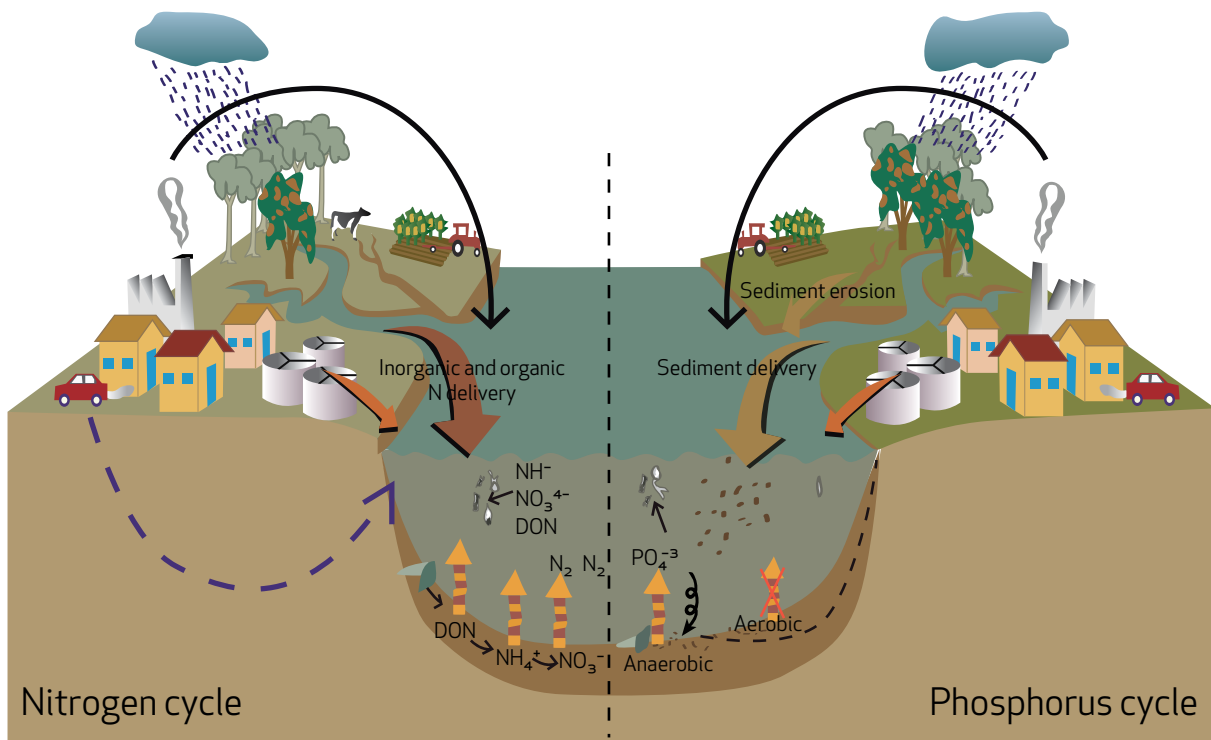







Table 1.12 Impacts, implications and management concepts: Nitrogen cycle






Impacts	Implications	Management concepts
<p>The major nitrogen reservoir is the atmosphere which is comprised of 78% nitrogen gas (N₂). Nitrogen enters waterbodies through the atmosphere. External sources of nitrogen to a waterbody impact the nitrogen cycle. Sources of nitrogen to a waterbody include:</p> <ul style="list-style-type: none"> • animal wastes (faeces and urine) • fertilisers • stormwater runoff • decomposing plant and animal matter (e.g. grass clippings) • leaking septic or sewerage systems. <p>Certain species of cyanobacteria (e.g. <i>Anabaena</i>, <i>Nodularia</i>) can be a source of nitrogen to the waterbody by fixing N₂ directly from the atmosphere. This increases the nitrogen levels of the waterbody and gives these species a competitive advantage making them difficult to eradicate. Figure 1.3 presents the sources and influencing factors on nitrogen in a waterbody.</p>	<p>High nitrogen concentrations encourage the growth of problematic aquatic weeds such as <i>Salvinia molesta</i>, <i>Eichornia crassipes</i> (water hyacinth) and <i>Pistia stratiotes</i> (water lettuce) as well as increasing the occurrence of algal and cyanobacteria blooms. When these blooms and weeds start to die and decay they lower water quality by consuming oxygen from the water column. As decaying blooms are broken down by organisms, the increase in respiration to achieve this breakdown will exert a significant demand on the dissolved oxygen supply of the water. This can lower dissolved oxygen levels to the point where fish kills may occur. Fish kills bring a range of problems such as lowered biodiversity, public complaints and disposal issues.</p>	<ul style="list-style-type: none"> • Stormwater treatment system in the upstream catchment • Floating wetlands • Recirculation systems • Animal waste management • Agriculture runoff management • Establishment and protection of riparian revegetation • Manage point sources such as on-site sewage treatment systems • Appropriate fertiliser application on surrounding land. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Figure 1.3 Nitrogen and phosphorus cycle



Nutrients (nitrogen and phosphorus) are transferred to waterways via a number of mechanisms including, diffuse loads, point source loads, atmospheric deposition, and groundwater flow

-  Diffuse sources of nitrogen enter waterways as dissolved inorganic and dissolved or particulate organic form
-  Decomposition of organic matter releases Dissolved Organic Nitrogen (DON)
-  Ammonification converts DON into ammonium (NH_4^+) which may be released into the water column if not converted further
-  Nitrification converts NH_4^+ into nitrate (NO_3^-) which is generally denitrified to nitrogen gas (N_2) and released
-  Dissolved nitrogen is available for uptake

-  Diffuse sources of phosphorus predominantly enters waterways attached to sediment particles
-  Phosphorus is deposited with sediments
-  Phosphorus release is prevented when sediments are aerobic
-  P release occurs when sediments are anaerobic
-  Dissolved P is available for uptake

Phosphorus cycle

Phosphorus is an essential nutrient for ecosystems. Phosphorus is present in water in both dissolved and particulate forms. Orthophosphate is the major form of biologically available phosphorus found in water.

Particulate forms include those incorporated into plant and animal matter, and those bound to suspended matter such as sediment. Figure 1.3 presents the sources and influencing factors on phosphorus in a waterbody.

Table 1.13 Impacts, implications and management concepts: Phosphorus cycle

Impacts	Implications	Management concepts
Phosphorus availability is highly dependent upon the pH of the water and the oxygen levels in the hypolimnion (bottom layer of the water column when waterbodies are stratified). The less oxygen in the hypolimnion, and the lower the pH, the more bioavailable phosphorus will exist in the water column. Most of the phosphorus entering a waterbody is attached to sediment particles. Therefore, if the waterbody experiences stratification coupled with high sediment loads, particularly if phosphorus fertilisers are applied to the surrounding land, then it is likely that the waterbody will have high phosphorus concentrations. Figure 1.3 presents the sources and influencing factors on phosphorus in a waterbody.	Although sediments have some capacity to absorb and recycle phosphorus inputs, if the waterbody suffers from high inputs of organic matter and nutrients then this capacity may be exceeded. This will lead to the sediment providing the waterbody with bioavailable forms of phosphorus and exerting a demand on the dissolved oxygen supply, a phenomenon known as 'internal loading' (Pettersson, K., 1998). Internal loading typically results in eutrophication. In particulate form phosphorus is not bioavailable, however, phosphorus is continually recycled and can become remobilised from sediments under anaerobic conditions (i.e. when the waterbody is stratified).	<ul style="list-style-type: none"> • Stormwater treatment system in the upstream catchment • Floating wetlands • Recirculation and aeration systems • Animal waste management • Agriculture runoff management • Establishment and protection of riparian revegetation • Manage point sources such as on-site sewage treatment systems • Appropriate fertiliser application on surrounding land. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Carbon cycle

All living things are made of carbon. Carbon can be found in gas, solid and liquid forms. The total amount of carbon on earth is fixed and always remains the same. Carbon

is mobile and continuously cycled through the earth's systems. Carbon can be stored or 'sequestered' as organic matter in reservoirs such as soil or plant matter.

Table 1.14 Impacts, implications and management concepts: Carbon cycle

Impacts	Implications	Management concepts
Sequestered carbon can be released back to the atmosphere via soil disturbance, land clearing, plant and animal respiration and burning of fossil fuels. Taking water out of a waterbody means oxygen can reach previously inundated organic matter. This results in large emissions of carbon dioxide as the organic matter oxidises. This is an important consideration for waterbody management.	Carbon emissions are a major driver of the greenhouse effect and climate change.	<ul style="list-style-type: none"> • Minimise land clearing and vegetation removal • Minimise disturbance of soil and sediments.

Turbidity and sedimentation

Turbidity is a measure of the cloudiness of water and is dependent on the concentration of suspended solids within the water column. As rain falls and flows over a catchment, sediment and organic matter are picked up and deposited into the waterbody. Depending on the size of the particles and other conditions in the waterbody, sediment either stays in the water column, or settles

onto the bottom of the waterbody. Not all turbid waters are an indication of poor water quality. Some inland waterbodies are naturally very turbid and the animals and plants that grow in them have adapted to live in these conditions (WetlandInfo, 2013). It is important to find out whether the waterbody is naturally turbid or clear before implementing any management actions.

Table 1.15 Impacts, implications and management concepts: Turbidity and sedimentation

Impacts	Implications	Management concepts
<p>Erosion of surrounding soil is a significant source of sediment to waterbodies. Various types of erosion can occur within a catchment which can pollute waterbodies with sediment, these include:</p> <ul style="list-style-type: none"> • upstream gully erosion • hoof erosion both upstream and around the waterbody • sheet erosion from exposed soil on surrounding land including construction sites or cleared paddocks • erosion of the waterbody's banks through trampling or exposed soil. <p>Another source of turbidity is waste discharges from sewage systems, mining sites or factories.</p> <p>Resuspension of sediment from the bottom of a waterbody can also cause turbidity issues. Resuspension can occur for a number of reasons for example rain events, windy conditions or aquatic animals which feed from the bottom sediments of a waterbody (e.g. Carp).</p>	<p>High turbidity levels affect the health of the flora and fauna of the waterbody by clogging fish gills and by reducing penetration of light which inhibits the photosynthetic ability of submerged aquatic plants. High turbidity levels give cyanobacteria a competitive advantage over other algae species. Cyanobacteria contain gas vesicles which allow them to float to less turbid surface layers where they can avail of the sunlight. When turbidity levels are high the submerged vegetation will die and the health of the waterbody will decline.</p>	<ul style="list-style-type: none"> • Establishing and maintaining healthy submerged and emergent macrophytes within the waterbody • Establishing and maintaining healthy riparian vegetation on waterbody margins • Repairing areas of bank erosion (e.g. lining with geofabric) and revegetating using endemic species • Stormwater treatment within the upstream catchment • Installation of floating wetlands within the waterbody • Managing runoff from construction and agriculture sites. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Stratification

The warming of the surface layer of a waterbody results in thermal stratification. Thermal stratification divides a waterbody as follows:

- epilimnion – upper oxygenated layer
- hypolimnion – lower stagnant, deoxygenated layer

- metalimnion (or thermocline) – middle layer between the epilimnion and hypolimnion.

Under these conditions, downward mixing is greatly restricted because of the difference in density between warm surface water and cooler bottom water (Figure 1.4).

Figure 1.4 Thermal stratification

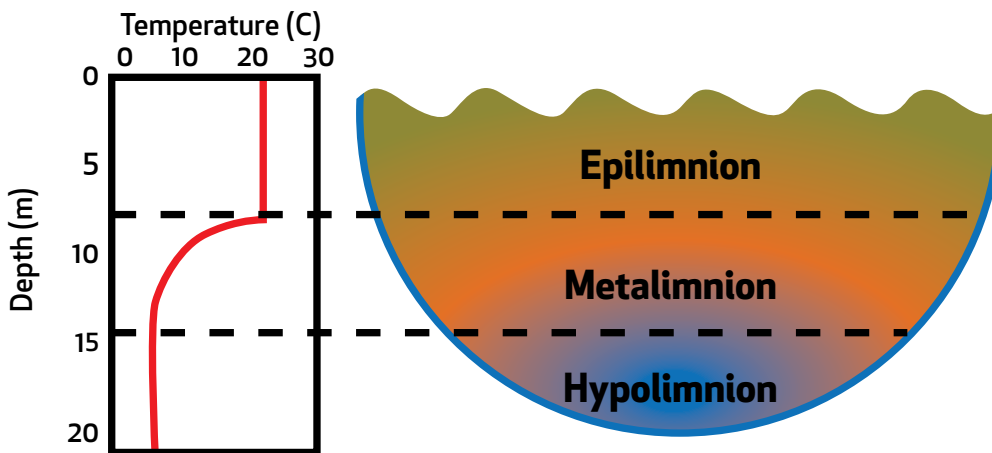


Table 1.16 Impacts, implications and management concepts: Stratification

Impacts	Implications	Management concepts
<p>Waterbodies which experience low water flows are particularly susceptible to stratification especially when weather conditions are warm with little wind. Waterbodies which have little or no riparian vegetation have little shade and therefore minimal protection from the sun heating the surface water.</p>	<p>Stratification has a major influence on the water quality and functioning of the waterbody. During stratification the hypolimnion is denied gas exchange with the atmosphere. This can lead to low dissolved oxygen conditions if the waterbody is susceptible to high input of oxygen demanding substances (i.e. organic matter). This in turn can lead to mobilisation of phosphorus from the sediments resulting in high nutrient concentrations in the hypolimnion.</p> <p>Stratification also gives cyanobacteria a competitive advantage over other algae species. Most algae will permanently sink from the warm upper epilimnion layer to the cooler lower hypolimnion layer. Cyanobacteria on the other hand can remain buoyant and float and accumulate at or near the surface in the epilimnion layer. In the epilimnion layer they receive the light they need to grow and in the absence of other algae species have little competition for the essential dissolved nutrients.</p>	<ul style="list-style-type: none"> • Recirculation and aeration systems • Modification of waterbody bathymetry to increase hydraulic efficiency and wind forced mixing • Plant tall riparian vegetation to promote shading of waterbody • Installation of floating wetlands to reduce surface water temperatures • Reduce depth of waterbody. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

Ecosystem states

A waterbody can be described as having different ecosystem states. Certain triggers can cause switches between these different states. A waterbody is considered to be in a healthy and stable ecosystem state when it has clear water and an established submerged and emergent waterplant community, also known as a macrophyte community. If a waterbody has persistent high turbidity then the submerged macrophyte community will die off due to lack of light penetration and the ecosystem will switch to a less stable floating macrophyte state. If the high turbidity is

coupled with high nutrients then the ecosystem state will decline further to an algal dominated state. If there is no intervention and the high sediment and nutrient loads persist then the system will eventually decline to a cyanobacterial dominated state. The process of switches between ecosystem states is summarised in Figure 1.5. It is very difficult to return a waterbody from an algal or cyanobacterial dominated state to a macrophyte dominated state. It is preferable to retain the macrophyte dominated state if at all possible. For more information on alternative states in waterbodies, refer to the Urban Lakes Discussion Paper (Water by Design, 2012) and Scheffer *et al.*, (2001, 2007).

Figure 1.5 The alternative states observed in shallow waterbodies

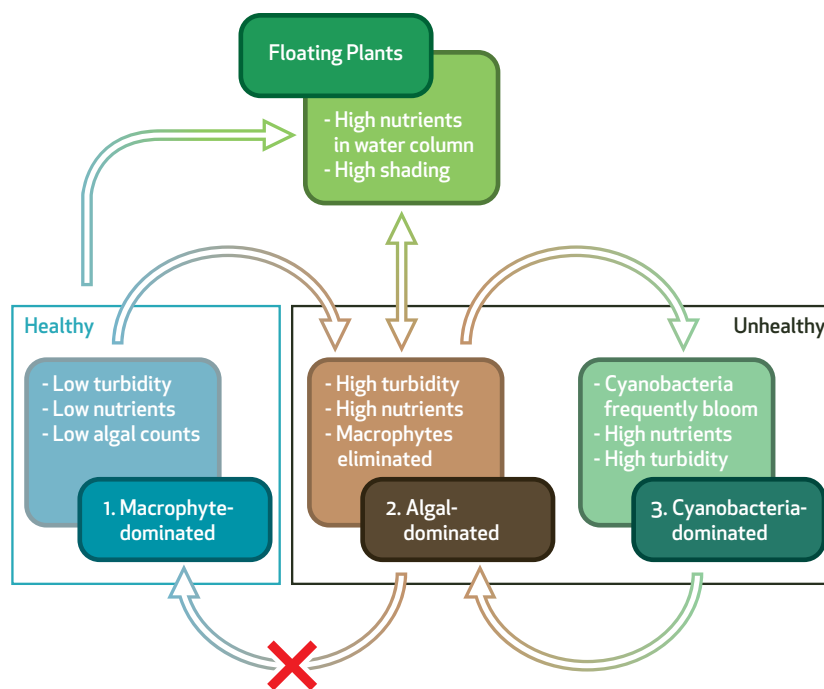


Table 1.17 Impacts, implications and management concepts: Ecosystem states

Impacts	Implications	Management concepts
<p>A number of factors can impact ecosystem states, including:</p> <ul style="list-style-type: none"> • high sediment loads • high nutrient loads • removal of macrophytes. 	<p>If the ecosystem state declines to cyanobacteria-dominated state then the resulting cyanobacterial blooms will cause a range of aesthetic, health and safety as well as biodiversity issues.</p>	<ul style="list-style-type: none"> • Installation of stormwater treatment system in the upstream catchment to remove pollutants prior to entering the waterbody • Removal of the waterbody sediments • Resetting part or all of the waterbody system as a wetland • Installing water recirculation system (e.g. wetland, sand filter) to deplete algal biomass and nutrient loading within the waterbody • Configuring waterbody to receive flushing flows • Installing floating wetlands to manage nutrients and turbidity • Planting the waterbody with emergent and submerged vegetation. <p>For further information on the above management concepts see Module 4 'Maintenance and Operations'.</p>

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Waterbody Management Guideline

Module 2

Development Assessment

VERSION 1 SEPTEMBER 2013

waterbydesign



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2.1 INTRODUCTION

2.1.1 Purpose of module 2

The purpose of this module, 'Development Assessment', is to assist local government officers and developers to assess and manage pre-existing waterbodies on a new development site. It does not provide detail on how to design new waterbodies proposed as part of a development or on private property for water supply. For further information on these components see the *Townsville Constructed Lakes Design Guideline* (DesignFlow, 2010) and *Planning Your Farm Dam* (DERM, 2011a).

Determine if module 2 applies

Prior to commencing the process outlined in this module, be sure to check that the waterbody in question is within the scope of this guideline. Remember this guideline does not apply to riverine and marine wetlands and excludes waterbodies that have natural water flows, function as treatment systems (stormwater treatment systems, contaminant removal, sewage treatment ponds etc.) regional drinking water storages or are used for aquaculture or industrial purposes. Although the concepts presented in this module could be applied to the above waterbody types, it is not its primary purpose.

2.1.2 How to use module 2

Module 2 is divided into four main sections. Figure 2.1 outlines how to use each section.

Figure 2.1 How to use module 2

Section 2.2	
Background to Waterbodies and Development Assessment	This section provides background on how waterbodies become a consideration in the development assessment process.
Section 2.3	
The Development Assessment Process for Waterbodies	This section outlines a process for assessing a pre-existing waterbody on a development site to ensure the most appropriate outcome is achieved for the waterbody post development.
Section 2.4	
Producing a Development Code for Waterbodies	This section provides advice on how to write planning scheme codes to achieve appropriate outcomes for waterbodies that exist on development sites prior to development.
Section 2.5	
Worked Example	This section uses a hypothetical example to demonstrate the processes documented in this module.

2.2 BACKGROUND TO WATERBODIES AND DEVELOPMENT ASSESSMENT

Unless appropriately managed, developing a site will degrade the condition of pre-existing waterbodies. Causes of this degradation include:

- poor sediment and erosion controls during development
- ongoing pressures such as increased pollution, altered hydrology and removal of riparian vegetation.

After development, most pre-existing waterbodies become the responsibility of local governments to manage, although some remain privately owned. If a development produces a poor waterbody outcome, this waterbody will become very difficult and expensive to manage. It is not sustainable for local governments to assume responsibility of poor quality waterbodies. Waterbodies must therefore be managed during development to ensure appropriate and sustainable outcomes are achieved.

The **goals** of development assessment are to ensure that on the development site pre-existing waterbodies with:

- high value are protected during development and values are retained post development
- low value and high risk are removed in a safe, low cost manner with minimal environmental impacts.

Figure 2.2 Farm dam in poor condition



Photo: Karen McNeale, Redland City Council

Most waterbodies located on sites prior to being developed are old farm dams. Before development, many of these are in poor condition (Figure 2.2). In some circumstances some waterbodies may become 'naturalised' to their surrounding landscape and be in good condition prior to development (Figure 2.3).

It is vital to determine if the pre-existing waterbody is part of or connected to a broader wetland as this will determine the options available for the system. It is also important to recognise the scope and limitations of the development assessment process and that seeking options that consider whole of catchment may require extra work beyond the scope of what development assessment can achieve. When determining the outcome for the waterbody it is important to recognise that protecting and retaining high value waterbodies during development will result in local government investing ongoing resources for long term, continued maintenance post development.

Figure 2.3 A naturalised waterbody



Photo: Julian Wakefield, Sunshine Coast Council

2.3 THE DEVELOPMENT ASSESSMENT PROCESS FOR WATERBODIES

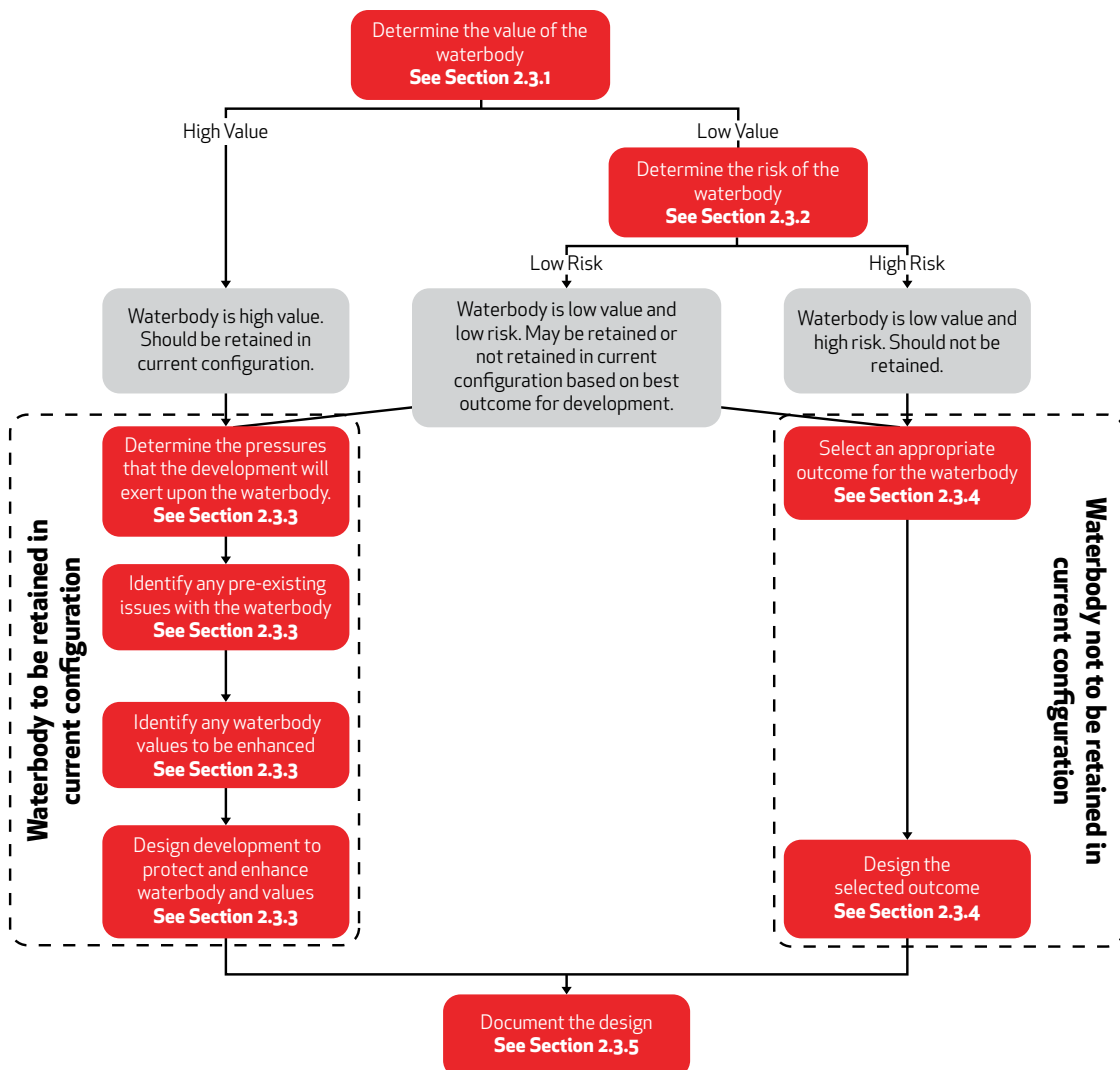
This section provides guidance on achieving the requirements of a code for pre-existing waterbodies written in accordance with Section 2.4. Local governments can use this section as a source of information to write their own planning scheme policy for managing waterbodies. Simply reference this section within the appropriate planning scheme policy or use it to assess development applications. This section can also be used when preparing a development application to assist in achieving a well made application.

The Process

The first step is to determine the value of the waterbody through applying a value based scoring system (Section 2.3.1). The resulting value score is used to determine the options for the waterbody. If the scoring system

shows that the waterbody has high value then it should be retained in its current configuration. If the scoring system shows that the waterbody is of low value, then a further assessment based on risk must be carried out to determine the level of risk retaining the waterbody in its current configuration will present (Section 2.3.2). If the result of this risk assessment shows that the waterbody presents a high risk then it is advisable not to retain the waterbody in its current configuration. If the result of the risk assessment shows that the waterbody is of low risk, then the development assessment officer must decide based on local conditions and the best outcome for the development whether or not to retain the waterbody. The final step of the development assessment process is to document the design for assessment and construction (Section 2.3.5). Figure 2.4 outlines this process.

Figure 2.4 The development assessment process for waterbodies



Retaining a waterbody in its current configuration

Retaining a waterbody in its current configuration means to keep the waterbody almost exactly as it is. It should only be altered to mitigate risks to its long term sustainability. Section 2.3.3 describes in detail the process for retaining waterbodies in their current configuration.

Not retaining a waterbody in its current configuration

Not retaining a waterbody in its current configuration means that it is considered too high risk to remain exactly as it is. Section 2.3.4 provides options for waterbodies not to be retained in their current condition.

2.3.1 Determine the value of the waterbody

Use the value based scoring system to determine the value of the waterbody (Table 2.1). The values are a subset of those discussed in Module 1, Section 1.3 and were chosen to be fit for purpose for development assessment needs.

Prior to completing the scoring system, read the following steps:

1. Understand the background, history and context of the waterbody. In particular, consider how the waterbody was formed and how the presence of the waterbody impacts the natural hydrology of the catchment.
2. Score the waterbody values in the interests of the broader community and not for individual needs.
3. Score the waterbody values for all attributes based on current status, not past or potential future status.
4. When scoring Recreation and Amenity values consider the value from the perspective of if the public had access to the waterbody.
5. Add up the individual scores to get the total score for the waterbody value.
6. If the total score is equal to or greater than 18, the waterbody is considered to be of high value and should be retained in its current configuration.
7. If the total score is less than 18 it is considered to be of low value and a risk assessment should be undertaken to determine what to do with these waterbodies of low value.

Table 2.1 Scoring system to determine the value of a waterbody for development approval purposes

Type of Value	Score	Criteria
Connectivity	7	The waterbody contributes significantly to ecological connectivity, provides a significant functional corridor for native wildlife and has the potential to link corridors.
	4	The waterbody provides some ecological connectivity and/or provides a functional corridor for native wildlife.
	1	The waterbody provides no ecological connectivity and does not provide a functional corridor for native wildlife.
Biodiversity	7	The waterbody provides both good quality aquatic and terrestrial habitat for native species.
	5	The waterbody provides either good quality aquatic or terrestrial habitat for native species.
	3	The waterbody provides some aquatic and/or terrestrial habitat for native species.
	1	The waterbody provides little or no aquatic or terrestrial habitat for native species.
Recreation	5	If the community were provided access to the waterbody in its current condition and configuration, it could be highly used for recreation. Factors to consider may include water quality, public health and safety, location, aesthetics etc.
	3	If the community were provided access to the waterbody in its current condition and configuration, it could be moderately used for recreation. Factors to consider may include water quality, public health and safety, location, aesthetics etc.
	1	If the community were provided access to the waterbody in its current condition and configuration, it would be unlikely to be used for recreation. Factors to consider may include water quality, public health and safety, location, aesthetics etc.
Amenity	5	If the community were provided access to the waterbody in its current condition and configuration, the waterbody could be highly used by the community for its amenity. Factors to consider may include water quality, location, aesthetics etc.
	3	If the community were provided access to the waterbody in its current condition and configuration, the waterbody could be moderately used by the community for its amenity. Factors to consider may include, water quality, location, aesthetics etc.
	1	If the community were provided access to the waterbody in its current condition and configuration, it would be unlikely for the community to use the waterbody for its amenity. Factors to consider may include water quality, location, aesthetics etc.
Cultural heritage	5	The waterbody is of high cultural and/or spiritual value to the community.
	3	The waterbody is of some cultural and/or spiritual value to the community
	1	The waterbody is of no cultural or spiritual value to the community.
Total Score	5 to 29	

If the results of the value assessment are:

Total score less than 18 → Waterbody is of low value → Further Assessment Required → Go to Section 2.3.2

Total score equal to or greater than 18 → Waterbody is valuable → Retain → Go to Section 2.3.3

2.3.2 Determine the risk of the waterbody

If the value assessment in Section 2.3.1 resulted in a score less than 18 then the waterbody is of low value and this section should be used to carry out a risk assessment to determine what to do with the low value waterbody.

Table 2.2 outlines a scoring system to determine the risk of a waterbody.

1. Use the criteria in Table 2.2 to assign a score to the waterbody for each of the six types of waterbody risks listed. The assessment should consider both existing risks, and the likelihood of the proposed development type (e.g. residential, commercial, industrial) to exacerbate or create risks.
2. Add the score for each type of waterbody risk to obtain a total score for the waterbody from 6 to 30.

Where a waterbody's total score is equal to or greater than 10, the waterbody is considered high risk and it is therefore advisable not to retain the waterbody in its current configuration. Proceed to Section 2.3.4 for further information on how to select an appropriate outcome for the waterbodies that are not to be retained.

Where a waterbody's total score is less than 10 it is considered to be of low risk. Low risk waterbodies may be either retained (Section 2.3.3) or not retained (Section 2.3.4) in their current configuration. The development assessment officer should work with the developer to decide the best outcome and design accordingly.

Table 2.2 Scoring system to determine the risk presented from retaining a waterbody

Type of Waterbody Risk	Score	Criteria
Structural integrity	5	Waterbody is not structurally sound. Human population (now or in the future) is at risk in the event of failure.
	3	Waterbody is certified as structurally sound. Human population located downstream (now or in the future) is at risk in the event of failure. OR Works will be undertaken as a part of development to ensure waterbody is structurally sound and can be certified as such. Human population located downstream (now or in the future) is at risk in the event of failure.
	1	Waterbody is certified as structurally sound. No human population (now or in the future) is at risk in the event of failure. OR Works will be undertaken as a part of development to ensure waterbody is structurally sound and can be certified as such. No human population (now or in the future) will be at risk in the event of failure.
Water quality	5	The waterbody has a history of poor water quality and the future development is industrial.
	3	The waterbody has a history of poor water quality and the future development is commercial or high density residential. OR The waterbody has no history of poor water quality and the future development is industrial.
	1	The waterbody has no history of poor water quality and the future development is low/medium density residential.

Type of Waterbody Risk	Score	Criteria
Safety	5	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b), a score of greater than 21 is achieved.
	4	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b), a score of 17 to 21 is achieved.
	3	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b), a score of 12 to 16 is achieved.
	2	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b), a score of 7 to 11 is achieved.
	1	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b), a score of less than 7 is achieved.
Maintenance access	5	Appropriate maintenance access is not, and will not, be provided.
	3	Appropriate maintenance access is (or will be) provided to between one and three (inclusive) of the following: the inlets, outlets, body of water and perimeter of the waterbody.
	1	Appropriate maintenance access is (or will be) provided to the inlets, outlets, body of water and perimeter of the waterbody.
Weeds and pests	5	The waterbody contains declared weeds and/or pests.
	3	The waterbody contains non-declared weeds and/or pests, or species which could become weeds and/or pests.
	1	The waterbody contains no species that could become weeds or pests.
Economics – removal*	5	Removing or repurposing the waterbody will have little effect on the cost of the development. It is much less expensive to remove or repurpose now rather than later. Removing or repurposing of the waterbody makes good economic sense.
	3	Removing or repurposing the waterbody will increase the cost of the development. It is moderately more expensive to remove or repurpose now rather than later. Removing or repurposing of the waterbody may make economic sense.
	1	Removing or repurposing the waterbody will have a large effect on the cost of the development. There is no advantage to remove or repurpose now rather than later. Removing or repurposing of the waterbody does not make good economic sense.
Total Score	6 to 30	

*Economic feasibility of repurposing or removing a waterbody is highlighted in this table to factor the cost and the risk of not taking an appropriate decision at a time where the cost is considered reasonable. A transparent and justifiable analysis must be provided to support the score.

If the results of the risk assessment are:

Total score greater than or equal to 10 → Waterbody is high risk → Do not retain → Go to Section 2.3.4

Total score less than 10 → Waterbody is low risk → Based on best development outcome decide whether waterbody should be retained (Section 2.3.3) or not retained (Section 2.3.4)

2.3.3 Retaining waterbodies in their current configuration

If a waterbody is of high value (value score equal to or greater than 18) or if a waterbody is of low value but also of low risk (risk score less than 10) and it is desirable to retain that waterbody in its current configuration then follow the process outlined in this section.

To retain a waterbody in its current configuration:

- determine the pressures that the development will exert upon the waterbody
- identify any pre-existing issues with the waterbody
- identify any waterbody values to be enhanced
- design development to protect and enhance waterbody and values.

Determine the pressures that the development will exert upon the waterbody

Development exerts pressures on waterbodies. These pressures can be indirect (occurring in the surrounding area of the waterbody) or direct (occurring directly to the waterbody). Table 2.3 describes the common pressures that development exerts upon a waterbody. This list of pressures has been derived from the State of the Environment Queensland Report, 2011. Use Table 2.3 as a guide to determine which pressures the development in question is likely to exert on the waterbody.

Table 2.3 Common pressures that development exerts upon a waterbody

	Pressure	Description
Indirect pressure	Catchment disturbance	Development results in landuse change, including vegetation clearing, which can result in erosion and sediment loading to the waterbody.
	Impacts on the fringing zone	Developing land adjacent to waterbodies creates edge effects such as weed ingress, degrading the waterbody.
	Loss of connectivity of the waterbody to the overall landscape	Developing land can cause fragmentation between habitats.
	Hydrological disturbances	Developing land alters hydrology by modifying catchment characteristics, typically increasing impervious land cover. This increases the magnitude and frequency of runoff events resulting in changes to waterbody inflows and waterbody detention time. This can cause erosion and alter ecological communities by changing the inundation or drying periods for vegetation and animals that live in the waterbody.
Direct pressure	Impacts on waterbody soils	Development can directly cause mechanical disturbance of waterbody soils which can lead to exposure and activation of acid sulfate soils (low pH and metal mobilisation).
	Impacts on waterbody flora and fauna	Development can directly remove habitat and encourage the introduction of pest flora and fauna.
	Impacts on water quality	Development can increase stormwater pollution delivered to waterbodies, impacting water quality.

Identify any pre-existing issues with the waterbody

Many valuable waterbodies will also contain pre-existing issues which if left untreated will develop into significant

problems in the future. Table 2.4 describes common pre-existing issues with waterbodies.

Table 2.4 Common pre-existing issues with waterbodies

Issue	Description
Structural integrity	Some waterbodies may not be structurally sound. This may be because they were not designed or constructed to engineering standards, or because they have degraded over time.
Public health and safety e.g. steep batters	Some waterbodies will have health and safety issues such as steep sloping batters above and/or below the waterline. While these health and safety issues may not have been a concern prior to development when public access was restricted, they may become a significant safety issue if public access is provided post development.
Erosion	Many waterbodies will contain erosion around inlets and outlets.

Identify any waterbody values to be enhanced

In some instances, if a waterbody is to be retained, it may be beneficial to enhance some existing values. Any opportunities for this should be identified at this stage.

Design development to protect and enhance waterbody and values

The development should be designed to:

- mitigate any development pressures and pre-existing issues identified in Table 2.3 and Table 2.4
- enhance any identified waterbody values.

Table 2.5 and 2.6 describe how to investigate and mitigate any development pressures and pre-existing issues.

Table 2.5 How to investigate development pressures and design appropriate mitigation strategies

	Pressure	Investigation	Mitigation Strategy
Indirect Pressures	Catchment disturbance	If not carefully managed, clearing and developing land will deliver large sediment loads to the waterbody.	Implement best practice erosion and sediment control (e.g. IECA, 2008) on both the development site and any subsequent building sites.
	Impacts on the fringing zone	Use the proposed plan of development to assess the future development footprint relative to the waterbody.	A densely vegetated buffer of native plants comprised of trees, shrubs and groundcovers must be provided in accordance with the wetland perimeter planting in the <i>Water Sensitive Urban Design Technical Design Guidelines for South East Queensland</i> (Water by Design, 2006). Further information is provided in the <i>Townsville Constructed Lakes Design Guideline</i> (DesignFlow, 2010) and the <i>Queensland Wetland Buffer Planning Guideline</i> (DERM, 2011b).
	Loss of connectivity of the waterbody to the overall landscape	Any potential impact that development poses to the terrestrial or aquatic connectivity function provided by the waterbody should be identified and mitigated.	Further information is provided in the <i>Queensland Wetland Buffer Planning Guideline</i> (DERM, 2011b).
	Hydrological disturbance	Establish a water balance model for the waterbody and use it to compare the pre-development hydrology of the waterbody with the post development hydrology, particularly issues which cause stress to vegetation such as changes in depth, frequency and duration of inundation. Water level exceedance curves and spells analysis are a useful way of depicting this.	<p>Mitigation strategies should focus on mimicking the pre-development hydrology, focusing on the depth, frequency and duration of inundation. Where the pre-developed hydrology cannot be perfectly mimicked, an aquatic ecologist or similar expert should be consulted to determine the impact of the change. No negative impact should be allowed.</p> <p>For further information on the effects of hydrology on aquatic vegetation in constructed wetlands see Hoban <i>et al.</i>, (2006).</p> <p>Mitigation strategies will need to be tested using the water balance model but may include:</p> <ul style="list-style-type: none"> • bypassing a portion of flows around the waterbody • modifying outlet arrangements • minimise amount of impervious area to be developed.

	Pressure	Investigation	Mitigation Strategy
Direct Pressures	Impacts on waterbody soils	Check acid sulfate soils (ASS) mapping to assess if ASS or potential ASS are likely to be present.	Develop and implement an ASS management plan.
	Impacts on waterbody flora and fauna	Where habitat for highly valued species has been identified, use the proposed plan of development to assess to what extent the development may impact upon this habitat.	Develop a strategy to manage the potential impact. This may include developing a hierarchy to avoid, minimise or mitigate impacts on habitat.
	Impacts on water quality	Without treatment or other mitigation, stormwater from urban developments will negatively impact upon waterbodies.	As a minimum, treat stormwater to comply with stormwater pollutant load reduction targets (see DERM, 2010). Where a waterbody is sensitive to water quality, stormwater may be required to be treated beyond these standards. Untreated stormwater should not enter the waterbody.

Table 2.6 How to investigate pre-existing issues and design appropriate mitigation strategies

Pre-existing Issue	Investigation	Mitigation Strategy
Structural integrity	If as-constructed plans for the pre-existing waterbody are not available, undertake geotechnical investigations to determine the structural integrity of the waterbody, particularly all embankments.	The mitigation measure will depend on the waterbody design and condition. Consult a suitably qualified engineer. The community must not face any risk in the event of failure. All works must be certified by a suitably qualified engineer.
Public health and safety e.g. steep batters	Assess public access and safety concerns using the proposed plan of development against design advice for constructed wetlands and sediment ponds contained in the <i>Water Sensitive Urban Design Technical Design Guidelines for South East Queensland</i> (Water by Design, 2006) and <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b).	Undertake works to bring the waterbody into alignment with the guidance provided in the <i>Water Sensitive Urban Design Technical Design Guidelines for South East Queensland</i> (Water by Design, 2006) and <i>Rectifying Vegetated Stormwater Assets</i> (Water by Design, 2012b). Be sure not to compromise waterbody values in the process. Where the waterbody cannot be brought into alignment with the guidance, public access should be restricted using existing or enhanced dense vegetation.
Erosion	Investigate the potential for scour of inlets and outlets in accordance with local standards such as the <i>Queensland Urban Drainage Manual</i> (DEWS, 2013).	Inlet and outlet scour protection should be in accordance with local design standards such as the <i>Queensland Urban Drainage Manual</i> (DEWS, 2013).

2.3.4 Waterbodies not to be retained

If a waterbody is of low value (value score less than 18) and of high risk (risk score equal to or greater than 10) then it is advisable not to retain the waterbody in its current configuration. In these cases an appropriate

outcome must be selected for the waterbody and designed accordingly. There are four main outcomes for low value, high risk waterbodies that are not to be retained in their current configuration (Table 2.7).

Table 2.7 Outcomes for waterbodies with low value

Outcome	Description
Remove waterbody	The waterbody is removed by either removing the embankment, or filling the waterbody and reinstating a natural channel.
Convert waterbody to a stormwater treatment system	The waterbody is converted to a stormwater treatment system such as a bioretention system or stormwater treatment wetland (Figure 2.5).
Redesign waterbody to a high ecological value wetland (not for stormwater treatment)	The waterbody is redesigned to a high ecological value wetland, rehabilitating or mimicking nearby native ecosystems
Convert waterbody to a flood mitigation system	The waterbody is converted to a flood mitigation system (e.g. a detention basin) (Figure 2.6).

Figure 2.5 A waterbody converted into a stormwater treatment wetland



Photo: Andrew O'Neill, Water by Design

Figure 2.6 A waterbody redesigned to incorporate a detention basin



Photo: Jack Mullaly, Water by Design

The following sections detail the standards for removing waterbodies and converting waterbodies into stormwater treatment systems and redesigning into high ecological value wetlands. If prior to development a waterbody provides a service (e.g. conveyance or flood mitigation) which is required after development, this service must be provided via an alternate means.

Removing a waterbody

Removing a waterbody can be undertaken in a variety of ways. Site assessment will help determine the most appropriate method for each particular waterbody.

Methods may include:

- removing or modifying the wall or embankment and reinstating and stabilising a natural channel
- filling of the waterbody and reinstating and stabilising a natural channel.

Whether the waterbody is removed by breaking down the wall or embankment or by filling the waterbody is dependent on how the waterbody was constructed:

- a waterbody that was constructed by building a wall or embankment should be removed by breaking down or modifying the wall or embankment
- a waterbody that was constructed by digging a hole should be removed by filling the hole.

The reason for this is to avoid erosion or boggy areas through too steep or flat channel grade. If a waterbody constructed by building a wall or embankment is removed by filling, the grade of channel rehabilitated on the downstream end of the wall may be too steep to stabilise. If a waterbody constructed by digging a hole is removed by breaching a wall, the grade of the rehabilitated channel upstream of the waterbody will likely be too steep, or the length of channel may be excessively long to achieve an acceptable grade.

Regardless of the method used, the waterbody should be dewatered prior to being removed. Module 4, Section 4.4.2 provides information on methods for dewatering waterbodies. Relevant approvals to discharge water must be obtained prior to commencing work.

When removing a waterbody, consideration should be given to the quality of the sediment. Sediment in waterbodies will often be contaminated. The act of exposing (dewatering) or eroding sediments can mobilise this pollution. Waterbody sediments should be tested for contamination. If contamination is found, sediments must be either removed or capped with an impermeable clay liner. Note that if capping is undertaken, the design must be such that the impermeable clay liner will not erode to expose the sediments.

Where a waterbody is filled, clean fill must be used. The fill must be compacted to suit the future landuse.

Rehabilitation and reinstating of a waterway should be undertaken in accordance with the *Brisbane City Council Natural Channel Design Guidelines* (2003) or other relevant local standards or guidance.

Convert to a stormwater treatment system

Most developments with a pre-existing waterbody will also be required to achieve stormwater pollution targets. Converting the waterbody into a stormwater treatment system such as a constructed wetland or bioretention system is recommended as it saves space and money. This should be undertaken in accordance with the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (Water by Design, 2006) and the *Bioretention Technical Design Guideline* (Water by Design, 2012a).

Redesign waterbody to a high ecological value wetland

Redesigning the waterbody to a high ecological value wetland can take several forms. To guide the redesign of the waterbody refer to the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (Water by Design, 2006). Note that the *Technical Design Guideline* is tailored towards constructing wetlands to achieve stormwater pollution targets, or maximise pollution treatment. Where stormwater treatment is not the priority, design should focus on creating sustainable, easily maintained wetlands with appropriate ecologies. The result may be a permanently inundated or ephemeral wetland. Ephemeral wetlands can be safe and low maintenance and are therefore a recommended option (Figure 2.7). Designing ephemeral wetlands should also consider:

- creating an ephemeral wetland dominated by *Melaleuca* species to mimic natural *Melaleuca* wetlands as this is likely to be a low maintenance, sustainable solution
- creating a sustainable, biodiverse terrestrial ecosystem as described in Blanche (2010)
- modification of the outlet structure to achieve appropriate inundation duration (the existing outlet arrangement of the waterbody is likely to result in inundation for periods longer than is suitable for an ephemeral wetland)
- careful selection of outlet structure to prevent blockage.

Figure 2.7 Inside a detention basin redesigned as an ephemeral wetland



Photo: Jack Mullaly, Logan City Council

Convert to a flood mitigation system

All developments are required to comply with local flood management regulations. Detention basins are often constructed in new development to attenuate flooding. In many instances waterbodies can easily be converted into detention basins (see Figure 2.6).

Waterbody to detention basin conversions should be undertaken in accordance with local regulations and guidance, as well as the *Queensland Urban Drainage*

Manual (DEWS, 2013), and *Australian Rainfall and Runoff* (Pilgrim, 1987).

In some instances it is possible to convert a waterbody into either a combined stormwater treatment system and detention basin or a combined wetland and detention basin. Where this occurs, the design should also be in accordance with guidance provided previously for stormwater treatment systems and wetlands.

2.3.5 Document the design

At the completion of the design it is appropriate to document the design, both for construction and development approvals. Three main design documents should be produced:

- design report
- design drawings
- specifications.

Design report

A design report documenting the analysis methods and assumptions made during the design process should be submitted to the approval authority, together with the design drawings.

The design report should include:

- details on location and nature of pre-existing waterbody issues (e.g. marked aerial photographs)
- details of development impacts on waterbody (e.g. marked aerial photographs)
- description of design intent
- supporting calculations or modelling results
- a summary of key design parameters
- detailed design drawings
- proposed construction and establishment methodology
- description of any maintenance requirements and evidence that the ultimate asset owner is satisfied with these requirements.

The report should refer to local standards for any other specific reporting requirements.

Design drawings

A set of engineering and landscape drawings suitable for design approval and construction tendering should be completed at the end of the design process. The drawings should clearly detail the design of the final outcome.

Specifications

Design specifications must be documented for assessment and construction. Typically this can be done by either including the specifications as notes on the detailed design drawings, producing a standalone specification document or a combination of both. The most important consideration is that anyone either assessing or constructing the system must be able to easily access the information contained within the specification. For this reason, even if a standalone specification document is produced, the detailed design drawings and design report must make mention of the specification document.

2.4 PRODUCING A DEVELOPMENT CODE FOR WATERBODIES

This section provides a brief background on planning schemes and planning scheme codes along with advice to local government on how to write a planning scheme code for pre-existing waterbodies on development sites to achieve the goals described in Section 2.2.

2.4.1 The Planning Scheme

A planning scheme is a statutory instrument made by a local government. It directs what land can and cannot be used for within a local government area. It guides

how development may occur. Local governments can use their planning scheme to specify how a pre-existing waterbody is managed during development. This includes specifying the outcome to be achieved.

The key elements of a planning scheme are described in Table 2.8. For further information on these elements or planning schemes, consult the *Queensland Planning Provisions* (DSDIP, 2011).

Table 2.8 The key elements of a planning scheme

Planning Scheme Element	Description
Strategic framework	The strategic framework establishes at a high level the vision for future development within the local government area.
Priority infrastructure plan	The priority infrastructure plan identifies when and where infrastructure will be constructed. It facilitates new development to contribute to priority infrastructure.
Tables of assessment	Tables of assessment identify what assessment level applies to development in a particular area or subject to a particular hazard or feature.
Codes	Codes articulate the outcomes sought from development. The four types of code are zone codes, local plan codes, overlay codes and development codes.
Zone codes	Zone codes organise all the land to which a planning scheme applies into groups of related or compatible use. The zone indicates suitable future uses for this land.
Local plan codes	Local plan codes articulate development outcomes specific to a local area.
Overlay codes	Overlay codes identify areas of land which are sensitive to, present opportunities to or constrain development.
Development codes	Development codes articulate all remaining outcomes sought from development that are not included in zone codes, local plan codes and overlay codes.
Planning scheme policies	Planning scheme policies support development in achieving the outcomes of the strategic framework and codes. Planning scheme policies articulate technical standards for achieving the outcomes of the strategic framework and codes.

2.4.2 The Planning Scheme Code

A planning scheme code must clearly state the desired outcomes for pre-existing waterbodies on development sites. The Queensland Planning Provisions (DSDIP, 2011) states that all codes must contain:

- statements clearly stating the purpose of the code
- overall outcomes clearly identifying how the purpose of the code will be achieved
- assessment criteria including performance outcomes that meet the overall outcomes and purpose of the code.

Codes may also contain acceptable outcomes that meet the performance outcomes, the overall outcomes and purpose of the code. The performance outcomes and acceptable outcomes (if included) form the crux of a code.

Performance outcomes form a checklist of outcomes that development must adhere to. The development is assessed against and must achieve the performance outcomes.

Acceptable outcomes (if included in the code) are actions that could be taken by development to meet the adjacent performance outcome. If a development implements an acceptable outcome listed in a code it complies with the adjacent performance outcome.

2.4.3 Choosing the correct code

There are four possible codes; zone codes, local plan codes, overlay codes and development codes. Zone codes and local plan codes are not appropriate for pre-existing waterbodies because the outcomes sought (e.g. protecting values and reducing risk) are independent of the landuse type (zone codes) or location (local plan codes). Overlay or development codes should be used. The difference between an overlay code and a development code is mapping. A development code applies uniformly across the local government area. An overlay code uses mapping to clearly identify all the locations to which the overlay code applies and is therefore more targeted. Table 2.9 provides further information to help choose between overlay and development codes.

Table 2.9 Pros and cons of overlay codes and development codes for specifying pre-existing waterbody outcomes

Code Type	Benefits	Negatives
Overlay code	<ul style="list-style-type: none"> • clearly identifies waterbodies to which it applies • provides certainty to developers 	<ul style="list-style-type: none"> • more resource intensive and time consuming to establish • waterbody must be mapped for code to apply
Development code	<ul style="list-style-type: none"> • easier to establish • applies to all waterbodies even if local government is unaware of a waterbody prior to development application 	<ul style="list-style-type: none"> • a waterbody can be 'overlooked' at the development stage

2.4.4 What to say in the code

The crux of a code is the performance outcomes and acceptable outcomes. In order to achieve the goals of managing pre-existing waterbodies on the development site a waterbody code must specify two key points:

- Where a waterbody of low value exists on a development site prior to development, the development ensures that the waterbody does not present a safety, economic or environmental risk after development.
- Where a waterbody of high value exists on a development site prior to development, the development ensures that those values are protected during development and maintained post development.

The code must also specify what constitutes a value. It is recommended that the following values are included:

- connectivity
- biodiversity
- recreation
- amenity
- cultural heritage.

See Module 1 Section 1.3 for further description on the above waterbody values. It is optional to use acceptable outcomes and there are positives and negatives to doing so. The positive of acceptable outcomes is that they provide clarity for development by stipulating a possible method for complying with the adjacent performance outcome. The negative of acceptable outcomes is that they lack detail. Codes are succinct statements. Where achieving a performance outcome is complex

or includes numerous considerations, an acceptable outcome does not provide enough detail to facilitate the correct decision. In the case of pre-existing waterbodies, there are many considerations that go into deciding the appropriate outcome. It is therefore recommended that only performance outcomes are provided.

An example code is provided in the worked example (see Section 2.5.3).

2.4.5 Creating a standalone code or combining with another code

The last step is to decide whether to include the performance outcomes regarding pre-existing waterbodies within its own code, or to incorporate it into another related code. Including it within another related code helps to keep the planning scheme succinct and simple. It also helps with grouping related activities. For example, waterbodies and stormwater quality and quantity management will often be addressed in tandem in a development application and hence grouping them in a single code is sensible. In other scenarios it may prove more appropriate to incorporate waterbodies with biodiversity (which includes wetlands) codes.

However, if the waterbodies to which the code applies are mapped, and thus an overlay code is to be used, it must be a standalone code. If mapping is not used, it is recommended that the waterbody code is combined with other related codes. The exact combination of codes will depend on how the local government chooses to structure the codes in its planning scheme as a whole.

2.5 WORKED EXAMPLE

This worked example demonstrates:

- how a hypothetical local government may go about establishing a planning scheme that ensures pre-existing waterbodies on development sites are appropriately managed to improve safety, reduce cost, have no detrimental environmental impact and preserve any existing values of the waterbody.
- how to use the process outlined in Section 2.3 to determine the appropriate outcome for a pre-existing waterbody on a development site.

2.5.1 Setting

Sunnyside Council is a small to medium sized local government in South East Queensland. It contains several creek systems and one river. The lower reaches of these catchments are typically urban. The upstream reaches are a combination of rural, forest and conservation areas. There are a large number of waterbodies in Sunnyside Council. Approximately 70% are on private land, with the remaining 30% on Council land.

Sunnyside Council is experiencing a boom in urban development. As a result, many small parcels of land which were previously farms are being developed into urban housing, commercial and industrial sites. As a result, many old farm dams are becoming the subject of development applications. In some instances old farm dams have been left in place as lakes to 'beautify' the new development. Because of pressures such as stormwater pollution from this urban development, these lakes have deteriorated in condition causing Sunnyside Council to spend very large amounts of money rectifying them.

Sunnyside Council recently updated its planning scheme and included provisions to ensure pre-existing waterbodies are appropriately managed in new urban development.

2.5.2 Deciding the desired outcomes

The reason Sunnyside Council referred to pre-existing waterbodies in their planning scheme was to prevent inappropriate waterbody outcomes and minimise their economic risk. They also recognised that some pre-existing waterbodies were in good condition and could become valuable community assets if appropriately protected. Sunnyside Council chose to protect those waterbodies with the following values:

- connectivity
- biodiversity
- recreation
- amenity
- cultural heritage.

2.5.3 Writing the code

Initially Sunnyside Council considered mapping all the waterbodies in their local government area. However, after considering the expense and time to complete this task they decided to instead use a development code to list their requirements with respect to pre-existing waterbodies.

To help keep their planning scheme succinct, Sunnyside Council chose to include the pre-existing waterbody code within another larger, related code. They chose to include it within their Stormwater and Drainage Code which also included provisions for topics such as:

- stormwater drainage
- natural channel design
- stormwater quality.

Sunnyside Council drafted provisions regarding pre-existing waterbodies for inclusion in the Stormwater and Drainage Code (Table 2.10). No acceptable outcomes were provided as it was considered that too much detail was required, and thus an acceptable outcome was not an appropriate method of conveying how to achieve the performance outcomes.

Table 2.10 Sunnyside Council's pre-existing waterbody provisions for their Stormwater and Drainage Code

Performance Outcomes	Acceptable Outcomes
Pre existing waterbodies	
<p>PO17</p> <p>Development ensures that pre-existing waterbodies of high value continue to provide these values post development.</p> <p><i>Note – The Stormwater and Drainage Code provides guidance on how to achieve the performance outcome</i></p>	<i>No acceptable outcome provided</i>
<p>PO18</p> <p>Development ensures that pre-existing waterbodies with low value are redesigned to avoid poor safety, economic and environmental outcomes post development</p> <p><i>Note – The Stormwater and Drainage Code provides guidance on how to achieve the performance outcome</i></p>	<i>No acceptable outcome provided</i>

2.5.4 Writing the planning scheme policy

Sunnyside Council wished to adopt the technical information portrayed in this module. Therefore, for technical standards, methods and information to be provided to achieve their code, they incorporated a reference to Section 2.3 of this module in their Stormwater and Drainage Planning Scheme.

2.5.5 Determining the appropriate outcome for a pre-existing waterbody

This section of the worked example demonstrates how to use the process specified in Section 2.3 to determine the appropriate outcome for a pre-existing waterbody on a development site.

Project Overview

A six hectare, 70 lot residential development was proposed in Sunnyside Council. The land had previously been a small farm and contained a dam, approximately 1500 m² in size. Due to development of the neighbouring land, the site was surrounded on all sides by residential areas. Because of Sunnyside Council's recent amendments to its planning scheme, the development was required to produce an appropriate outcome for the waterbody using the process outlined in Section 2.3.

Determining the value of the waterbody

The first step of the development assessment process is to determine the value of the waterbody (Figure 2.8). This is achieved by carrying out a value based assessment using the criteria outlined in Table 2.1. The results Sunnyside Council's value assessment and the rationale for each score are provided in Table 2.11.

The waterbody scored a total of 11. Because it scored less than 18, it was deemed to be of low value. As a result, further risk assessment was required to determine the outcome for the waterbody.

Figure 2.8 Step 1 - Determine the value of the waterbody

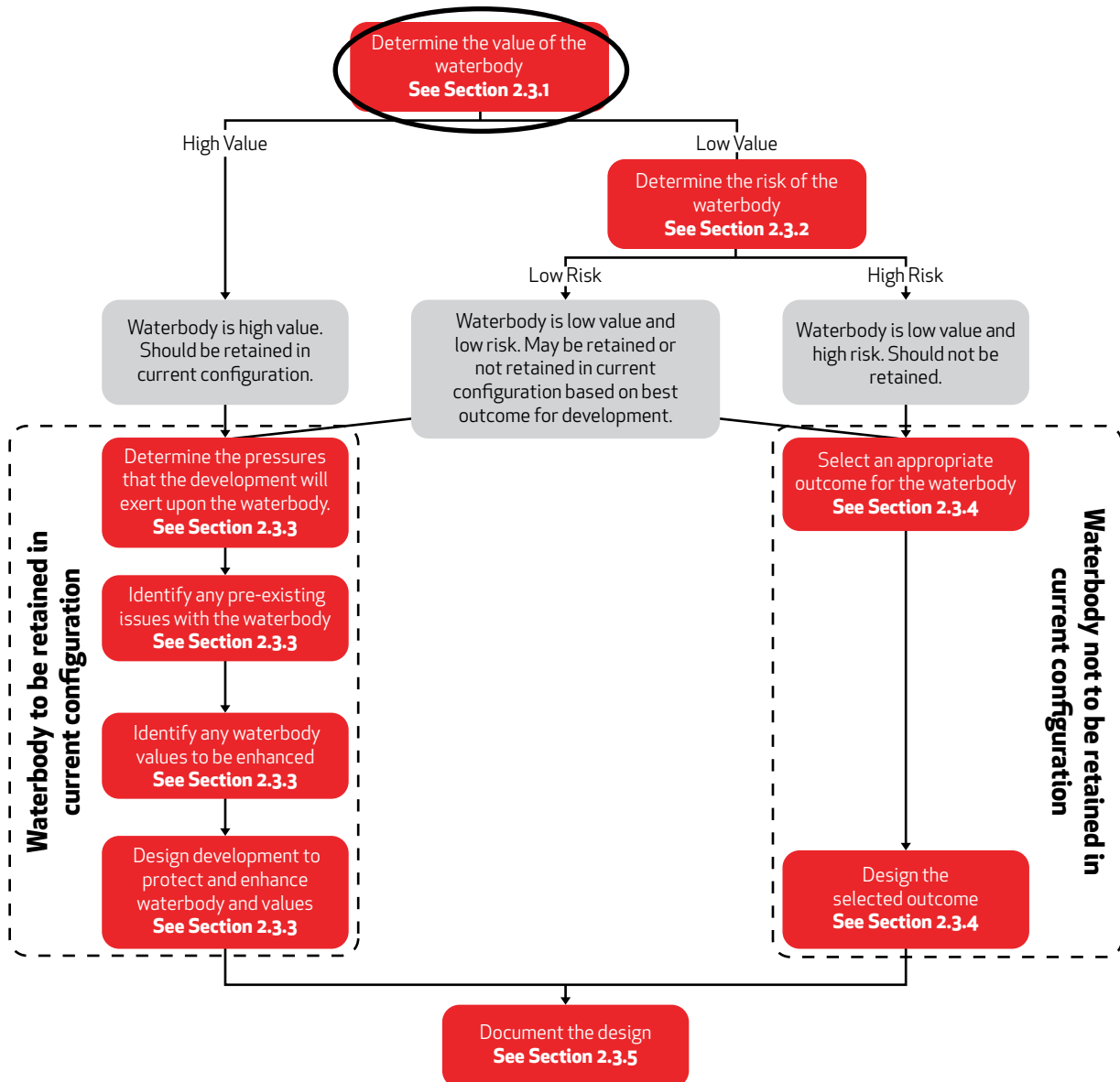


Table 2.11 Results of the value assessment

Type of Value	Score	Score Criteria	Rationale for Score
Connectivity	1	The waterbody provides no ecological connectivity and does not provide a functional corridor for native wildlife.	Previous urban development surrounding the site had isolated the waterbody and it no longer provides connectivity.
Biodiversity	5	The waterbody provides either good quality aquatic or terrestrial habitat for native species.	The waterbody contained good quality terrestrial vegetation providing habitat for native species.
Recreation	1	If the community were provided access to the waterbody in its current condition and configuration, it would be unlikely to be used for recreation. Factors to consider may include quality of access, water quality, public health and safety, location, aesthetics etc.	The waterbody was relatively small in size and located away from other recreation facilities such as parkland. It was considered unlikely that the community would use the waterbody for recreation.
Amenity	3	If the community were provided access to the waterbody in its current condition and configuration, the waterbody could be moderately used by the community for its amenity. Factors to consider may include quality of access, water quality, location, aesthetics etc.	The good quality terrestrial habitat and moderately good water quality within the waterbody made it an attractive landscape feature and thus likely to be used by some members of the community for amenity.
Cultural heritage	1	The waterbody is of no cultural or spiritual value to the community.	The waterbody was of no spiritual or cultural value to the community.
Total	11		

Determining the risk of the waterbody

Sunnyside Council’s waterbody received a low value score. The next step for Sunnyside Council was to carry out a risk assessment outlined in Table 2.2 to determine what to do with the low value waterbody (Figure 2.9). If it was determined to be of high risk, the waterbody would not be retained in its current configuration. If it was determined not to be a risk, the development assessment officer would work with the developer to decide whether or not to retain the waterbody.

A risk assessment was undertaken to determine if the waterbody presented any risks. The results of this assessment and the rationale for each score are provided in Table 2.12.

The waterbody scored a total of 16 (Table 2.12). Because it scored greater than 10, it was deemed to be of high risk. Because the waterbody was determined to be of low value and high risk, it was inappropriate to retain the waterbody in its current configuration. As a result, an alternate outcome for the waterbody was required.

Figure 2.9 Step 2 - Determine the risk of the waterbody

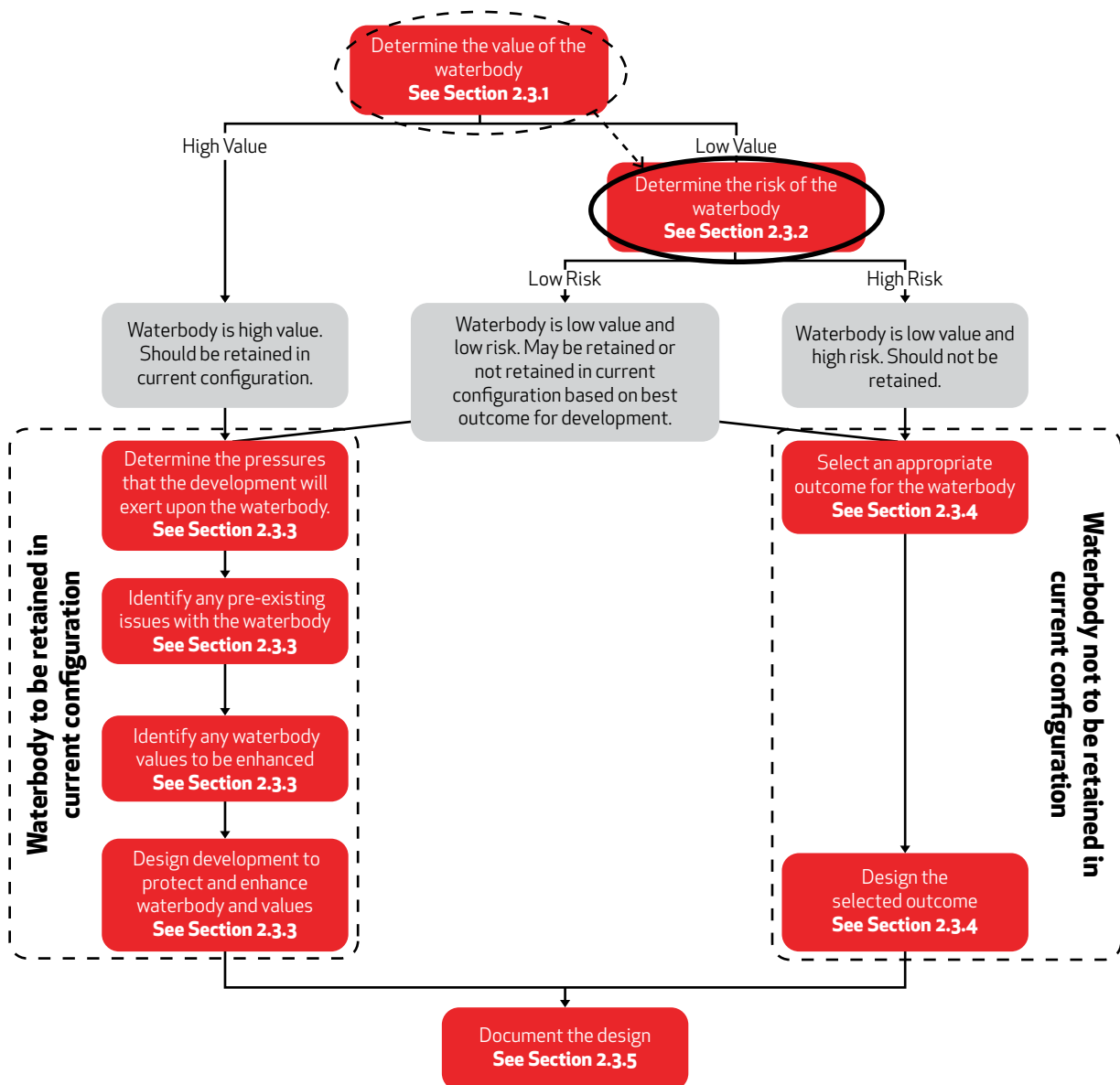


Table 2.12 Results of the risk assessment

Type of Value	Score	Score Criteria	Rationale for Score
Structural integrity	3	Works will be undertaken as a part of development to ensure waterbody is structurally sound and can be certified as such. Human population located downstream (now or in the future) is at risk in the event of failure.	The waterbody was structurally sound and will be certified as such. Due to surrounding urban development, a downstream human population is at risk in the event of the waterbody failing.
Water quality	1	The waterbody has no history of poor water quality and the future development is low/medium density residential.	The water quality was fair and the proposed development is for a residential subdivision.
Safety	5	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets (Water by Design, 2012b)</i> , a score of greater than 21 is achieved.	When assessed against the method outlined in Appendix A of <i>Rectifying Vegetated Stormwater Assets (Water by Design, 2012b)</i> , a score of 24 was achieved.
Maintenance access	3	Appropriate maintenance access is (or will be) provided to between one and three (inclusive) of the following: the inlets, outlets, body of water and perimeter of the waterbody.	No maintenance access existed, but will be provided as a component of the final design.
Weeds and pests	1	The waterbody contains no species that could become weeds or pests.	The waterbody was free of weeds and pests.
Economics – removal	3	Removing or repurposing the waterbody will increase the cost of the development. It is moderately more expensive to remove or repurpose now rather than later. Removing or repurposing of the waterbody may make economic sense.	Removing the waterbody was found to significantly increase the cost of the development.
Total	16		

Select an appropriate outcome for the waterbody

Sunnyside Council's next step was to select an appropriate outcome for their low value, high risk waterbody (Figure 2.10)

Four options were available for the waterbody (see Table 2.7):

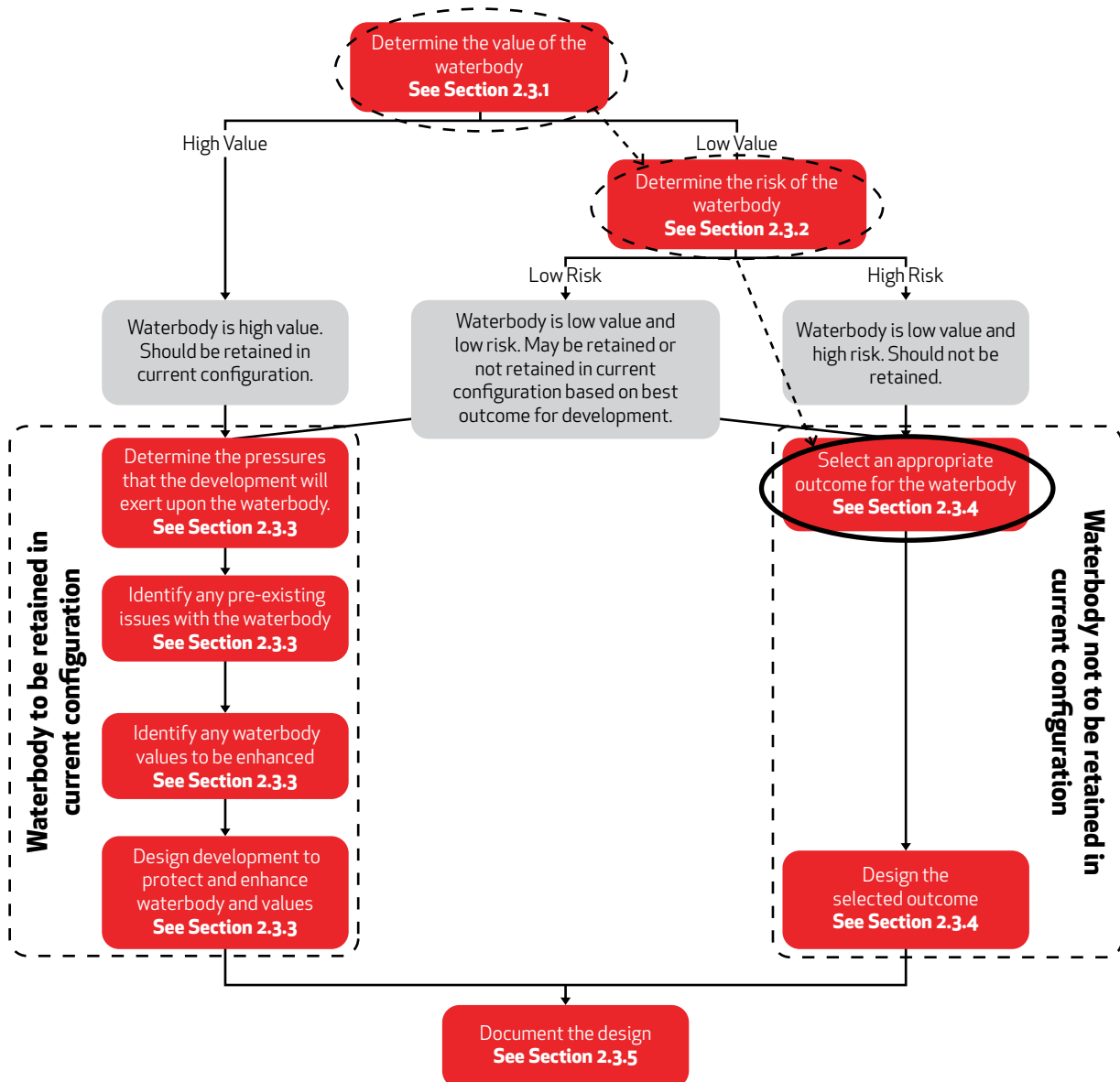
- Removing the waterbody
- Converting the waterbody to a stormwater treatment system
- Redesigning the waterbody to a high ecological value wetland (not for stormwater treatment)
- Converting the waterbody to a flood mitigation systems (e.g. a detention basin)

Removing the waterbody was deemed to be too expensive and was dismissed as an option.

Under the provisions of Sunnyside Council's planning scheme, the development was required to comply with stormwater quality objectives and flood mitigation objectives.

These requirements meant that regardless of the fate of the waterbody, a stormwater treatment system and a detention basin were planned. In order to save space, reduce cost, and comply with the requirements of the planning scheme for stormwater quality, flooding and the waterbody itself, it was decided to redesign the waterbody into a combined stormwater treatment system and detention basin.

Figure 2.10 Step 3 - Select an appropriate outcome for the waterbody



Design the selected outcome

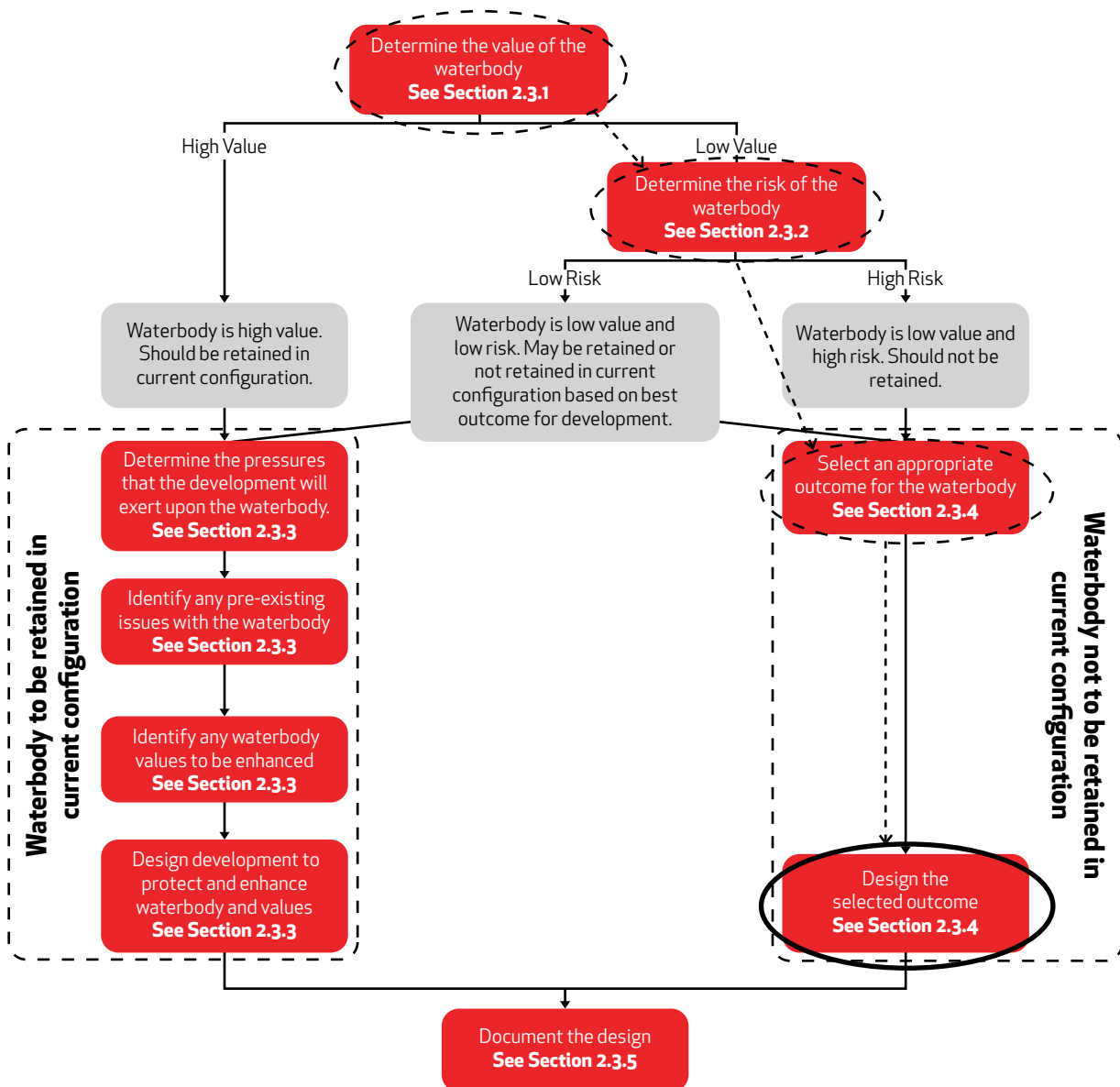
The next step for Sunnyside Council was to plan and design their selected outcome (Figure 2.11). The stormwater treatment system options considered for the development were either a bioretention system or a constructed wetland. Because of the size of the waterbody relative to the development, an appropriately sized constructed wetland could not be located within the waterbody. However, the waterbody was suitably sized to facilitate a bioretention system (which requires a smaller surface area in comparison to constructed wetlands) and also provide the flood mitigation

requirements of the development. Therefore, a combined bioretention and detention basin was selected for the site.

The design was completed in accordance with:

- *The Bioretention Technical Design Guidelines* (Water by Design, 2012a)
- *The Queensland Urban Drainage Manual* (DEWS, 2013)
- *Australian Rainfall and Runoff* (Pilgrim, 1987).

Figure 2.11 Step 4 - Design the selected outcome for the waterbody



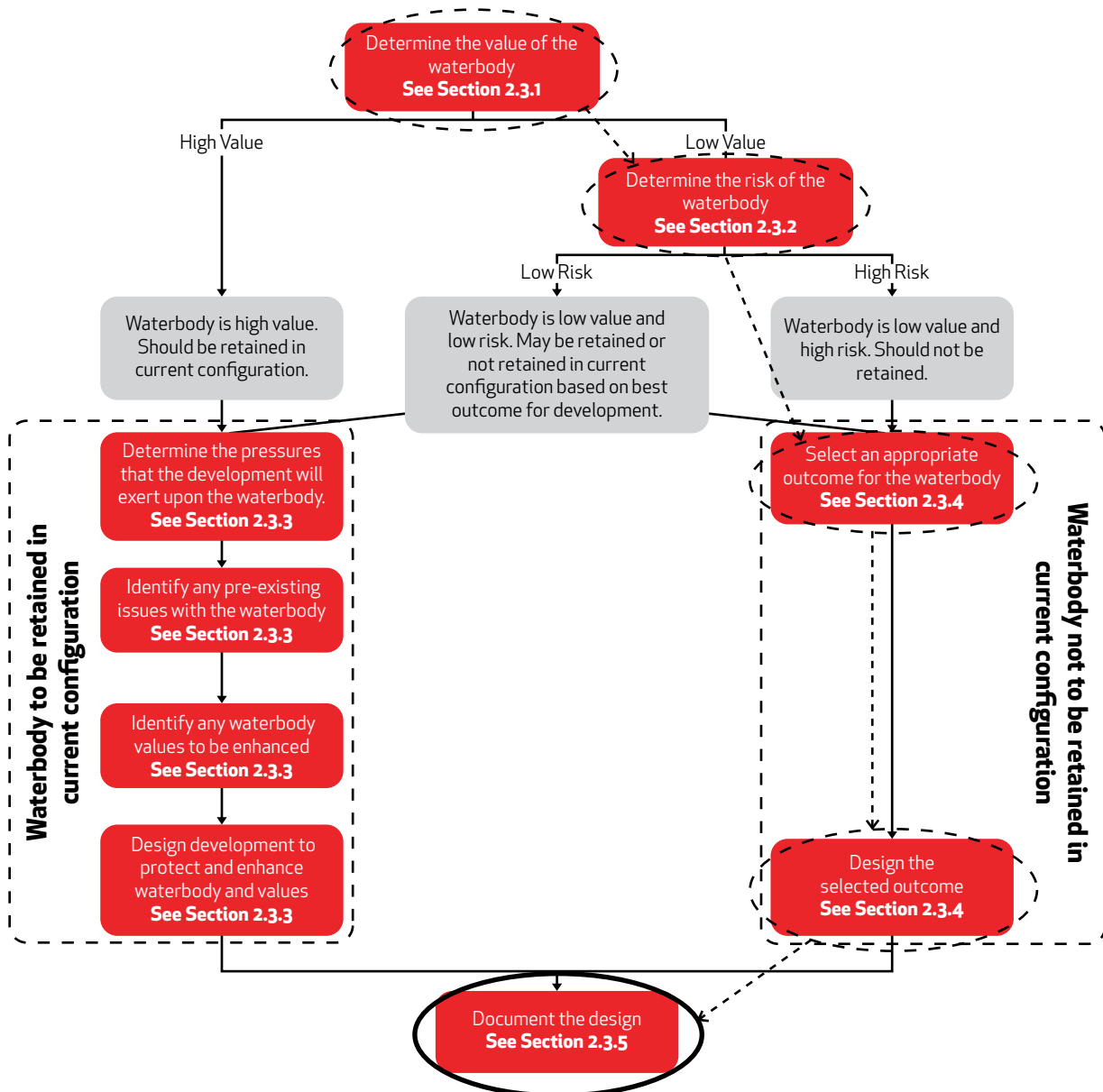
Document the design

The final step for Sunnyside Council was to document the design (Figure 2.12).

A design report and design drawings were produced for the site, including the conversion of the waterbody

into a combined bioretention and detention basin. Specifications were included on the design drawings, and provided sufficient detail for assessment by Sunnyside Council, price estimation and construction by potential contractors.

Figure 2.12 Step 5 - Document the design



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Waterbody Management Guideline

Module 3

Asset Management

VERSION 1 SEPTEMBER 2013

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Table 3.7 Sunnyside Council roles and responsibilities gap analysis
Table 3.8 Criteria and indicators for prioritisation
Table 3.9 Prioritisation of three waterbodies
Table 3.10 Results of Council's waterbody prioritisation

3.1 INTRODUCTION

3.1.1 Purpose of module 3

The purpose of this module, 'Asset Management', is to assist local government officers to apply asset management skills and techniques to local government owned waterbodies. The module helps to ensure that waterbodies are managed efficiently and effectively

to agreed standards of service. This module helps both new and experienced asset managers to manage waterbodies in a manner that is consistent with traditional asset management techniques.

3.1.2 How to use module 3

Module 3 is divided into seven key sections. Figure 3.1 describes how to use each section.

Figure 3.1 How to use module 3

Section 3.2	
Getting Started	This section contains foundational knowledge for managing waterbodies.
Section 3.3	
Identify Roles, Responsibilities and Resources	This section outlines how to ensure each waterbody management task is assigned to the most appropriate department.
Section 3.4	
Identify and Characterise Waterbodies	This section provides advice on how to identify, locate and gather data on waterbodies in a timely and efficient manner.
Section 3.5	
Manage Finances	This section provides guidance on building a business case for maintaining waterbodies and whether or not to capitalise them.
Section 3.6	
Prioritise Waterbodies	This section discusses how to balance the outcome sought with the cost of works to prioritise which waterbodies to spend resources on maintaining.
Section 3.7	
Review and Revise	This section outlines the importance of continually improving waterbody management and processes.
Section 3.8	
Worked Example	This section uses a hypothetical example to demonstrate the waterbody management processes documented in this module.

3.2 GETTING STARTED

Asset management is well established within local government for hard infrastructure such as roads. *The International Infrastructure Management Manual* (IIMM) (INGENIUM, 2011) and the *Australian Infrastructure Financial Management Guidelines* (AIFMG) (IPWEA, 2010) establish a framework for asset management that is applied by many local governments.

Applying asset management principles to waterbodies is a relatively new concept. It presents some unique management challenges. Despite this, the principles applied for other asset types can be applied and adapted for waterbodies. This module provides waterbody specific asset management advice that complements the IIMM and AIFMG.

3.2.1 Balancing effort and reward

When managing waterbodies, it is important to achieve a balance between effort and reward. To establish a comprehensive asset management framework from scratch requires a lot of effort. While the outcome at the end of this process will be very beneficial in the long term, it can be time consuming and resource intensive to get to this point. In fact, in some cases, when comprehensive asset management is the goal, the sheer scale of the task can prevent meaningful progress from being made at all.

On the other hand, when first beginning to manage waterbodies, a small targeted amount of effort in specific areas can produce significant rewards. For example, identifying for the first time all the waterbodies under the control of a local government and storing this information in a basic asset register is a simple task, but one which greatly assists in future waterbody management activities such as developing a budget for works. The benefit achieved from these early, simple projects can then be used as a catalyst for further, more time and resource intensive initiatives.

3.2.2 Procedures, guidelines and legislation

When maintaining and operating waterbodies care must be taken to comply with all relevant legislation. Users of this module should refer to their internal processes, including occupational health and safety processes, risk assessment procedures, work method statements and standard operating procedures. Maintenance should be undertaken in accordance with local, state and national legislation and guidelines.

Climate change

Climate change will impact waterbodies via more frequent and intense rainfall events, extended periods of high temperature, more intense drought, rising sea level and higher storm tides. Waterbodies are a long lived asset. The majority of waterbodies currently managed by local governments will still exist as the effects of climate change become more severe in the future. When managing waterbodies, always consider whether the management actions undertaken are appropriate in a changing climate.

A Hard Infrastructure Asset Management Perspective on Climate Change

The IIMM framework used by local government in the managing and maintaining of hard infrastructure does not consider climate change and limits the capacity of local governments to manage climate change impacts (Balston, 2012). In 2012 the National Climate Change Adaptation Research Facility published the results of a research project to develop a financial simulation model and supporting decision tools to provide a clear, comparative analysis of the financial impacts of climate change on three major asset classes of importance to Australian Local Government (Balston, 2012). While only addressing a select group of hard infrastructure assets, the report, *Quantifying the cost of climate change impacts on local government assets* (Balston, 2012) provides an insight into how climate change may be considered within traditional asset management frameworks in the future.

3.3 IDENTIFY ROLES, RESPONSIBILITIES AND RESOURCES

This section should be applied when looking to understand the roles, responsibilities and resources within a local government that are related to managing waterbodies and to streamline how activities are undertaken. How this section is applied, and to what level of detail will depend on the circumstances of the individual organisation. Some local governments may already understand how their existing corporate structure relates to managing waterbodies. In such cases, a detailed review may be unnecessary. However, most local governments will not be in this position. Small local governments may only have a limited number of staff and waterbodies. They may simply wish to improve how tasks are coordinated by facilitating regular briefing sessions with key staff from relevant departments. Large local governments responsible for managing a large number of assets within a complex corporate structure may require a more detailed assessment.

The process documented in this section provides sufficient detail for the largest and most complex of local governments, but is still simple enough to be scaled and adapted to smaller or less structurally complex local governments. The three steps of this process are:

- understanding the existing skills base (Section 3.3.1)
- identifying existing roles, responsibilities and resources (Section 3.3.2)
- identifying required roles, responsibilities and resources (Section 3.3.3)

Identifying roles, responsibilities and resources between departments, can help to ensure waterbody management is efficiently coordinated, required tasks are undertaken, budgets are identified and assigned, and duplication of effort is avoided. Identifying roles, responsibilities and resources can be carried out by either in-house staff or by contractors. Table 3.1 documents the pros and cons of each approach.

Local governments are dynamic entities

Local government's structures and roles frequently change. A review should be carried out following each major restructure to ensure that roles and/or tasks are not 'lost' within the system.

Table 3.1 Pros and cons of in-house vs. external review

Method	Pros	Cons
In-house	<ul style="list-style-type: none"> • good existing knowledge of assets, staff, structure and issues • high level of ownership. 	<ul style="list-style-type: none"> • takes people off-line • potential focus on one skill area • process may be overlooked in favour of everyday duties and never gain necessary momentum • lack of independence.
External	<ul style="list-style-type: none"> • good experience with undertaking similar work • good understanding of other local government structures for waterbody management • broad, impartial views and experience. 	<ul style="list-style-type: none"> • can be expensive • may not have full understanding of local government's key issues • limited ownership.

3.3.1 Understanding the existing skills base

Some waterbody management tasks are likely to be already addressed by asset management or operations teams, as part of their existing activities for managing other types of assets. However, budgets and resources are often not allocated specifically to managing waterbodies. This makes it difficult to determine exactly how much of each department's budget is for managing waterbodies. It can be difficult to establish overall costs (and hence budgets) for ongoing work.

It is important for each organisation to have a good understanding of what their existing skills base is, what suitable equipment for managing waterbodies is available in-house and what budgets may have been assigned for managing waterbodies.

In some cases, the existing in-house expertise will be sufficient. In other cases it may be necessary to raise awareness of the importance of the various aspects of managing waterbodies and how this can be incorporated into existing operations and maintenance regimes. Utilise in-house expertise where possible which will provide both access to valuable knowledge, and build ownership of waterbody management with internal stakeholders.

3.3.2 Identifying existing roles, responsibilities and resources

Methods to identify existing roles, responsibilities and resources for managing waterbodies may include:

- undertaking internal workshops or discussions with key staff
- developing questionnaires/task checklists
- engaging a third party to undertake a detailed review.

The level of detail will depend on what the local

government wants to achieve from the review. A review aiming to streamline activities may be as simple as determining who currently does what. A review to assist with developing a business case for appropriate funding may be more detailed.

A good way to quickly understand who does what within the organisation and what existing budgets are available is by developing a simple task checklist (Table 3.2), coupled with a questionnaire (see below example questions.) The questionnaire and task checklist should be sent to key staff and followed up with consultation to identify the responsibilities of different stakeholders for specific tasks. The task checklist should cover all phases of lifecycle, including:

- planning and policy development
- management and maintenance
- renewal and rectification.

The questionnaire and task checklist should provide enough information to gain a preliminary understanding of:

- what tasks are currently being completed at the department, team and individual levels
- how much money is currently being spent on waterbody management tasks within each department
- how much of this money is budgeted specifically for waterbody management
- how each department, team or individual determines what activities to do and when
- where any gaps or duplication may be occurring.

The information collected should be collated, reviewed and summarised. Further consultation should then be undertaken with senior staff (e.g. department heads, team leaders, directors) to see how the responses align with current practices. In particular, cross check that what staff 'think' they should be doing and what they actually should be doing is aligned.

Example questions to ask internal stakeholders

1. What triggers an inspection? (e.g. Is it part of a routine maintenance schedule? Is it generally reactive such as in response to a complaint or incident?)
2. Does your team determine what activities to undertake or does it receive direction from other groups or departments within local government?
3. What is the process to request inspection or maintenance be carried out?
4. Does your team have a written inspection and maintenance plan or strategy?
5. What human resources does your team currently have for undertaking the tasks identified in Table 3.2?

6. What equipment does your team currently have for undertaking the tasks identified in Table 3.2?
7. What is your team's overall annual budget allocation for undertaking the tasks identified in Table 3.2?
8. Do you think that you have sufficient budget and resources for undertaking the tasks identified in Table 3.2?
9. How many waterbodies does your team currently inspect or maintain?

Table 3.2 Example task checklist for waterbody management

Department: _____

Task	Is the task assigned to your department?	To what extent is the task completed?		
		Fully	Partially	Not at all
Stage: Planning for physical works and policy development				
Flood modelling and management				
Stormwater modelling and management				
Design of new waterbodies				
Modification of design for existing waterbodies (renewal/upgrade)				
Strategic assessment of waterbody condition (regional)				
Asset handover – conditions and constraints				
Research and design of best practice water sensitive urban design (WSUD) infrastructure				
Research and design of best practice waterbody design and construction				
Planning for removal of 'end-of-life' infrastructure				
Strategic assessment of waterbody management and resources (regional)				
Policy development for waterbodies				
Assessment of development related waterbody proposals				

Task	Is the task assigned to your department?	To what extent is the task completed?		
		Fully	Partially	Not at all
Construction supervision				
Preparation of a business case for capital spend				
Other (please specify)				
Stage: Ongoing maintenance and inspections				
Aquatic weed spraying				
Aquatic weed harvesting				
Aquatic macrophyte revegetation/planting				
Riparian/edge weed spraying or removal				
Riparian and edge revegetation/planting				
Mosquito monitoring and control				
Routine water quality monitoring				
Routine algal monitoring				
Reactive water quality or algal sampling (e.g. in response to complaints, spills, fish kills)				
Sediment removal or dredging within the waterbody				
Litter monitoring and removal				
Inspection and maintenance of surface gross pollutant traps				
Inspection and maintenance of underground gross pollutant traps				
Inspection and maintenance of inlet structures				
Inspection and maintenance of outlet structures				
Inspection and maintenance of amenities				
General inspection of overall waterbody condition				
Inspection and management of batter scour				
Inspection and management of pests (e.g. birds, fish)				
Inspection and management of water levels				
Other (please specify)				
Stage: Renewal and rectification				
Excavation to increase storage capacity or re-size sediment basins				
Installation of additional sediment capture infrastructure (e.g. gross pollutant traps)				
Waterbody reprofiling/re-sizing				

Task	Is the task assigned to your department?	To what extent is the task completed?		
		Fully	Partially	Not at all
Modification of existing hydraulic structure (e.g. to optimise water levels and flushing)				
Installation of new hydraulic structures (e.g. inlet and outlet structures)				
Installation of erosion protection infrastructure				
Construction of flow redirection paths				
Construction of access ramps (for weed harvesting)				
Installation of permanent fencing/vegetation to restrict access				
Installation of temporary fencing				
Installation of signage				
Excavation of adjacent areas for sediment drying/compacting				
Modification or removal of bird habitat				
Removal or culling of pests (e.g. birds, fish)				
Acid sulfate soil treatment (e.g. capping, replacement, remediation)				
Sediment treatment within the waterbody (e.g. sediment capping, aeration, recirculation)				
Installation of other water quality treatment infrastructure (e.g. floating wetlands)				
Installation of WSUD infrastructure (e.g. swales, bioretention systems, sediment basins)				
Other (please specify)				

3.3.3 Identifying required roles, responsibilities and resources

Using information gathered when identifying existing roles, responsibilities and resources for managing waterbodies (see Section 3.3.2), a gap analysis can be performed to determine which tasks are:

- assigned and being completed
- assigned but only partially completed
- assigned but not completed
- not assigned and not being completed.

The information gathered will also help to determine where there are gaps in funding, equipment and resources.

An example of a gap analysis matrix is provided in Table 3.3.

The outcomes of the gap analysis should be discussed with key local government representatives in order to identify a more efficient and streamlined process for managing waterbodies. This will ensure that:

- all tasks are appropriately assigned and completed
- all roles and responsibilities are clearly defined

- appropriate levels of funding and resources are allocated
- inefficiencies, such as duplication of tasks are avoided.

Who should be responsible for managing waterbodies?

One of the common problems encountered by local governments with managing waterbodies is unclear responsibilities. For example, one department may be responsible for managing hydrology and hydraulics within a waterbody, while another may be responsible for vegetation, when really both tasks are interrelated. There is merit in allocating the responsibilities and resources to manage all aspects of waterbodies to a single department. This one department should be responsible for ensuring the wellbeing of the waterbody as a whole, and where appropriate, sub-contract specific tasks to other departments.

Table 3.3 Example matrix showing outcomes of a gap analysis

Task	Department					
	Strategic Planning	Development Services	Engineering	Asset Management	Environmental Planning	Environmental Health
Stage: Planning for physical works and policy development						
Flood modelling and management						
Stormwater modelling and management						
Design of new waterbodies						
Modification of design for existing waterbodies (renewal/upgrade)						
Strategic assessment of waterbody condition (regional)						
Asset handover – conditions and constraints						
Research and design of best practice water sensitive urban design (WSUD) infrastructure						

Task	Department					
	Strategic Planning	Development Services	Engineering	Asset Management	Environmental Planning	Environmental Health
Research and design of best practice waterbody design and construction		Yellow				
Planning for removal of 'end-of-life' infrastructure			Green	Orange		
Strategic assessment of waterbody management and resources (regional)			Green			
Policy development for waterbodies	Yellow					
Assessment of development related waterbody proposals		Green	Green			
Construction supervision		Green	Green			
Preparation of a business case for capital spend			Yellow	Orange		
Stage: Ongoing maintenance and inspections						
Aquatic weed spraying						Green
Aquatic weed harvesting						Green
Aquatic macrophyte revegetation/planting						
Riparian/edge weed spraying or removal				Orange		
Riparian and edge revegetation/planting				Orange		
Mosquito monitoring and control						Green
Routine water quality monitoring			Yellow			
Routine algal monitoring			Yellow			
Reactive water quality or algal sampling (e.g. in response to complaints, spills, fish kills)			Yellow			
Sediment removal or dredging within the waterbody				Orange		
Litter monitoring and removal				Yellow		
Inspection and maintenance of surface gross pollutant traps				Yellow		
Inspection and maintenance of underground gross pollutant traps				Yellow		
Inspection and maintenance of inlet structures				Orange		
Inspection and maintenance of outlet structures				Orange		
Inspection and maintenance of amenities				Yellow		
General inspection of overall waterbody condition			Yellow			

Task	Department					
	Strategic Planning	Development Services	Engineering	Asset Management	Environmental Planning	Environmental Health
Inspection and management of batter scour						
Inspection and management of pests (e.g. birds, fish)						
Inspection and management of water levels						
Stage: Renewal and rectification						
Excavation to increase storage capacity or re-size sediment basins						
Installation of additional sediment capture infrastructure (e.g. gross pollutant traps)						
Waterbody reprofiling/re-sizing						
Modification of existing hydraulic structure (e.g. to optimise water levels and flushing)						
Installation of new hydraulic structures (e.g. inlet and outlet structures)						
Installation of erosion protection infrastructure						
Construction of flow redirection paths						
Construction of access ramps (for weed harvesting)						
Installation of permanent fencing/vegetation to restrict access						
Installation of temporary fencing						
Installation of signage						
Excavation of adjacent areas for sediment drying/compacting						
Modification or removal of bird habitat						
Removal or culling of pests (e.g. birds, fish)						
Acid sulfate soil treatment (e.g. capping, replacement, remediation)						
Sediment treatment within the waterbody (e.g. sediment capping, aeration, recirculation)						
Installation of other water quality treatment infrastructure (e.g. floating wetlands)						
Installation of WSUD infrastructure (e.g. swales, bioretention systems, sediment basins)						

3.4 IDENTIFY AND ASSESS WATERBODIES

3.4.1 Waterbody Asset Register

A waterbody asset register is a list or database that stores information on all the waterbodies in a local government area. It may be a standalone database or part of a broader wetland or water asset database. An asset register assists local government to effectively and cost efficiently manage local government owned waterbodies. It does this by documenting the number, location and characteristics of the waterbodies to be managed.

An asset register provides local government with the following benefits:

- Easy capture of data for future use.
- Quick and easy access to information on waterbodies.
- Informed planning and budgeting for maintaining and rectifying waterbodies.
- Streamlined, efficient and effective waterbody management.

The following sections provide guidance on how to establish a register of waterbody assets, including:

- information to be included in the waterbody asset register
- the form of the asset register
- populating the asset register
- maintaining the asset register.

3.4.2 Information to be included in the waterbody asset register

To create a waterbody asset register, first identify what information should be included. A broad range of data and information can be included on a waterbody asset register. The asset register should provide enough information to understand the key characteristics and condition of the waterbody.

The types of information that can be included on the waterbody asset register are listed in Table 3.4.

Individual local governments can determine what information to include on their register according to their existing asset management structure and waterbody management objectives.

Creating an asset register can be staged. Basic information can initially be collected on all waterbodies. More detailed information can be collected and added later.

Public vs. private waterbodies

Local governments have the option of capturing information on both the waterbodies that they are responsible for maintaining (public waterbodies) and those that are privately owned. Before creating a waterbody asset register, check with other departments regarding their needs. Other departments may be willing to share the workload of developing the asset register if it satisfies their needs. Different information may need to be collected for public and private assets.

Table 3.4 Types of information that could be included in a waterbody asset register

Category	Example of information to include	Source/s
Waterbody identifier	Unique identification (ID) code for each waterbody. This code becomes the link for all databases	Manually created, automated in Geographic Information System (GIS)
Waterbody name	Waterbody name, wetland name, park name or street name	Manually created and applied using combination of GIS, Nearmap, Google maps and street directory, WetlandMaps
Location	Street address Lot and plan numbers Grid reference	GIS (cadastre)
Catchment/basin	Catchment and sub-catchment name Catchment and sub-catchment area	GIS (catchment boundaries)
Connectivity	Waterbody isolated, within a riverine system, within a floodplain	GIS, field verification, Nearmap, Google maps, WetlandMaps
Waterbody fringe area	Riparian zone, surrounding wetland zone	GIS, development approvals, as-constructed drawings, field verification, Nearmap, Google maps, WetlandMaps
Waterbody formation	Artificial, modified from natural - farm dam, ornamental lake, stormwater treatment wetland etc.	GIS, development approvals, as-constructed drawings, field verification, Nearmap, Google maps, WetlandMaps
Current use	Farm dam, ornamental lake, stormwater treatment wetland etc.	GIS, development approvals, as-constructed drawings, field verification, Nearmap, Google maps, WetlandMaps
Responsibility	Local government division, local government team	GIS
Sewerage	Sewered, un-sewered, combination within catchment	GIS
Age	0-5 years, 6-10 years, 11-20 years, >20 years	GIS, development approvals, as-constructed drawings, field verification, Nearmap, Google maps, WetlandMaps
Waterbody size	Waterbody surface area, waterbody 'system' surface area, depth, volume etc.	GIS (surface area and volume), field assessment to determine depth
General description	General description of the waterbody and surrounds, including key issues, aesthetic values, location, size, amenity values and proximity to landuses	GIS, Nearmap, Google maps, field assessment, consultation, WetlandMaps
Waterbody physical features	Presence of islands, shape, structures etc.	GIS (aerial photographs, Digital Elevation Map, drainage, stormwater), Nearmap, Google maps, field assessment
Park category features	Service levels Local, district, region etc.	GIS (parks layer or hierarchy)

Category	Example of information to include	Source/s
Water type –Salinity, temperature and pH	Fresh, brackish, saline Tidal – yes or no pH – alkaline or acidic	GIS, field assessment
Water quality	In situ data (turbidity, dissolved oxygen) Nutrients (total phosphorus, filtered reactive phosphorus, total nitrogen, ammonia, nitrogen oxides) Microbial (<i>Escherichia coli</i> , intestinal enterococci)	Historical datasets or monitoring, field assessment, consultation
Waterbody floor	Mud, sand, rock, cobble	Substrate classifications
General field observations	Rainfall, wind, cloud cover, debris, odours, suspended matter, algae, water column/ substrate, gross pollutants, surface scums, sediment accumulation	Historical datasets or monitoring, field assessment
Hydraulic function	Location and condition of inlets and outlets, description of inlets or outlets, flooding, regular overtopping, persistent high/low water levels, erosion/scour	GIS (stormwater, WSUD, drainage), field assessment, consultation
Aquatic habitats	Structure and condition of aquatic macrophytes, % cover, % native or exotic, % floating, emergent, submerged, exotic species present (weeds/fauna), presence of snags, overhang, shading etc.	Field assessment, maintenance schedules, management plans, consultation
Riparian/wetland habitats	Structure and condition of the surrounding riparian/wetland vegetation, % cover, % native or exotic, % floating, continuity, exotic species present (weeds/fauna), connectivity/corridor etc.	Field assessment, maintenance schedules, management plans, master plan, consultation
Safety	Batter slopes (above and below water level), presence and condition of fencing and barriers	Field assessment, management plans, master plan, as-constructed drawings, consultation
Profile/amenity	Proximity to residential/commercial areas, amenity provisions (seating, pathways, barbecues, playgrounds etc.), aesthetic values/issues, recreational usage etc.	GIS (landuse, proximity), field assessment, consultation
Maintenance data	Maintenance undertaken, resources used, who undertook works	Maintenance schedules and reports, contracts and invoices
Asset management plans	Links to asset management plan for individual asset	Asset management plans
Cost	Direct and indirect costs of managing waterbody	Maintenance schedules and report, contracts and invoices
Public feedback	Public feedback (both positive and negative) received regarding waterbody	Email, phone call, on-site discussions

Note: the above list is not exhaustive. Each local government should determine what information they have available and whether or not it is suitable to include on the asset register.

3.4.3 The form of an asset register

The form of a waterbody asset register depends on how advanced the organisation is in managing its assets (both waterbodies and otherwise) and how the asset register will be used.

Table 3.5 describes three common forms of asset register. When deciding what form of asset register to use, consider who will use it and what it will be used for. A local government developing a waterbody asset

register is likely to already have asset registers for other types of assets. The custodians of these other asset registers will have useful information to contribute to the waterbody asset register. They should be both consulted and actively engaged in the process. Doing so will promote consistency across the organisation and avoid time consuming alterations to the waterbody asset register in the future to bring it in line with other asset registers.

Table 3.5 Common forms of asset registers

Type	Description/Use	Positives	Negatives
Spreadsheet based	Spreadsheet based registers may be useful when first establishing a waterbody asset register because they are simple. However, they will not provide the long term functionality required to comprehensively manage waterbodies.	<ul style="list-style-type: none"> • simple to establish • inexpensive • easy to operate. 	<ul style="list-style-type: none"> • low functionality.
GIS based	GIS based registers build on the functionality of an excel spreadsheet, add a visual user interface and allow assets to be spatially located.	<ul style="list-style-type: none"> • moderate functionality • visual user interface • allows assets to be spatially located. 	<ul style="list-style-type: none"> • moderate level of skill to operate • moderate time and cost to establish.
Combined GIS and asset management software	Asset registers using linked GIS and asset management software (e.g. Maximo) combine the functionality of a GIS system with the ability to plan for, schedule and undertake maintenance, complete financial planning and easily record the condition of assets.	<ul style="list-style-type: none"> • high functionality • visual user interface • allows assets to be spatially located. 	<ul style="list-style-type: none"> • moderate level of skill to operate • high time and cost to establish.

3.4.4 Populating the asset register

Locating and mapping waterbodies

Most local governments will already have a considerable amount of information about their waterbodies such as local knowledge, routine maintenance schedules, pest management plans, water quality monitoring programs, geographic information system (GIS) layers and public complaints. Prior to creating a waterbody asset register, this information is likely to be in an ad-hoc form and managed by several departments, each dealing with its own set of issues and responsibilities.

Locating waterbodies for an asset register is simple. The vast majority of waterbodies will be located easily. A variety of sources of information should be consulted to ensure that all waterbodies are located.

Initial information can be gathered rapidly by undertaking a desktop review. The common sources of information available for the desktop review include:

- existing GIS layers, such as:
 - aerial photographs
 - contours or digital elevation model
 - waterways, waterbodies and riparian zones
 - cadastre (including landuse and zoning)
 - catchment boundaries
 - local government boundaries
 - parks and open space and natural areas designations

- environmentally relevant activities
- conservation areas
- conservation assessments
- state government waterways and wetlands maps
- regional ecosystems
- drainage, sewer and stormwater infrastructure
- flood maps
- Queensland wetlands mapping.
- Nearmap and Google Earth
- WetlandMaps
- Queensland's Groundwater Dependent Ecosystems (GDEs) mapping
- street directories
- as-constructed drawings
- existing master plans, management plans or concept plans
- existing flood models and reports.

From this initial review, a preliminary inventory of waterbodies can be established, along with basic information concerning each waterbody, such as:

- waterbody name and unique ID code
- location
- catchment and sub-catchment name
- local government division
- surface area
- surrounding landuse
- park category.

Data standards

The quality of data recorded in an asset register greatly influences its usefulness in future applications, but also the time and effort required to collect it. In deciding what standard of data to collect, consider:

- who is the end user of the data
- what the data will be used for
- the level of service intended to be provided to the asset
- the effort required to collect the data.

Assessing Waterbodies

Once the initial waterbody asset register has been developed, the local government may wish to assess their waterbodies further using a range of physical, ecological and social indicators. This step should involve a combination of **consultation** and **groundtruthing**.

Certain waterbody characteristics can only be assessed by consultation and groundtruthing. For example:

- condition and structure of aquatic and riparian/wetland habitats
- condition and function of hydraulic structures
- level of coarse and fine sediment accumulation
- presence of exotic or pest species
- aesthetic issues and values
- safety issues
- water quality and salinity levels
- potential localised contaminant sources.

Consultation

Local government officers who have in-house experience with the various aspects of managing waterbodies should be consulted early in the process. They can provide a wealth of local knowledge and experience. It will also help these officers take ownership of and contribute to the overall waterbody management process.

A good method of engaging with local government officers is to conduct an internal stakeholder workshop to:

- present the initial waterbody inventory
- discuss the key issues and values associated with waterbodies
- discuss possible approaches for further characterisation of the waterbodies.

The feedback gained from the workshop can:

- assist with identifying additional sources of data
- provide information on local government's overall issues and values associated with waterbodies
- provide information on specific waterbodies (e.g. historical water quality issues, fish kills, weed problems, algal blooms, profile and usage).

The workshop can also help to identify waterbodies with a range of issues, conditions and values for further field assessment and verification.

Groundtruthing

When assessing waterbodies in the field, it is important to consider what level of detail will provide the most information in an efficient, repeatable and cost effective manner. The field assessment should focus on local government's key issues and values (as determined from the stakeholder workshop and consultation). This can be achieved in several ways such as:

- undertaking a rapid assessment of all waterbodies
- undertaking more detailed assessments and/or monitoring of high priority waterbodies (as determined by the prioritisation process in Section 3.6)
- assessing waterbodies that are 'representative' of a range of classes, issues and values.

Efficiency can be increased by digitally recording as much information as possible in the field (e.g. using personal data assistants).

Maintaining a 'single point of truth'

Many departments within an organisation will be involved with managing waterbodies. Each department will have different requirements from the asset register in terms of usability, data captured and frequency of update. In situations where an asset register does not satisfy all stakeholders' needs, it may be tempting to create duplicate registers to serve different needs. However, doing so will create inconsistencies between registers (particularly if regularly updated) and lead to time consuming attempts to reconcile registers in the future. The waterbody asset register should therefore be maintained within the organisational asset system as a 'single point of truth'.

3.4.5 Maintaining the asset register

Once a waterbody asset register is established, it must be regularly maintained to ensure it continues to provide accurate and up to date information. Maintain the asset register to ensure that:

- the right information is being collected
- information on existing assets remains up to date
- information on decommissioned assets is removed
- all new assets are incorporated into the register in a timely manner.

Local governments will typically already have one or more staff whose role it is to maintain registers for other asset types. Consider either:

- assigning the role of maintaining the waterbody asset register to that person
- creating a new, similar position responsible for maintaining the waterbody asset register.

In many cases, it will be most efficient to assign the task of maintaining the waterbody asset register to an officer who is already completing this task for other similar asset types such as stormwater drainage. The waterbody asset register will be an additional demand on their time, and thus the person must be resourced to undertake the task.

3.5 MANAGE FINANCES

Managing and maintaining waterbodies costs money. The goals of managing waterbody finances are to ensure that:

- appropriate funding is available to manage and maintain waterbodies
- the local government remains financially viable in the long term.

This requires a good understanding of the cost of undertaking works (Section 3.5.1), how to make a case for funding (Section 3.5.2) and how financial asset management occurs in local government (Section 3.5.3).

3.5.1 Understanding costs

Understanding the cost of maintaining waterbodies assists in preparing budgets and ensures that resources are efficiently used. However, reliable data on the cost of managing waterbodies is hard to find. This is mainly because:

- local governments use different methods to maintain waterbodies and hence the cost of works varies
- waterbodies vary in condition and hence the cost of achieving the same outcome will vary even when the same maintenance techniques are applied
- waterbodies are maintained to different levels of service and different amounts of money will be required depending on the level of service
- money spent managing waterbodies is often not tracked against individual assets, and thus there is a lack of data to perform a detailed costs analysis.

The cost of proactive vs. reactive maintenance

Proactive maintenance is undertaking maintenance to a regular schedule. Proactive maintenance occurs more frequently compared to reactive maintenance and is comprised of simple, quick and easily achieved tasks. Reactive maintenance is undertaking maintenance in response to a major adverse event (e.g. a fish kill) and associated negative publicity (e.g. public complaints or media coverage). Reactive maintenance is less frequent but when it is required, more complex, time consuming and costly compared to proactive maintenance. Proactive maintenance is cheaper than reactive maintenance. Experience from multiple local governments has shown that when an adverse event (e.g. a fish kill) occurs in a waterbody, the cost of cleanup can extend into the hundreds of thousands of dollars and may still not prevent the problem from reoccurring. Undertaking simple, proactive maintenance can extend the usable life of waterbodies, prevent adverse events

from occurring as well as avoid the cost of clearing up and thus save costs compared to reactive maintenance. This is despite the fact that proactive maintenance incurs a regular, but small, cost.

Learning more about the cost of managing waterbodies

It is important to collect data on all works undertaken to all waterbodies and collect and store the data in the waterbody asset register. Attribute the data to a specific task (e.g. weeding) performed on a specific waterbody. Over time the data collected will increase understanding on the cost of managing waterbodies.

Similarly, testing different maintenance regimes and collecting data on each helps assess the efficiency of works. This can be achieved by establishing several case study waterbodies of a similar character and condition, and undertaking different maintenance regimes to determine the relative strengths and weaknesses of each.

3.5.2 Business case

In order to manage waterbodies efficiently and effectively, an appropriate budget is required. Without an appropriate budget, necessary works cannot be performed and the condition of waterbodies will deteriorate leading to an adverse event. Adverse events are costly to rectify, and can divert funds away from other important maintenance tasks (both waterbody related and otherwise).

A business case is a tool for obtaining appropriate funding to manage and maintain waterbodies. A business case is a document or presentation that captures the financial rationale for providing adequate funding for proactive maintenance of a waterbody. The level of detail provided in a business case depends on the amount of information required by stakeholders.

The business case must weigh up the benefits and costs to all stakeholders of various options for managing waterbodies to meet community expectations (including a 'business as usual' and 'do nothing' approach). It must consider the target audience (in this case the councillors, executive officers, managers and program leaders who contribute to budget decisions) and respond to their needs such as financial responsibility, value for money and accountability.

In the case of waterbodies, the aim is to achieve an appropriate level of funding to maintain waterbodies to a certain level of service. The business case should therefore weigh up the potential financial benefits of proactive approaches to waterbody maintenance

against other options and identify how this cost saving will benefit the organisation. A business case should focus on the economic benefits that an appropriate maintenance budget can provide.

Because the business case will weigh up various maintenance regimes, with money spent at different times throughout the lifecycle of the asset, it must account for inflation and the relative value of money over time. Undertaking a net present value analysis is a simple method of doing this.

3.5.3 Capitalising assets

Capitalisation is a technique used in accounting to help understand whether an organisation can remain financially sustainable in the future. Assets with a long life and variable expenditure during their life should be capitalised. For example, a road has a high construction cost, comparatively low maintenance cost (e.g. street sweeping, repairing pot holes) and periodic high expenditure (e.g. resurfacing the road). Capitalisation enables the organisation to take a lifecycle view of the asset's costs and plan for future expenditure.

A common misconception is that capitalisation is a tool for securing funding for maintaining assets. This is not its purpose and it will not deliver this. A business case is the appropriate tool to secure funding for maintaining assets.

Waterbodies present a financial risk to local governments when they are not appropriately considered in financial forecasts. Therefore, it is beneficial for local governments to capitalise them. Waterbodies share many of the properties of other long life infrastructures and it is therefore technically possible to capitalise waterbodies. At present, the Australian accounting standards, which govern how local governments undertake accounting, are not conducive to capitalising waterbodies or other green assets. Therefore, while it is desirable for local governments to capitalise waterbodies, it is currently very difficult to do so. Despite this, local governments should investigate how to capitalise waterbodies as it is in their overall financial interest to do so.

For further information on capitalising assets see the:

- *Australian Infrastructure Financial Management Guidelines* (IPWEA, 2010)
- *International Infrastructure Management Manual* (INGENIUM, 2011)
- *Australian Accounting Standards Board Standards for Asset Management* (ANAO, 2010).

3.6 PRIORITISE WATERBODIES

3.6.1 Developing a process to prioritise waterbodies

Waterbodies vary widely in size, condition, value and catchment pressures. Some waterbodies can be very challenging to manage. Budgets may be insufficient to permit all waterbodies to be managed to a desirable standard. In the context of waterbody management, a prioritisation process can be defined as 'a process for ranking the importance or priority for managing waterbodies according to an agreed set of criteria'. Prioritising waterbodies will ensure that work is undertaken in the most efficient manner possible. Prioritisation can be undertaken at the 'regional' level (e.g. ranking waterbodies according to priority) or at the 'waterbody' level (e.g. ranking key issues and values of individual waterbodies). This section only deals with prioritisation at the regional level. Module 4 'Maintenance and Operations' provides guidance on identifying waterbody issues and taking action at the waterbody level.

Whether a local government should embark on a detailed prioritisation process will depend on several factors, including the:

- size and population of the local government area
- number of waterbodies to be managed
- existing level of knowledge of waterbody issues and values.

Small local governments may only have a limited number of staff and a minimal number of waterbodies to manage. In such cases, a dedicated process to prioritise waterbody assets may not be required, or may be a simple matter of consulting with key staff to determine and document the priority waterbodies, issues and management tasks.

Establishing a method to prioritise waterbodies becomes more crucial for larger local governments that are responsible for managing a large number of assets.

Processes for prioritising waterbodies can take many forms. Queensland government has developed an [assessment toolbox](#) which provides summaries of the various prioritisation methods available. It is important to choose an assessment tool to best fit your organisation. This section outlines a generic assessment process which can be adapted according to local needs. The process presented here focuses on three key steps:

- GIS analysis (Section 3.6.2)
- consultation and groundtruthing (Section 3.6.3)
- scoring systems (Section 3.6.4).

3.6.2 GIS analysis

The first step of incorporating GIS analysis into a prioritisation process is to review the datasets available. This may require some level of data screening or validation to ensure that the datasets are complete and/or suitable for use in the prioritisation process. Once a list of suitable GIS layers has been identified, local government stakeholders should be consulted to identify the levels of GIS analysis that will align with local government's key issues, values and priorities concerning waterbodies.

Some examples of the criteria that could be used within a prioritisation process are provided in Table 3.6. It should be noted that these examples incorporate a combination of data sources, including GIS, field assessment and consultation. Each local government will need to adapt the prioritisation process and choose appropriate criteria according to their individual issues, values, risks, data availability and priorities.

Think outside the box

When selecting criteria for use in a GIS prioritisation process, try to think about how this information could be used as a surrogate for ranking a criterion. Examples include:

- in the absence of water quality data, landuse (or proximity to environmentally relevant activities) could be used to represent water quality
- in the absence of data on visitation rates or detailed field records, landuse proximity and waterbody size could be used as a representation of profile within the community.

Tools should be flexible

Any GIS tool that is developed should provide flexibility to be updated as more information becomes available. This will ensure that the most up to date information is stored within local government's waterbody asset register.

Table 3.6 Examples of criteria for use in a prioritisation process

Criteria	Indicators	Data Source/s
Water quality	Proximity of waterbody in relation to environmentally relevant activities Proportion of different landuses within waterbody catchment Modelled nutrient or suspended sediment generation rates Ratio catchment area : volume Comparison to Ecosystem Health Monitoring Program (EHMP) water quality classes Historical water quality issues or complaints	Water quality monitoring Water quality modelling Landuse, zoning Environmentally relevant activities Field assessment Consultation
Environmental risk	Proximity of waterbody to important wetlands, fisheries habitat etc.	Environmental risk layers or calculators Landuse, zoning Water quality modelling Purpose or function Field assessment Consultation
Community expectations	Historical issues or complaints Social impact scores or risk ratings	Social impact risk layers or calculators Field assessment Consultation
Hazard reduction	Field assessment of potential safety or environmental hazards Proximity to potential catchment hazards (e.g. high risk environmentally relevant activities)	Hazard risk assessment calculators Field assessment Landuse, zoning Environmentally relevant activities
Biodiversity	Proximity to protected areas, wetlands, koala protection areas etc. Proximity to conservation areas Potential for habitat enhancement (e.g. connectivity) Conservation (environmental) inventory scores	Regional ecosystems Koala habitat Conservation or environmental classifications State government wetland mapping
Profile/ services/ service levels	Proximity of waterbody in relation to residential or commercial areas and parkland or open space Actual vs. desired service levels Levels of visitation Class vs. condition	Landuse, zoning Parks hierarchy Park category (local, district, region) Size (surface area) Visitation rates
Cost to manage	The cost to manage waterbodies to a pre-determined level of service	Parks hierarchy Desired levels of service

3.6.3 Consultation and groundtruthing

GIS analysis is a good way of quickly prioritising a large number of waterbodies, based on a set of agreed criteria. However, there are many issues that cannot be picked up by GIS analysis (e.g. the presence of declared weeds). Therefore a simple desktop assessment should never be undertaken in isolation. Similarly, if groundtruthing and consultation are completed without a GIS component potential issues associated with location will be missed. A combined approach of desktop assessment, groundtruthing and consultation is necessary.

Stakeholder consultation will allow any issues that have not been picked up during the GIS process to be identified and discussed, based on local knowledge and expertise. This could be achieved in a stakeholder workshop or by documenting the outcomes and requesting written or verbal feedback. Groundtruthing should focus on assessing several waterbodies that are representative of a range of issues and values. The outcomes of the groundtruthing and consultation process should be compared to the findings of the GIS prioritisation and the database updated accordingly.

3.6.4 Scoring systems

Two examples of scoring methods to prioritise waterbodies are provided below. These examples are provided to illustrate how a scoring system could be devised. Many scoring systems exist and the methodology chosen should reflect the needs, data and priorities of the local government.

Option 1: Scoring based on priority criteria

(amended from DesignFlow, 2012 and Limnologic, 2012)

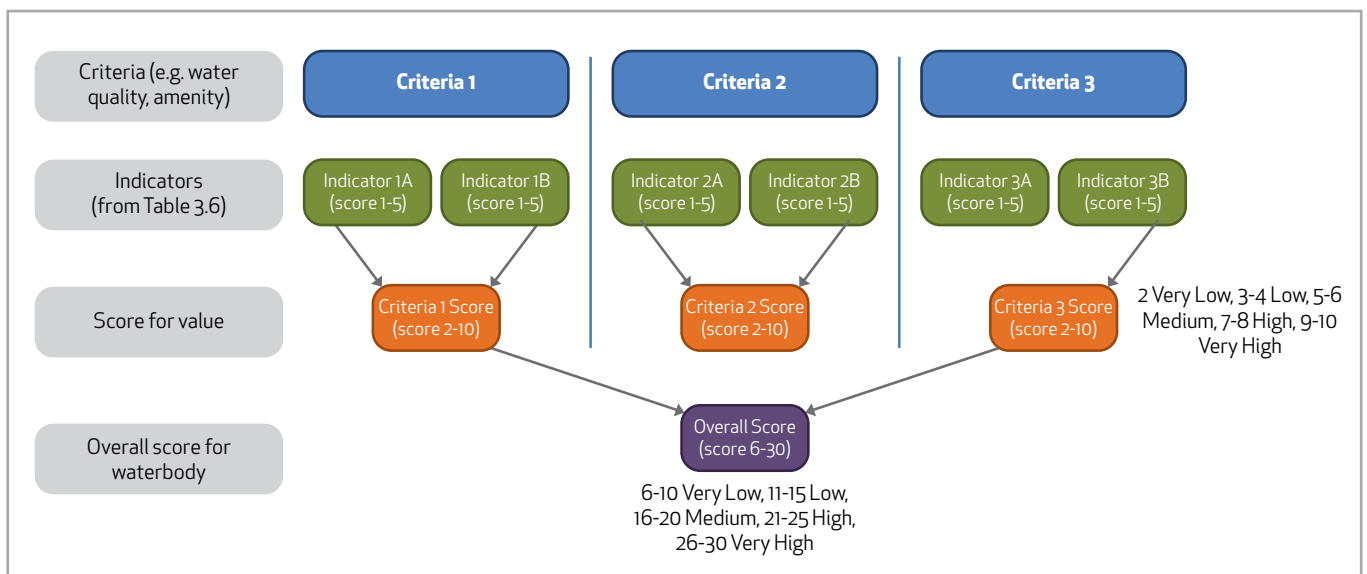
- Step 1 - Select appropriate criteria (Table 3.6 provides some examples) that will inform the prioritisation based on the local government's issues, priorities, values and available data.
- Step 2 - For each criterion, select several indicators (green in Figure 3.2) on which to rank the criteria.
- Step 3 - Give each indicator a score from 1 to 5 (5 being most valued) for each waterbody based on how well the waterbody performs at that indicator.
- Step 4 - Sum each indicator score within each criterion to give a score for those criteria from 2 to 10 (orange in Figure 3.2).

- Step 5 - Combine the criterion scores obtained in Step 4 to give an overall score from 6 to 30 for the waterbody (purple in Figure 3.2)
- Step 6 - Each criteria score and the overall score can then be ranked qualitatively (e.g. an overall score of 6 to 10 may be a very low priority, 11 to 15 a low priority and so on).

Once completed for each waterbody, the waterbodies are prioritised according to the chosen criteria.

In this option, a weighting could be applied to each criteria to reflect those which are more or less important.

Figure 3.2 Scoring of waterbodies based on priority criteria



Option 2: Scoring based on value for money

The purpose of this method is to prioritise waterbodies on the basis of the value for money that maintenance provides. This ensures that funds are spent where they are most effective at preventing the condition of waterbodies declining. This method is based upon the following principles:

1. without maintenance waterbodies will decline in condition
2. funding for maintaining waterbodies is limited
3. as a waterbody declines in condition, the cost of maintaining/rectifying the waterbody increases (Overview, Figure 0.1)

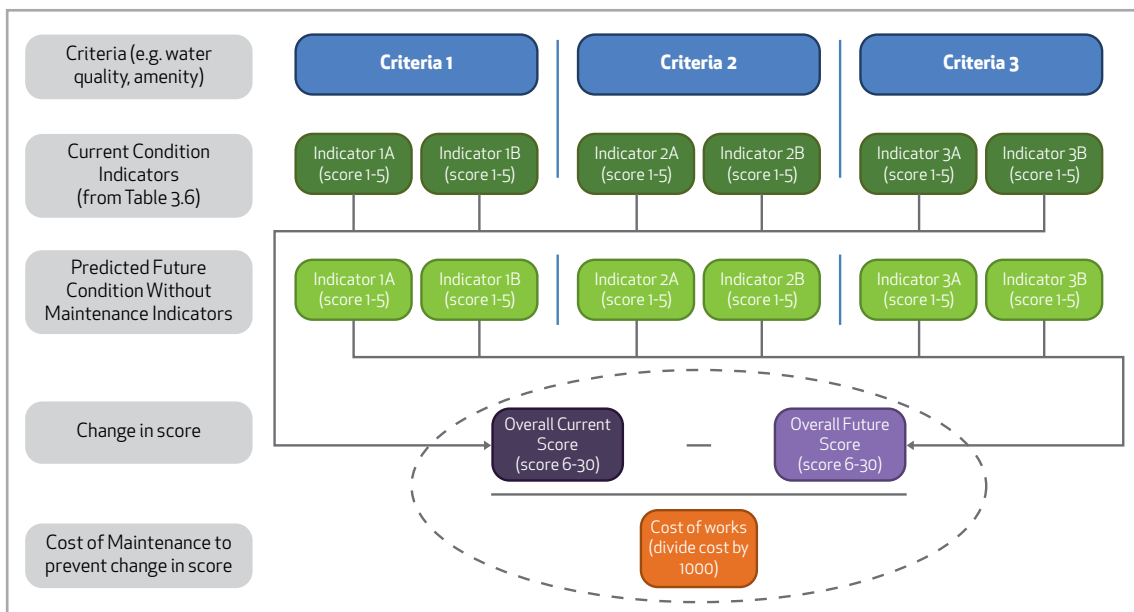
This method allows waterbodies of a distinct character and maintenance regime to be compared. For example, the scoring system can compare spending large amounts of money rectifying a very poor condition but high profile waterbody to spending a much smaller amount of money to maintain several other high profile waterbodies in their existing condition.

- Step 1 - Select appropriate criteria (Table 3.6 provides some examples) that will inform the prioritisation based on the local government's issues, priorities, values and available data.
- Step 2 - For each criterion, select several indicators (dark green in Figure 3.3) on which to rank the criteria.
- Step 3 - Give each indicator a score from 1 to 5 (5 being most valued) for each waterbody. Base this on how well the waterbody performed in that indicator.

- Step 4 - Sum each indicator score to give an overall score from 6 to 30 for the waterbody (dark purple in Figure 3.3).
- Step 5 - Estimate the likely condition of the waterbody in 12 months time without maintenance. Repeat Steps 3 and 4, and score each indicator based on the predicted condition of that indicator in 12 months time with no maintenance undertaken on the waterbody (light green in Figure 3.3). Then sum the likely indicator scores to calculate the likely future unmaintained score (light purple in Figure 3.3).
- Step 6 - Subtract the likely future unmaintained score (light purple in Figure 3.3) from the current score (dark purple in Figure 3.3).
- Step 7 - Estimate the cost to maintain the waterbody for 12 months (orange in Figure 3.3) and divide the cost by 1000 (e.g. 12 month maintenance cost is \$50,000 therefore the value in the orange box is 50)
- Step 8 - Divide the figure obtained in Step 6 by the value obtained in Step 7. The result is a waterbody value score which can be used to compare values.
- Step 9 - Repeat Steps 3 to 8 for each waterbody (and possibly for different maintenance scenarios within a single waterbody)
- Step 10 - Compile the waterbody value scores and rank from highest value to lowest value.

This provides a list of waterbodies in order of priority based on value for money.

Figure 3.3 Value for money based scoring of waterbodies



3.7 REVIEW AND REVISE

The waterbody management needs of local government change over time. Even the best planned asset management structure may develop faults (e.g. inaccurate data). It is therefore important to continually review and revise waterbody asset management procedures. How this review is undertaken will vary depending on which aspect of waterbody management is to be reviewed. For example, if reviewing roles, responsibilities and resources, a simple survey may

suffice, whereas if checking the accuracy of the asset register a random set of data may be audited to check its accuracy.

Regardless of the methods applied, reviewing and revising waterbody management processes will help the local government to efficiently and effectively manage its waterbodies, and respond to changing organisational environments and requirements for managing waterbodies.

3.8 WORKED EXAMPLE

This worked example demonstrates how a hypothetical local government may go about managing their waterbodies in a coordinated fashion.

3.8.1 Setting

Sunnyside Council is a small to medium sized local government in South East Queensland. It contains several creek systems and one river. The lower reaches of these catchments are typically urban. The upstream reaches are a combination of rural, forest and conservation. There are a large number of waterbodies in Sunnyside Council. Approximately 70% are on private land, with the remaining 30% on Council land.

Due to a series of adverse environmental incidents in Council managed waterbodies, including a fish kill, Sunnyside Council recently undertook to improve how it manages its waterbodies. The two main aims were to achieve acceptable environmental outcomes and avoid unnecessary cost to the community.

3.8.2 Identify roles, responsibilities and resources

Sunnyside Council had a reactive approach to waterbody management and only responded when incidents occurred, such as a fish kill. This reactive approach was expensive. In addition, the works undertaken by one department sometimes caused follow up problems for another department. In one instance, one department removed aquatic weeds, which resulted in the accidental removal of aquatic macrophytes. Replanting these aquatic macrophytes was expensive and impacted on the budget of another department. To help coordinate the waterbody management activities across different departments, Sunnyside Council decided to clarify its waterbody roles and responsibilities.

Sunnyside Council decided to undertake this process internally as they are a small local government with good interdepartmental relationships. The Environmental Planning Branch led this process.

A workshop was convened to discuss who was undertaking which tasks and a task checklist circulated to relevant staff in the following departments:

- Strategic Planning
- Development Assessment
- Stormwater Maintenance
- Parks and Natural Areas Maintenance
- Environmental Planning
- Finance
- Pest Management
- Stormwater and Flood Plain Management.

The results of the workshop and task checklist were documented and a gap analysis carried out (Table 3.7).

From the gap analysis presented in Table 3.7 Sunnyside Council determined that it was performing relatively well at planning policy development (although room for improvement still existed). However, they determined that most improvement could be made through improving the way existing Council assets were managed. In particular it became apparent that no single department was considering the waterbody as a whole, and that while most tasks were covered, they were not being addressed in a coordinated manner. It was decided that overall responsibility for maintenance and rectification of waterbodies should be given to a single department, who would sub-contract work to the department with the most appropriate skill set, or engage a contractor. After much discussion, the Stormwater and Flood Plain Management department agreed to take on this role, on the condition that they were to be appropriately funded, resourced and staffed.

Table 3.7 Sunnyside Council roles and responsibilities gap analysis

NO GAP: Task is assigned and being completed	GAP 1: Task is assigned but only partially completed	GAP 2: Task is assigned but not completed	GAP 3: Task is not assigned and not being completed								
Task	Department										
	Strategic Planning	Development Assessment	Stormwater Maintenance	Parks and Natural Areas Maintenance	Environmental Planning	Finance	Pest Management	Stormwater and Flood Plain Management			
Stage: Planning for physical works and policy development											
Flood modelling and management											
Stormwater modelling and management											
Design of new waterbodies											
Modification of design for existing waterbodies (renewal/upgrade)											
Strategic assessment of waterbody condition (regional)											
Asset handover – conditions and constraints											
Research and design of best practice water sensitive urban design (WSUD) infrastructure											
Research and design of best practice waterbody design and construction											
Planning for removal of 'end-of-life' infrastructure											
Strategic assessment of waterbody management and resources (regional)											
Policy development for waterbodies											
Assessment of development related waterbody proposals											
Construction supervision											
Preparation of a business case for capital spend											
Stage: Ongoing maintenance and inspections											
Aquatic weed spraying											
Aquatic weed harvesting											
Aquatic macrophyte revegetation/planting											

Task	Department							
	Strategic Planning	Development Assessment	Stormwater Maintenance	Parks and Natural Areas Maintenance	Environmental Planning	Finance	Pest Management	Stormwater and Flood Plain Management
Riparian/edge weed spraying or removal								
Riparian and edge revegetation/planting								
Mosquito monitoring and control								
Routine water quality monitoring								
Routine algal monitoring								
Reactive water quality or algal sampling (e.g. in response to complaints, spills, fish kills)								
Sediment removal or dredging within waterbody								
Litter monitoring and removal								
Inspection and maintenance of surface gross pollutant traps								
Inspection and maintenance of underground gross pollutant traps								
Inspection and maintenance of inlet structures								
Inspection and maintenance of outlet structures								
Inspection and maintenance of amenities								
General inspection of overall waterbody condition								
Inspection and management of batter scour								
Inspection and management of pests (e.g. birds, fish)								
Inspection and management of water levels								
Stage: Renewal and rectification								
Excavation to increase storage capacity or re-size sediment basins								
Installation of additional sediment capture infrastructure (e.g. gross pollutant traps)								

Task	Department							
	Strategic Planning	Development Assessment	Stormwater Maintenance	Parks and Natural Areas Maintenance	Environmental Planning	Finance	Pest Management	Stormwater and Flood Plain Management
Waterbody reprofiling/re-sizing								
Modification of existing hydraulic structure (e.g. to optimise water levels and flushing)								
Installation of new hydraulic structures (e.g. inlet and outlet structures)								
Installation of erosion protection infrastructure								
Construction of flow redirection paths								
Construction of access ramps (for weed harvesting)								
Installation of permanent fencing/vegetation to restrict access								
Installation of temporary fencing								
Installation of signage								
Excavation of adjacent areas for sediment drying/compacting								
Modification or removal of bird habitat								
Removal or culling of pests (e.g. birds, fish)								
Acid sulfate soil treatment (e.g. capping, replacement, remediation)								
Sediment treatment within the waterbody (e.g. sediment capping, aeration, recirculation)								
Installation of other water quality treatment infrastructure (e.g. floating wetlands)								
Installation of WSUD infrastructure (e.g. swales, bioretention systems, sediment basins)								

3.8.3 Identify and assess waterbodies

Next, Sunnyside Council identified and assessed its waterbodies. Many waterbodies were already known about because works were being undertaken on them. Others were identified that Council was previously not aware of. The process of identifying waterbodies included inspecting:

- GIS information
- aerial imagery (e.g. Nearmap, WetlandMaps)
- development applications
- as-constructed drawings.

Sunnyside Council chose to simply characterise its waterbodies to begin the process. The process of characterising waterbodies included:

- recording data from sources used to identify waterbodies (see above)
- field inspections.

The data captured on each waterbody included:

- waterbody identifier
- waterbody name
- location
- catchment/basin
- connectivity
- waterbody fringe area
- waterbody formation
- current use
- responsibility
- age
- waterbody size
- general description
- park category features
- water type
- water quality
- waterbody floor
- general field observations
- hydraulic function
- aquatic habitat
- profile/amenity

A final year engineering student was engaged by the Stormwater and Flood Plain Management department to undertake these tasks under the guidance of more senior staff. This provided a cost effective resource.

A total of 107 waterbodies were identified on Council land.

3.8.4 Prioritise waterbodies

When it came to prioritising waterbodies, Sunnyside Council initially considered prioritising their waterbodies based upon the value for money that maintenance of each waterbody would provide (see Figure 3.3). This was Sunnyside Council's preference because it aligned well with their goals of achieving acceptable environmental outcomes, and minimising cost to the community. Unfortunately, with little experience managing waterbodies, except for when responding to adverse events, Sunnyside Council did not have access to the cost data required. Therefore, Sunnyside Council chose to prioritise their waterbodies on the basis of the value they provide to the community (see Figure 3.2). By doing this they would be able to begin proactive maintenance of high priority waterbodies, collect data and later return and prioritise again based upon value for money.

Sunnyside Council chose to prioritise their waterbodies using three criteria. Two indicators were chosen for each criterion (Table 3.8).

Of the 107 waterbodies identified, the prioritisation for three is demonstrated in Table 3.9.

Table 3.8 Criteria and indicators for prioritisation

Criteria	Indicator	Type	Indicator of high score (5)	Indicator of low score (1)
Water quality	Predominant catchment landuse	GIS	Low impact landuse. Undeveloped.	Industrial. Heavily developed.
	Environmentally relevant activities in proximity	GIS	No environmentally relevant activities in catchment.	Many environmentally relevant activities in catchment.
Habitat provision	Mapped vegetation areas	GIS	High quality vegetation present in high quantity.	No or poor quality vegetation present.
	Assessment of habitat	Inspection	Habitat present.	No habitat present.
Amenity/profile	Proximity to residential landuse	GIS	Residential landuse in close proximity.	No residential landuse in close proximity.
	Qualitative visual assessment	Inspection	Aesthetically pleasing. Heavily used. Easy access.	Aesthetically unpleasing. No sign of use. No access.

Table 3.9 Prioritisation of three waterbodies

Waterbody	Criteria	Indicator	Indicator score (1-5)	Indicator score (2-10)	Criteria Priority*	Waterbody Score(6-30)	Waterbody Priority**
Waterbody 1	Water quality	Predominant catchment landuse	3	5	Medium	19	Medium
		Environmentally relevant activities in proximity	2				
	Habitat provision	Mapped vegetation areas	4	6	Medium		
		Assessment of habitat	2				
	Amenity/ profile	Proximity to residential landuse	4	8	High		
		Qualitative visual assessment	4				
Waterbody 2	Water quality	Predominant catchment landuse	2	3	Low	11	Low
		Environmentally relevant activities in proximity	1				
	Habitat provision	Mapped vegetation areas	3	4	Low		
		Assessment of habitat	1				
	Amenity/ profile	Proximity to residential landuse	2	4	Low		
		Qualitative visual assessment	2				

Waterbody	Criteria	Indicator	Indicator score (1-5)	Indicator score (2-10)	Criteria Priority*	Waterbody Score(6-30)	Waterbody Priority**
Waterbody 3	Water quality	Predominant catchment landuse	4	9	Very High	23	High
		Environmentally relevant activities in proximity	5				
	Habitat provision	Mapped vegetation areas	5	9	Very High		
		Assessment of habitat	4				
	Amenity/ profile	Proximity to residential landuse	1	5	Medium		
		Qualitative visual assessment	4				

*	2 = Very Low	3-4 = Low	5-6 = Medium	7-8 = High	9-10 = Very High
**	6-10 = Very Low	11-15 = Low	16-20 = Medium	21-25 = High	26-30 = Very High

The results of Council's prioritisation of their 107 waterbodies are shown in Table 3.10

Table 3.10 Results of Council's waterbody prioritisation

Priority	Number of waterbodies
Very high	7
High	31
Medium	54
Low	10
Very low	5

3.8.5 Managing finances

Collecting maintenance data

As discussed in Section 3.8.4, Sunnyside Council will collect maintenance data in the future to facilitate maintenance planning and allow costs to be factored into future prioritisation.

Developing a business case

In order to appropriately resource their Stormwater and Flood Plain Management department to manage waterbodies, Sunnyside Council decided to develop a business case for funding. Sunnyside Council recognised that developing a business case which compared their current reactive maintenance approach with a more proactive, appropriately resourced approach was the suitable method to make a case for appropriate funding.

For their business case Sunnyside Council had limited cost data on proactive maintenance, but plenty of data on the cost of reactive maintenance. Sunnyside Council contacted other local governments in the region with experience in proactively maintaining waterbodies. These other local governments were able to provide Sunnyside Council with cost data on proactive maintenance.

Using this data, Sunnyside Council undertook a net present value (NPV) assessment of the cost of maintaining their waterbodies reactively versus proactively for the next 25 years. The NPV demonstrated

that even when providing for additional human resources, proactive maintenance stood to save Council many millions of dollars over 25 years.

The business case was presented to Council's Infrastructure Committee. Although the Committee was concerned about the total budget requested they agreed to fund 50% of the required budget the following financial year, with a view to fully fund a year later if on-ground results could be demonstrated.

Capitalising waterbodies

Sunnyside Council recognised that in order to be sustainable, capitalising waterbodies would be an important task. As Australian accounting standards are currently not conducive to doing this, Council have decided to focus their resources on other tasks and will return to capitalise their waterbodies in the future.

3.8.6 Review and revise

Having just completed their first attempt at managing waterbodies, Sunnyside Council intends to review and revise elements of the process in the near future including:

- adding more information to the asset register
- collecting data on the cost of maintaining waterbodies
- continuing to seek an appropriate budget for maintaining waterbodies.

3.9 REFERENCES

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Waterbody Management Guideline

Module 4

Maintenance and Operations

VERSION 1 SEPTEMBER 2013

waterbydesign



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4.1 INTRODUCTION

4.1.1 Purpose of module 4

The purpose of this module, '*Maintenance and Operations*,' is to assist local government maintenance officers and asset managers to undertake on-ground works to maintain, rectify and where necessary remove waterbodies. It is designed primarily for local government managed waterbodies but the technical

information can be applied to waterbodies managed by other entities. This module provides information on common waterbody issues, including how to investigate, identify and resolve issues. The information can be used by all managers of waterbodies.

4.1.2 How to use module 4

This module contains four key sections (Figure 4.1).

Figure 4.1 How to use module 4

Section 4.2	
Scheduling Inspections and Maintenance	This section discusses how to schedule maintenance actions and inspections for waterbodies.
Section 4.3	
Identifying Issues and Selecting Actions	This section discusses the key problems that may occur within waterbodies and outlines methods to investigate, monitor, manage and rectify problems.
Section 4.4	
Management Actions	This section describes how to undertake key waterbody specific management actions.
Section 4.5	
Worked Example	This section uses a hypothetical example to demonstrate the waterbody management and maintenance processes outlined in this module.

4.2 SCHEDULING INSPECTIONS AND MAINTENANCE

Proactive maintenance usually involves activities that are simple to perform. These activities could include weeding and removing litter and debris. Activities that require specialised equipment or skills such as removing sediment may require a return trip to the waterbody with the appropriate equipment or personnel.

Ongoing, regular inspections and proactive maintenance can be scheduled in a number of different ways (Figure 4.2).

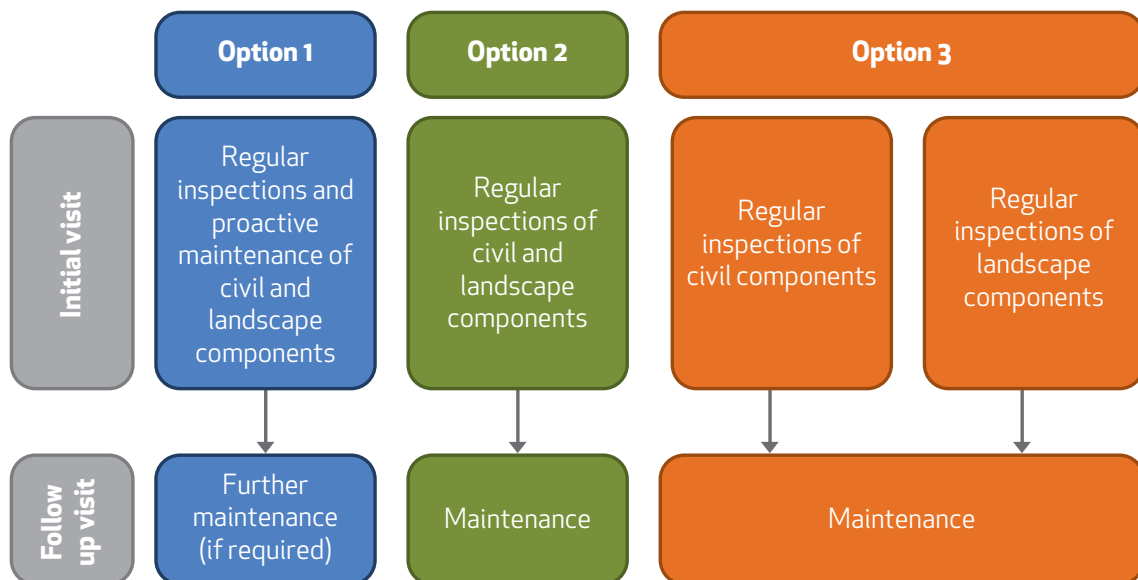
- Option 1 – Undertake regular inspections and proactive maintenance of both civil and landscaping components of the waterbody. If issues are identified during these inspections that cannot be completed with the equipment at hand then return to the waterbody with the appropriate equipment to resolve issue.
- Option 2 – Undertake regular inspection of both civil and landscaping components of waterbody. Return to the waterbody later to then complete all maintenance.

- Option 3 – Undertake regular but separate inspections of civil and landscaping components of the waterbody. Return to the waterbody later to then complete all maintenance.

The method chosen will depend upon the resources and internal structure of the local government.

The frequency with which inspections and maintenance are carried out on waterbodies depends on the season, recent rainfall, the landuse within the catchment, and any short term activities occurring within the catchment (e.g. earthworks). Inspections and maintenance of waterbodies should be regular. Proactive maintenance prevents problems from developing within waterbodies and ultimately saves money. Inspection frequencies should be increased during the wet season and in response to catchment pressures such as landuse change.

Figure 4.2 Options for undertaking inspections and maintenance



4.3 IDENTIFYING ISSUES AND SELECTING ACTIONS

When maintaining and operating waterbodies, asset managers are often required to identify, then respond to specific issues. Being able to easily identify issues, the cause of those issues and take appropriate management action is vital to how easily, quickly and cost effectively those issues are resolved. This section provides a comprehensive list of issues which have been grouped into one of five categories, namely:

- health and safety (Section 4.3.1)
- water quality (Section 4.3.2)
- profile and amenity (Section 4.3.3)
- engineering and hydraulic function (Section 4.3.4)
- flora and fauna (Section 4.3.5).

For each category a table is provided (amended from DesignFlow, 2012 and Limnologic, 2012) which describes common waterbody issues, helps the user identify each issue and provides appropriate management and rectification responses. Photographs are provided to help to identify the issues. Be aware that some waterbody issues may affect topics covered by more than one table. Be sure to check each table before undertaking management or rectification.

4.3.1 Health and safety

In certain circumstances waterbodies can be a risk to human health and safety. They are often located in close proximity to places where people live, work and recreate. Asset managers are often required to deal with waterbody issues which present a health and safety risk to the community.

Health and safety issues in waterbodies include:

- injury or drowning
- mosquitoes
- polluted water
- structural integrity

Table 4.1 expands on each of the above issues, detailing:

- methods to investigate and monitor each issue
- management actions – actions that can be implemented rapidly and cost effectively
- rectification actions – actions that require planning, design and budget to implement
- relevant supporting information.

Figures 4.3 to 4.7 provide photographs to help with identifying different health and safety issues.

Table 4.1 Waterbody health and safety issues and associated management and rectification actions

Issue – Risk of injury or drowning			
Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Potential safety issues (e.g. drowning) may be due to:</p> <ul style="list-style-type: none"> • steep waterbody batters • lack of edge barriers • lack of perimeter vegetation • lack of a safety bench 	<p>Discuss with asset owner to identify and document any issues. Undertake desktop review and initial site inspection.</p> <p>Undertake risk assessment.</p>	<p>If risk is deemed unacceptable the following actions should be considered:</p> <ul style="list-style-type: none"> • Install temporary protection (temporary fencing) to exclude public entry. • Erect signage to highlight risk to public and that a response is being identified. 	<p>Rectification actions will depend on the scale, type and degree of risk. Actions may include:</p> <ul style="list-style-type: none"> • planting waterbody batters with dense vegetation (emergent and terrestrial) to restrict access • installing edge barriers such as balustrades and kick rails along pathways and erect permanent fencing where risk of access is high • modifying the waterbody edge to provide safe batters above and below the water level (a maximum batter slope of 1:4 is recommended and/or a 1:8 safety bench below the water level) • reducing the depth of the waterbody, particularly around the edges • where the waterbody is located near areas highly used by children (i.e. children’s playground), consider moving the area to another part of the parkland. <p>Refer to <i>Rectifying Vegetated Stormwater Assets</i> – Appendix B (Water by Design, 2012b) for additional guidance on the design of the approaches to and the area immediately below permanent water.</p>
<p>Relevant supporting information</p> <p>Water by Design (2012b)</p>			

Issue – Human health risk due to large mosquito populations

Description	Investigations/monitoring	Management actions	Rectification actions
<p>The presence of large mosquito populations represents both a potential human health risk (as mosquitoes transmit many pathogens including protozoa, nematodes and viruses) and a nuisance to local residents.</p>	<p>Discuss safety with asset owner and environmental health department to identify and document any issues.</p> <p>Undertake site inspection to check for evidence of mosquito breeding sites around the margins of the waterbody and also in any isolated shallow pools in the near vicinity. Check for evidence of litter which may support mosquito breeding.</p> <p>Undertake risk assessment.</p> <p>Record whether or not:</p> <ul style="list-style-type: none"> the mosquito problem is associated with the waterbody (or the surrounding ecosystems) simple management actions can be implemented to reduce populations a mosquito control plan should be prepared and rectification actions implemented. <p>Where a mosquito control plan is required then an audit of the mosquito species and population density both within waterbody and adjacent habitats is required.</p>	<p>Simple management actions may include:</p> <ul style="list-style-type: none"> implementing a regular litter removal program spraying with ecologically friendly larvicides (Seek advice from environmental health experts within local government if the use of chemical control agents is deemed necessary. Not recommended as a long term strategy due to insecticide resistance, cost and possible inability to apply to all areas). 	<p>Where rectification is required, a mosquito control plan should be prepared in accordance with the <i>Mosquito Management Code of Practice for Queensland</i> (Local Government Association of Queensland, 2002)</p> <p>Rectification options may include:</p> <ul style="list-style-type: none"> draining isolated pockets of pooled water filling in uneven areas where stagnant water accumulates increasing depth in open water areas to >60 cm to limit mosquito breeding increasing the slope of submerged batters (see 'Risk of injury or drowning' in this table for further discussion of waterbody batter slope) increasing the diversity of plants (both emergent and submerged) in the waterbody improving waterbody circulation and flushing introducing mosquito predators (native fish).

Relevant supporting information

Local Government Association of Queensland (2002), Queensland Health (2002), Water by Design (2012a), Water by Design (2012b)

Issue – Health risks due to human contact with polluted water

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Potential health risks may exist where public have direct access to water contaminated with chemicals, faecal matter or cyanobacteria.</p> <p>Certain types of cyanobacteria can release toxins when they die that affect the liver or nervous system of animals and humans. This can be a major public health issue. In addition, all cyanobacteria contain toxins within their cell walls that can cause skin irritations and allergic responses in human skin tissue from direct contact with the cells.</p>	<p>Discuss waterbody contamination history with the asset owner, engineering and environmental health departments to identify and document any issues.</p> <p>Undertake desktop review, site inspection and risk assessment.</p> <p>Detailed investigations will depend on the nature of the contamination. Refer to 'Algal or cyanobacterial blooms', 'Chemical contamination' or 'Faecal and/or nutrient contamination' in Table 4.2.</p>	<p>Where contamination is reported, the relevant agency should be notified and monitoring/management completed in accordance with DERM (2009) and NHMRC (2008). Management actions will be guided by monitoring outcomes but may include:</p> <ul style="list-style-type: none"> installing of temporary protection (e.g. temporary fencing to exclude public entry) erecting signage to highlight risk to public and that a response is being identified community consultation clean-up/treatment or adaptive management as required. <p>For ongoing management actions, refer to 'Algal or cyanobacterial blooms', 'Chemical contamination' or 'Faecal and/or nutrient contamination' in Table 4.2.</p>	<p>Refer to 'Algal or cyanobacterial blooms', 'Chemical contamination' or 'Faecal and/or nutrient contamination' in Table 4.2.</p>
<p>Relevant supporting information</p> <p>DERM (2009), NHMRC (2008), WHO (1999)</p>			

Issue – Structural integrity

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Structural integrity of waterbodies pertains to the failure (e.g. collapse) of a wall or embankment. Failure of a wall or embankment can put downstream communities and infrastructure at risk.</p>	<p>Discuss with asset owner and engineering department to identify and document any issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p> <p>Seek specialist engineering advice.</p>	<p>The management actions undertaken will depend on the cause and risk posed by the structural issues.</p>	<p>If the risk is deemed unacceptable, actions to rectify the structural issues must be undertaken. The actions undertaken will depend on the cause and risk posed by the structural issue. Actions may include:</p> <ul style="list-style-type: none"> removing the waterbody replacing part or all of the waterbody wall or embankment converting or redesigning the waterbody.
<p>Relevant supporting information</p> <p>Nil</p>			

Figure 4.3 A waterbody with vertical batters



Photo: Julian Wakefield, Sunshine Coast Council

Figure 4.4 A waterbody with easy access to water's edge, and a lack of perimeter vegetation



Photo: Colin Bridges, Gold Coast City Council

Figure 4.5 A waterbody with low lying adjacent areas likely to pond water after high rainfall



Photo Karen Waite, Moreton Bay Regional Council

Figure 4.6 A waterbody with a cyanobacterial bloom



Photo: Karen Waite, Moreton Bay Regional Council

Figure 4.7 Chemical contamination entering a waterbody



Photo: Colin Bridges, Gold Coast City Council

4.3.2 Water quality

The water quality in a waterbody is a function of the characteristics of the waterbody itself and the water flows into and out of the waterbody as well as the inputs to the waterbody from the catchment. Waterbodies with good water quality function well and have few management requirements. Conversely waterbodies with poor water quality can present a risk to human health, cause fish kills and aesthetic issues and have adverse downstream impacts. Waterbodies with poor water quality are an ongoing management burden to local governments. When assessing a waterbody for water quality issues it is important to understand the natural water quality characteristics of the waterbody. For example, some waterbodies have naturally high turbidity levels or may naturally exhibit variable salinity. Understanding the natural water quality of the waterbody will help guide appropriate management of that waterbody.

The following can cause water quality issues:

- algal or cyanobacterial blooms
- chemical contamination
- persistent high turbidity levels
- presence of exotic fish species
- faecal and/or nutrient contamination
- variable salinity
- stratification and low dissolved oxygen.

Table 4.2 expands on each of the above indicators, detailing:

- methods to investigate and monitor each issue
- management actions – actions that can be implemented rapidly and cost effectively
- rectification actions – actions that require planning, design and budget to implement
- relevant supporting information.

Figures 4.8 to 4.10 provide photographs to help with identifying different water quality issues.

Table 4.2 Waterbody water quality issues and associated management and rectification actions

Issue – Algal or cyanobacterial blooms			
Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Algal and cyanobacterial blooms are indicators of poor water quality and aquatic health within a waterbody system. While most species of algae (e.g. green algae and diatoms) are not dangerous to humans or animals, some may reduce aesthetic values through changes in water colour, odours and surface scum.</p> <p>The presence of persistent cyanobacterial/algal biomass may be due to a range of factors, including:</p> <ul style="list-style-type: none"> • untreated stormwater inflows • nutrient released from the sediments • excessive waterbody residence times • high internal carbon (organic) loading (i.e. resulting from decay of aquatic weeds such as Salvinia) • low submerged or emergent macrophyte cover • excessive waterbird population • rapid variations in salinity • high turbidity levels. 	<p>Discuss algal and cyanobacterial issues with asset owner, engineering and environmental health departments to identify and document any historical issues.</p> <p>Undertake desktop review, site inspection and risk assessment.</p> <p>Further assessment is only required if persistent blooms are recorded and if the asset owner considers it necessary to obtain a more detailed understanding of waterbody processes to inform rectification. This may include monitoring for the following parameters:</p> <ul style="list-style-type: none"> • chlorophyll-a, total phosphorus, soluble phosphorus, total nitrogen and nitrate-N • temperature, redox, salinity, pH and dissolved oxygen depth profiles at a number of locations • cyanobacterial identification and counts • cyanobacterial toxin concentrations (i.e. where counts exceed the red alert level). 	<p>If cyanobacterial/algal risks are deemed unacceptable, a specialist should be consulted to develop a monitoring program and implement an adaptive management framework in accordance with DERM (2009) and NHMRC (2008). Management actions will be guided by monitoring outcomes but may include:</p> <ul style="list-style-type: none"> • contacting relevant agencies • restricting access to the waterbody (e.g. installing temporary fencing) • erecting signage to highlight risk to public and that a response is being identified • isolating waterbody to minimise downstream risks (e.g. blocking outlets) • community consultation • treatment (e.g. algaecides) • phosphorus management (e.g. Phoslock®) • netting or raking of filamentous algae. <p>Immediate actions are not generally required for managing harmless algal blooms. However, long term rectification actions may be necessary to improve aesthetic values and aquatic habitat condition (refer to rectification actions).</p>	<p>The rectification actions will be resolved as part of the waterbody investigations. Potential rectification responses to persistent algal or cyanobacterial blooms include:</p> <ul style="list-style-type: none"> • installation of stormwater treatment system in the upstream catchment to remove pollutants prior to entering the waterbody • removal of the waterbody sediments • resetting part or all of the waterbody system as a wetland • installing water recirculation system (e.g. wetland, sand filter) to deplete algal biomass and nutrient loading within the waterbody • configuring waterbody to receive flushing flows • installing floating wetlands to manage nutrients and turbidity • planting the waterbody with emergent and submerged vegetation. <p>If cyanobacterial toxin concentrations exceed the primary contact recreation Water Quality Objectives, (WQO. DERM, 2009) powdered activated carbon dosing may be required (note that specialist advice should be sought before this action is undertaken).</p>
<p>Relevant supporting information</p> <p>DERM (2009), NHMRC (2008), WHO (1999)</p>			

Issue – Chemical contamination

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>The presence of chemical contamination may be indicated by:</p> <ul style="list-style-type: none"> • obvious discolouration of the water within the waterbody (e.g. orange, red, grey) • chemical residues floating on the surface of the waterbody (e.g. oily scum) • fish kills. 	<p>Discuss with asset owner, engineering and environmental health departments to identify and document any historical issues.</p> <p>Undertake desktop review of potential contamination sources (e.g. proximity to environmental relevant activities) and site inspection.</p> <p>Undertake risk assessment.</p>	<p>Suspected contamination by toxic chemicals should be reported immediately to the relevant state government department.</p> <p>If toxic chemicals are found at levels which exceed the relevant WQOs (DERM, 2009) an adaptive management program should be implemented in accordance with the risk assessment framework set out in NHMRC (2008).</p> <p>Management actions may include:</p> <ul style="list-style-type: none"> • contacting relevant agencies • restricting access to the waterbody (e.g. installing temporary fencing) • erecting signage to highlight risk to public and that a response is being identified • isolating waterbody to minimise downstream risks (e.g. blocking outlets) • installing floating booms • community consultation • treatment or adaptive management as required. 	<p>Cleanup of spills should be conducted with advice from the relevant state government department and an appropriate specialist as required, in accordance with the NHMRC (2008) risk assessment framework.</p> <p>The rectification actions will be resolved as part of the waterbody investigations. Potential rectification responses may include:</p> <ul style="list-style-type: none"> • installing stormwater treatment systems in the upstream catchment to remove pollutants prior to entering the waterbody • installing valves at inlets to isolate inflows • installing permanent floating booms at inlets • redesigning the waterbody system as a treatment wetland.

Relevant supporting information

NHMRC (2008)

Issue – Persistent high turbidity levels

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Excessive turbidity, total suspended solids or total dissolved solids can smother aquatic habitats and reduce sunlight penetration. This can provide conditions favourable to algal growth (gas-vacuolate cyanobacteria and flagellated algae) and invasion by exotic species (e.g. carp, tilapia) that have competitive advantages in turbid waters.</p>	<p>Discuss with asset owner and engineering department to identify and document any current or historical issues.</p> <p>Undertake desktop review and site inspection. Record turbidity level in situ using a water quality probe. Further monitoring during both wet and dry weather may be required if potential sediment sources are identified.</p> <p>Undertake risk assessment.</p> <p>If turbidity levels within the waterbody consistently exceed the relevant Water Quality Objectives (1-20NTU for the protection of moderately disturbed freshwaters) in DERM (2009), then further investigation may be required to determine the source/s of the high turbidity (e.g. development sites, stormwater inflows, sediment resuspension) and to consider other catchment management solutions.</p>	<p>Treatment of persistent high turbidity levels will not normally require any ongoing management actions (investigations will either show the risk to be acceptable, or require rectification be undertaken) – refer to rectification</p>	<p>Rectification actions will be dictated by the field investigations and whether or not the risk is identified by the asset owner as acceptable. Rectification actions may include:</p> <ul style="list-style-type: none"> • establishing and maintaining healthy submerged and emergent macrophytes within the waterbody • establishing and maintaining healthy riparian vegetation on waterbody margins • repairing areas of bank erosion and revegetating using endemic species • stormwater treatment within the upstream catchment (e.g. providing additional sediment capture upstream of waterbody such as sediment basins and sand filters) • installing floating wetlands within the waterbody • managing runoff from construction sites in accordance with legislative requirements and IECA Australasia (2008) • removing exotic fish species (such as Carp) • replacing topsoil used within the waterbody (refer AS4419, 2003) • repairing areas of the waterbody where the clay liner has been exposed.
<p>Relevant supporting information</p> <p>AS4419 (2003)</p>			

Issue – Presence of exotic fish species

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Exotic fish species (e.g. European carp, tilapia, mosquito fish, goldfish) are generally able to tolerate a wide range of water quality and environmental conditions, and so have a competitive advantage over many native fish species.</p> <p>Exotic fish contribute to the deterioration of water quality through sediment resuspension (bottom feeders), habitat destruction/fragmentations and increased internal loading of nutrients.</p>	<p>Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment</p> <p>Depending on the outcomes of the risk assessment, the asset owner may wish to undertake a fish survey to determine the native and exotic fish population, biomass and size distribution present.</p> <p>(Note: The capture, removal or destruction of fish is governed by strict ethical considerations and should only be undertaken by qualified staff, in accordance with NHMRC (2004) and with relevant permits obtained from the Queensland Department of Agriculture, Fisheries and Forestry (DAFF)).</p>	<p>The presence of exotic fish species will not normally require any ongoing management actions – refer to rectification</p>	<p>If the risk is deemed unacceptable, rectification actions to reduce/eliminate the invasion of exotic fish species may include:</p> <ul style="list-style-type: none"> • trapping and removal of pest species in accordance with NHMRC (2004) • reconfiguring waterbody for regular dewatering/fish management. This may include installation of fish barriers at inlet zones to waterbodies • improving aquatic habitat conditions to encourage recruitment and breeding of native species. This may include establishing and maintaining healthy submerged and emergent macrophytes, installing artificial habitat structures and introducing large woody debris (re-snagging) • implementing a native fish stocking program • improving hydraulic connectivity of on-river waterbodies (where possible) by modifying/replacing existing inlet/outlet structures to provide for suitable upstream passage of native fish and other aquatic organisms • improving water quality conditions.
<p>Relevant supporting information</p> <p>NHMRC (2004), DAFF (2013b)</p>			

Issue – Faecal and/or nutrient contamination

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Contamination of the waterbody by faecal microorganisms and nutrients may be due to:</p> <ul style="list-style-type: none"> • large wildlife populations (e.g. birds, bats, possums) on or adjacent to the waterbody • untreated sewage entering the waterbody via stormwater inflows • leakage of septic systems into groundwater, surface water or stormwater • diffuse runoff from surrounding landuses, particularly areas with high concentrations of domestic animals (e.g. dogs, cats, cattle, sheep, pigs, poultry) • internal nutrient loading from the sediments. <p>The presence of faecal contamination is often difficult to detect, however may be indicated by:</p> <ul style="list-style-type: none"> • obvious discolouration of the waterbody water (e.g. grey, blue-grey) • unusual foaming on the surface of the waterbody, especially at inflow sites • unusual water odours (e.g. effluent). 	<p>Discuss with asset owner, engineering and environmental health department to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p> <p>Depending on the outcomes of the risk assessment, the asset owner may wish to undertake additional site surveys and/ or implement a water quality monitoring program in accordance with NHMRC (2008).</p>	<p>If faecal contamination is found at levels which exceed the relevant Water Quality Objectives (DERM, 2009) an adaptive management program should be implemented in accordance with the risk assessment framework set out in NHMRC (2008).</p> <p>Management actions may include:</p> <ul style="list-style-type: none"> • contacting relevant agencies • restricting access to the waterbody (e.g. installing temporary fencing) • erecting signage to highlight risk to public and that a response is being identified • isolate waterbody to minimise downstream risks (e.g. block outlets) • community consultation • routine inspections and maintenance of existing dog waste bins • re-use or drawdown of water level to prevent accumulation of contaminants • treatment or adaptive management as required. 	<p>If the risk is deemed unacceptable, rectification actions may include:</p> <ul style="list-style-type: none"> • removing, moving on or culling waterfowl from the waterbody system (permit may be required) • treating contamination sources from the catchment, including illegal sewer connections to drainage system, sewage treatment plant overflows, stormwater, on-site septic systems • treatment or containment of drainage from intensive agriculture and industry • signage, public education programs and behaviour change programs • installing and maintaining dog or domestic animal waste bins • installing floating wetlands to manage nutrients • repairing leaking sewer pipes.
<p>Relevant supporting information</p> <p>NHMRC (2008), DERM (2009)</p>			

Issue – Variable salinity

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Brackish waterbodies which experience large variations in salinity should be avoided.</p> <p>For freshwater waterbody systems, large fluctuations in salinity levels may provide conditions that are unfavourable for submerged macrophytes and favour algae (particularly cyanobacteria).</p> <p>Increased salinity within freshwater waterbodies may be due to:</p> <ul style="list-style-type: none"> • tidal intrusion of saline water into the waterbody • saline groundwater flowing into the waterbody • contamination from upstream landuses (e.g. industrial, agricultural) via stormwater inflows or diffuse runoff. 	<p>Discuss with asset owner and engineering department to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p> <p>Refer to Appendix G of the <i>Queensland Water Quality Guidelines</i> (DERM, 2009) to determine acceptable variations in salinity.</p> <p>Depending on the outcomes of the risk assessment, the asset owner may wish to undertake additional site surveys and/or implement a monitoring program including monitoring electrical conductivity both after rain and during long dry periods to observe changes in salinity. For freshwater waterbodies, electrical conductivity levels of >1500 mg/L pose an immediate risk to aquatic plants. For saline waterbodies, the risk of cyanobacterial blooms increases where electrical conductivity is <10 000 mg/L. Refer to the <i>Townsville Constructed Lakes Design Guidelines</i> (DesignFlow, 2010) for guidance on additional investigations to determine the source of the saline/freshwater intrusion.</p>	<p>Variable salinity will not normally require any ongoing management actions – refer to rectification</p>	<p>If the risk of variable salinity is deemed unacceptable, rectification actions should be undertaken.</p> <p>If observations during large tide events and salinity monitoring confirm tidal backwatering into the waterbodies, consider:</p> <ul style="list-style-type: none"> • raising the water level within the waterbody so that saline water cannot enter through the waterbody outlet. This will require modifying the configuration of the outlet structure. Upstream flooding impacts should be considered • installing a backflow preventing device on the outlet pipe to the downstream saline environment • raising bund levels to prevent tidal backwatering. <p>If saline groundwater intrusion is evident within the waterbody and vegetation health is obviously impacted, it may be necessary to replace or repair the waterbody liner. Alternative options include:</p> <ul style="list-style-type: none"> • trenching along the waterbody batter and placing a clay or bentonite barrier across the groundwater intrusion site • replanting the waterbody with saline or brackish tolerant plant species (note: there is an increased risk of mosquitoes in saline/brackish waters which will need to be monitored). Refer to 'Human health risk due to large mosquito populations' in Table 4.1 • raising operational water levels to create a hydraulic barrier and prevent groundwater flows entering the waterbody. <p>If other catchment sources are suspected, contact the relevant state government department to investigate potential sources of contamination.</p>

Relevant supporting information

DERM (2009), DesignFlow (2010)

Issue – Stratification and low dissolved oxygen

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Water column stratification may be present due to a range of factors including:</p> <ul style="list-style-type: none"> • excessive water depth (>2.5m) – although stratification can occur in highly eutrophic waterbodies less than 1m deep • high surface water temperatures • elevated salinity in freshwater waterbody systems • freshwater inflows to saline waterbodies • elevated organic carbon, nutrient and sediment loading • long residence times or lack of wind mixing • low or absent cover of submerged or emergent aquatic macrophytes • unsuitable waterbody configuration/orientation. <p>One of the major concerns associated with stratification is dissolved oxygen depletion. This may result in the release of dissolved (bioavailable) nutrients from the waterbody sediment which encourages algae and floating weed growth. Low dissolved oxygen concentrations are also a major cause of fish kills and sediment odour problems.</p>	<p>Discuss with asset owner, engineering and environmental health departments to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p> <p>Depending on the outcomes of the risk assessment, the asset owner may wish to undertake additional monitoring to determine the spatial extent and duration of stratification. This will involve regularly monitoring electrical conductivity, water temperature, dissolved oxygen, pH and redox potential through the entire water column at several locations throughout the waterbody system.</p> <p>(Note: as dissolved oxygen concentrations vary considerably throughout the day due to the process of respiration and photosynthesis it is recommended that monitoring is undertaken at multiple times during the day)</p>	<p>Intermittent stratification will not normally require ongoing management actions – refer to rectification for management of persistent stratification.</p> <p>Re-use or drawdown of water level may help prevent stratification.</p>	<p>If the risk of persistent stratification is deemed unacceptable, rectification actions may include:</p> <ul style="list-style-type: none"> • installing mixing systems such as aerators and water pumps • modifying waterbody bathymetry to improve hydraulic efficiency and wind forced mixing (e.g. infilling backwater, moving inlet/outlet structures, targeted planting, removal of clumped vegetation to promote longer flow paths, removal of islands, dredging) • establishment and management of healthy riparian vegetation on waterbody margins to improve shading and reduce sources of diffuse runoff • removing or treating (e.g. Phoslock®) the waterbody sediments (refer to ‘Fine sediment or organic matter accumulation’ in Table 4.4) • installing stormwater treatment systems in the upstream catchment to remove pollutants before they enter the waterbody • installing floating wetlands to reduce surface water temperatures.
<p>Relevant supporting information</p> <p>Nil</p>			

Figure 4.8 A waterbody with an algal bloom



Photo: Karen Waite, Moreton Bay Regional Council

Figure 4.9 Chemical contamination of a waterbody



Photo: Leo Newlands, Redland City Council

Figure 4.10 A waterbody with high turbidity



Photo: Julian Wakefield, Sunshine Coast Council

4.3.3 Profile and amenity

Waterbodies are often located in close proximity to places where people live, work and recreate, and can greatly increase the amenity of surrounding areas (Figure 4.11). Waterbodies can however develop issues that reduce local amenity. When waterbodies are located in high profile areas, the public often expect these issues to be rapidly rectified. Waterbody amenity can be impacted by issues such as:

- algal/cyanobacterial blooms
- weeds and pests
- offensive odours
- litter.

Table 4.3 expands on each of the above issues, detailing:

- methods to investigate and monitor each issue
- management actions – actions that can be implemented rapidly and cost effectively
- rectification actions – actions that require planning, design and budget to implement
- relevant supporting information.

Figures 4.12 to 4.14 provide photographs to help with identifying different profile and amenity issues.

Figure 4.11 A waterbody contributing to the amenity of its surrounding landscape



Photo: Julian Wakefield, Sunshine Coast Council

Table 4.3 Waterbody profile/amenity issues and associated management and rectification actions

Issue - Algal or cyanobacterial blooms			
Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Cyanobacteria and algal blooms can lead to diminished amenity and aesthetics resulting from the presence of unsightly surface scum, mats of filamentous algae, water discolouration and odour problems.</p> <p>Although this has been identified as a separate issue, the investigations and management/rectification actions will be similar to those for the maintenance and improvement of water quality.</p>	<p>Discuss with asset owner, engineering and environmental health department to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment</p>	<p>Refer to 'Algal or cyanobacterial blooms' in Table 4.2</p>	<p>Refer to 'Algal or cyanobacterial blooms' in Table 4.2</p>
<p>Relevant supporting information</p> <p>Nil</p>			

Issue - Weeds and pests			
Description	Investigations/ monitoring	Management actions	Rectification actions
<p>The presence of aquatic and/or riparian weeds and pest animals is one of the major contributors to reduced public amenity/aesthetics associated with waterbodies.</p> <p>Although the presence of weeds has been identified as a separate issue, the investigations and management/rectification actions will be similar to those for the maintenance and improvement of water quality.</p>	<p>Discuss with asset owner, engineering and environmental health department to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p>	<p>Refer to Table 4.5 'Waterbody flora and fauna issues and associated management and rectification actions'.</p>	<p>Refer to Table 4.5 'Waterbody flora and fauna issues and associated management and rectification actions'.</p>
<p>Relevant supporting information</p> <p>DERM (2011), DEEDI (2011a)</p>			

Issue – Offensive odours

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Odours can detract from public open space and present a nuisance for local residents. There are a number of reasons why odours may develop in waterbodies such as:</p> <ul style="list-style-type: none"> • decomposing organic matter • exposed or anoxic sediments • chemical contamination • organic loading (sewage or faecal contamination). 	<p>Discuss with asset owner, engineering and environmental health department to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p> <p>Site inspections should be undertaken during early morning or low wind conditions to confirm presence of odour. Check the waterbody for possible sources of odour. This will include checking for:</p> <ul style="list-style-type: none"> • decomposing organic matter • evidence of algal blooms (e.g. surface scum) • anoxic sediments (surface bubbling, sulphur-based odours when the sediment is disturbed) • chemical residues upon the water surface • large populations of water birds • chemical spillage (via the stormwater drainage system) • cross-connections from the sewage system, or cross-contamination from on-site septic systems in rural areas • dry weather inflows. 	<p>Where the odour issue is believed to be temporary or low nuisance then no action is required.</p> <p>Where odour is believed to be permanent and a high nuisance then rectification will be required. In the interim the odour issues could be managed by:</p> <ul style="list-style-type: none"> • notifying residents of the issue • erecting signage notifying people of the issue. 	<p>Rectification actions may include:</p> <ul style="list-style-type: none"> • installing mixers or aerators into the waterbody to increase dissolved oxygen levels (see 'Stratification and low dissolved oxygen' in Table 4.2 and 'Access for maintenance' in Table 4.4) • removing organic matter and sediment (see 'Fine sediment or organic matter accumulation' in Table 4.4) • managing bird populations (see 'Faecal and/or nutrient contamination' in Table 4.2) • removing or treating chemical contamination (see 'Chemical contamination' in Table 4.2) • identifying and sealing sewerage cross connections • rectifying the source of algal blooms (see 'Algal or cyanobacterial blooms' in Table 4.2).
<p>Relevant supporting information</p>			
<p>Nil</p>			

Issue – Litter

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>The presence of excessive amounts of litter reduces the amenity of the waterbody. Some types of litter such as aluminium cans can increase public health risk by harbouring mosquitoes.</p>	<p>Discuss with asset owner, engineering and environmental health department to identify and document any current or historical issues.</p> <p>Undertake desktop review, initial site inspection and risk assessment.</p> <p>Check for possible sources of litter. This will include checking for:</p> <ul style="list-style-type: none"> • catchment runoff from residential, commercial or industrial zones • failure of gross pollutant traps • direct dumping of litter in adjacent parkland areas • overflowing or unmanaged bins. 	<p>Where risk is medium then litter removal should occur on a scheduled or reactive basis. If gross pollutant traps or trash racks exist then maintain them as required.</p>	<p>If the risk is deemed unacceptable rectification actions may include:</p> <ul style="list-style-type: none"> • retrofitting the upstream drainage system with litter controls (e.g. a gross pollutant trap or a trash rack) • incorporating a gross pollutant trap to the inlet zone of the waterbody • providing litter disposal bins in the adjacent public open space • creating access to the zones in the waterbody where litter tends to accumulate for litter collection. This will typically be at the downwind end of the waterbody along the line of prevailing winds • undertaking a behaviour change campaign (for example, see Mackenzie-Mohr) within the catchment to modify behaviour to reduce litter entering waterbody.
<p>Relevant supporting information</p>			
<p>Nil</p>			

Figure 4.12 Waterbody with a cyanobacterial bloom



Photo: Karen McNeale, Redland City Council

Figure 4.13 Waterbody with a weed infestation



Photo: Kate MacKenzie, Sunshine Coast Council

Figure 4.14 Waterbody with litter



Photo: Colin Bridges, Gold Coast City Council

4.3.4 Engineering and hydraulic function

Waterbodies often play important hydraulic and hydrologic roles within the stormwater and broader waterway network and catchment. Waterbodies are dynamic systems which change over time. It is important to consider the long term maintenance requirements and any natural functioning of the waterbody and the broader system prior to implementing management actions. For example, always consider the waterbody formation and ask is the waterbody supporting or hindering natural catchment functioning.

A waterbody can develop engineering and hydraulic issues such as:

- water level remaining consistently too high
- water level remaining consistently too low
- flooding of adjacent land, parkland or property, or regular overtopping of the waterbody bund
- accumulation of coarse sediment within the waterbody
- accumulation of fine sediment or organic matter within the waterbody
- poor flushing or dead pockets
- poor access for maintenance
- scour of batters.

Table 4.4 expands on each of the above issues, detailing:

- methods to investigate and monitor each issue
- management actions – actions that can be implemented rapidly and cost effectively
- rectification actions – actions that require planning, design and budget to implement
- relevant supporting information.

Figures 4.15 to 4.21 provide photographs to help with identifying different engineering and hydraulic function issues.

Table 4.4 Waterbody engineering and hydraulic function issues and associated management and rectification actions

Issue – Water level is consistently too high			
Description	Investigations/monitoring	Management actions	Rectification actions
<p>Persistent high water levels (minor flood conditions) within the waterbody causing issues adjacent to the waterbody (e.g. death of vegetation, water logging of adjacent parkland area, tidal backwatering).</p>	<p>Determine what the original flow processes for the system were pre-European settlement and use this information to inform management actions. Discuss elevated water level with asset owner and engineering department to identify and document any current or historical issues.</p> <p>Complete site inspection following rainfall and during dry conditions to assess elevated water levels and identify potential causes. This will include checking for:</p> <ul style="list-style-type: none"> • blockage of the outlet pipe or weir • incorrect design or construction of the outlet pipe or weir • blockage or siltation of downstream drainage system or waterway causing backwater in the outlet pipe • increased catchment inflows due to changes in catchment landuse or drainage • groundwater inflows to the waterbody • low bund levels relative to tidal variation. <p>Undertake risk assessment.</p> <p>Where the risk of elevated water levels is high or very high and the solution is not straightforward then further technical assessment may be required. Seek advice from an engineer if the outlet is regularly blocked or undersized. Review catchment landuse to determine if there has been a significant increase in catchment imperviousness. Catchment modelling may be required to determine waterbody inflows. Assess the capacity of the waterbody outlet to cope with increased flows. Installations of a water level gauge may assist with technical assessment.</p>	<p>Management options for elevated water levels may include:</p> <ul style="list-style-type: none"> • undertaking regular inspection and maintenance of waterbody outlet • cleanout of downstream waterways to ensure free drainage of waterbody • erecting signs to inform the community about the water level issue in the waterbody. 	<p>If the risk is deemed unacceptable rectification actions may include:</p> <ul style="list-style-type: none"> • decreasing future risk of blockage (i.e. submerged outlets, inclined grates, large conveyance opening to allow for accumulation of litter) • providing increased capacity (i.e. new pit or pipes) • raise bunds above tidal influence • providing easy inspection and maintenance access (see 'Access for maintenance' in this table) • allowing adaptive management of the waterbody water levels (e.g. install valve or staged outlet to allow water levels to be lowered or raised easily) • remove the structure and decommission the waterbody • sealing the base of the waterbody to prevent groundwater inflows.
Relevant supporting information			
Nil			

Issue – Water level is consistently too low

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Persistent low water levels within the waterbody (even during only short periods without rain) causing the base of the waterbody to become exposed.</p>	<p>Determine what the original flow processes for the system were pre-European settlement and use this information to inform management actions. Discuss low water level with asset owner and engineering department to identify and document any current or historical issues.</p> <p>Complete site inspection following rainfall and during dry conditions to assess low water levels and identify potential causes. This will include checking for:</p> <ul style="list-style-type: none"> • incorrect outlet structure • leaking outlet structure • leaking maintenance drain • the waterbody catchment is small (i.e. not enough inflow to sustain water level) • the base or bund of the waterbody is not properly sealed • depth of waterbody has reduced due to siltation • inflows are bypassing the waterbody. <p>Undertake risk assessment.</p> <p>Where the risk of low water levels is high or very high and the solutions is not straightforward then further technical assessment may be required. Seek advice from a waterbody specialist to confirm the reason for the water level reduction:</p> <ul style="list-style-type: none"> • obtain design information for the waterbody in particular catchment areas, inflow points, earthworks/ bathymetry and outlet structure • obtain certification and construction information for the waterbody • where required collect survey data to confirm the design levels are achieved 	<p>Management options for low water levels may include erecting signs to inform the community about the water level issue in the waterbody.</p>	<p>If the risk is deemed unacceptable rectification actions may include:</p> <ul style="list-style-type: none"> • reconfiguring or installing a new outlet structure • fixing any leaks in the outlet structure • replacing leaking maintenance drain valves • for a waterbody with a small catchment, reducing the size of the waterbody or decommissioning • diverting more catchment runoff into the waterbody • using a proprietary product which flocculates fine sediment to the base of the waterbody to create a thick impermeable liner. Apply following a number of rainfall events where suspended solids are elevated to maximise sediment capture on base • draining and sealing the base or bund of the waterbody properly • decommissioning the waterbody • redesigning a waterbody which has a 'leaky' base to ephemeral wetland.

Issue – Water level is consistently too low

Description	Investigations/monitoring	Management actions	Rectification actions
	<ul style="list-style-type: none"> • review the catchment area to ensure the catchment is suitably large enough to sustain water in the waterbody (waterbodies which are large in size compared to their catchment may experience significant water level variation) • review the depth of the system to confirm whether siltation has occurred (may require survey) • complete boreholes in the base of the waterbody to confirm the presence of a clay liner or otherwise. 		<p>Where the waterbody has been constructed recently and certified by a geotechnical engineering or civil engineer, consider taking action for compensation to cover costs of rectification works</p>
<p>Relevant supporting information</p> <p>Nil</p>			

Issue – Flooding of adjacent land, parkland or property, or regular overtopping of the waterbody bund

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Drainage into or out of the waterbody has the potential to flood adjacent land, park or property due to poor hydraulic controls (i.e. uncontrolled water flow out of waterbody)</p>	<p>Determine what the original flow processes for the system were pre-European settlement and use this information to inform management actions. Discuss flooding issues with asset owner and engineering department to identify and document any current or historical issues.</p> <p>Complete site inspection following rainfall to assess flow behaviour through the waterbody system with a focus on inflows and outflows from the waterbody and any recorded flood prone areas.</p> <p>Undertake risk assessment.</p> <p>Further assessment may be required if risk is identified as high. This may include undertaking detailed desktop catchment investigation (areas, landuse including changes, flood/stormwater management reports, flow calculations and/or modelling, complaints register)</p>	<p>Management actions may include:</p> <ul style="list-style-type: none"> • undertaking regular inspection and maintenance of waterbody outlet • regular cleanout of downstream waterways to ensure free drainage of the waterbody. 	<p>If the risk is deemed unacceptable, rectification options may include:</p> <ul style="list-style-type: none"> • modifying outlet structure to control flooding (i.e. lower water levels, increase capacity, staged outlet) • installing or increasing the size of the high flow weir outlet from the waterbody • increasing the capacity of downstream waterways • stabilising flood inflow and outflow locations • diverting upstream catchment into or around waterbody.
<p>Relevant supporting information</p> <p>DEWS (2013)</p>			

Issue – Coarse sediment accumulation

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Coarse sediment is the largest (in terms of quantity) urban stormwater pollutant. Therefore coarse sediment deposition in the inlet zones to waterbodies will eventually be an issue for management.</p> <p>Excessive sediment accumulation within the waterbody may result in the blockage of the preferred flow path and the development of multiple flow paths.</p> <p>The growth of emergent macrophyte vegetation upon silted areas may also influence the hydraulic behaviour of a waterbody system.</p>	<p>Discuss coarse sediment accumulation with asset owner and engineering department to identify and document current or historical issues.</p> <p>Complete site inspection of each of the inflow points into the waterbody to assess coarse sediment accumulation:</p> <ul style="list-style-type: none"> • visible sediment accumulation above or below the normal water level. Sediment accumulation is often most evident near the waterbody inlet zone/s • growth of emergent macrophytes within the waterbody • collection of sediment cores. <p>Undertake risk assessment.</p> <p>Where coarse sediment has accumulated, the cause should be identified. For example:</p> <ul style="list-style-type: none"> • untreated catchment runoff • catchment landuse or activities • failure of stormwater treatment systems within the catchment to adequately capture coarse sediments • erosion of upstream waterways. 	<p>Management actions for coarse sediment can be undertaken (provided access to the inlet zone is possible) and include:</p> <ul style="list-style-type: none"> • desilting the inlet area with machinery or dredges • desilting sediment basins or gross pollutant traps located upstream of the waterbody. 	<p>If the risk is deemed unacceptable and cannot be treated by management actions alone, rectification actions may include:</p> <ul style="list-style-type: none"> • de-watering the waterbody and mechanically removing the sediments • managing the coarse sediment at its source (e.g. stabilising the upstream waterway) • installing gross pollutant traps or sediment basins at the inflow points to the waterbody • creating maintenance access to the inflow zones or sediment capture systems • creating sediment drying and dewatering areas. <p>Note: An analysis of the sediment quality should be undertaken prior to removing sediments in order to determine the contamination level.</p>
<p>Relevant supporting information</p> <p>Simpson <i>et al.</i>, (2005)</p>			

Issue – Fine sediment or organic matter accumulation

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Fine sediment or organic matter accumulation on the bed of the waterbody system has a significant influence on waterbody function. Fine or organic sediment carries a large quantity of particulate nutrients.</p> <p>At the bed of the waterbody the sediment may become anaerobic and nutrients may be released in soluble form into the waterbody water column. Therefore, the fine organic sediment that accumulates on the base of the waterbody can become an almost limitless source of nutrients to support algal blooms and weed growth.</p>	<p>It can generally be assumed that most waterbodies will have fine sediment accumulation. The question is how much accumulation. Discuss fine sediment accumulation with asset owner and engineering services to identify and document any current or historical issues.</p> <p>Complete site inspection of the waterbody to assess fine sediment accumulation. This will require collection of sediment cores using a simple grab sampler or corer and visual inspection. Sample testing may be considered but in most cases the accumulation of fine sediment and organic matter will be obvious. The sediment assessment should be combined with water quality profiling for dissolved oxygen, pH and redox to assess the state of the sediment (i.e. anoxic).</p> <p>Undertake risk assessment.</p> <p>Where fine sediment has accumulated the cause should be identified. For example:</p> <ul style="list-style-type: none"> • untreated catchment runoff • failure of stormwater treatment systems within the catchment to adequately capture fine sediments • erosion of upstream waterways • waterbody is undersized for catchment and thus receiving high sediment and organic loads. 	<p>Where fine sediment and organic matter accumulation is minor and the waterbody water quality is in relatively good condition, monitor waterbody water quality and health. There is no need to remove sediment or organic matter.</p> <p>Clean upstream gross pollutant traps at regular intervals.</p>	<p>Where fine sediment and organic matter accumulation is significant, and has resulted in anoxic conditions and poor water quality in the waterbody then rectification is required. Rectification options include:</p> <ul style="list-style-type: none"> • redesigning the waterbody to a wetland (if shallow enough) • filling in the waterbody • dewatering the waterbody, allowing to dry out and removing the sediment • dredging or desilting the waterbody in wet conditions • sealing the fine sediment under a layer of flocculated sediment (i.e. flocculent added to waterbody) • reconfiguring the inlet to allow capture of organic matter • where a waterbody is very undersized for its catchment, reconfigure inlet zone to either: <ul style="list-style-type: none"> - include dedicated sediment capture area - divert a portion of flows around waterbody.
<p>Relevant supporting information</p> <p>Simpson <i>et al.</i> (2005)</p>			

Issue – Poor flushing or dead pockets

Description	Investigations/monitoring	Management actions	Rectification actions
<p>Poor flushing or dead pockets are indicated by patches of still, stagnant water, sometimes accompanied by an odour and/or algal growth. This is caused locally by areas of open water that are rarely flushed (isolated 'dead pockets') or more broadly waterbodies that have relatively small or infrequent inflows.</p>	<p>Determine what the original flow processes for the system were pre-European settlement and use this information to inform management actions. Discuss poor flushing and dead pockets with asset owner and engineering services to identify and document any current or historical issues.</p> <p>Complete site inspection around the full perimeter of the waterbody to identify potential for dead pockets indicated by:</p> <ul style="list-style-type: none"> • small backwaters which do not receive flowing water • poor water quality and presence of algal blooms. <p>Use aerial images of the waterbody to review where problem areas are located.</p> <p>Poor waterbody bathymetry such as isolated deep zones may also result in localised stratified or deoxygenated zones.</p> <p>Undertake risk assessment.</p>	<p>Where poor flushing exists but is not leading to poor water quality, then no management action is required. Monitor the poorly flushed zones via regular visual inspection.</p>	<p>Where poor flushing is resulting in poor water quality outcomes (i.e. algal blooms) then rectification should occur. Options include:</p> <ul style="list-style-type: none"> • installing recirculation system • removal of islands • reconnecting islands to bank • retrofitting of inlets/ outlets to maximise flushing • redirecting flows through the waterbody to ensure flows pass through dead pockets • reshaping base of the waterbody to remove or fill in dead pockets • decommission the waterbody • redesigning dead pockets to wetland zones.
<p>Relevant supporting information</p> <p>Nil</p>			

Issue – Access for maintenance

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Poor access for maintenance of hydraulic structures and pump infrastructure, removal of sediment from inlet areas, litter removal and weed harvesting can result in deterioration of the system.</p> <p>Ideally maintenance access should be provided to the following locations:</p> <ul style="list-style-type: none"> • stormwater inflows to the waterbody for sediment desilting • edge of the waterbody for weed harvesting or to launch boat • hydraulic controls • broad perimeter of the waterbody for riparian weed management • the side of the waterbody that is downwind from the prevailing wind direction (for removing litter). 	<p>Discuss maintenance access allowance with asset owner, maintenance and engineering departments to identify any current or historical issues.</p> <p>Complete site inspection to identify existing maintenance allowance and obvious access problems.</p>	<p>Provided the maintenance access is constructed from suitable materials (i.e. gravel, concrete or reinforced vegetation), then maintenance will be minimal and based on inspections. Maintenance may involve weeding, removing litter and filling of wheel ruts.</p>	<p>Where maintenance access is deficient installation of formal access will be required. The nature of access for different maintenance activities should be discussed with the asset owner. Rectification actions may include:</p> <ul style="list-style-type: none"> • provision of maintenance access for vehicles, boats and weed harvesters (e.g. ramps for sediment removal, tracks for access to structures) • provision of work areas for sediment drying, maintenance of hydraulic structures and erosion/scour • installation of access tracks.
<p>Relevant supporting information</p> <p>Water by Design (2012a)</p>			

Issue – Scour of batters

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Scoured batters may be hazardous due to the instability of the waterbody edges and presence of under-cut edges.</p> <p>Scour of the batters may result from:</p> <ul style="list-style-type: none"> • high, uncontrolled discharges due to storm inflows • lateral surface flows entering the waterbody via drainage lines • localised high velocities (e.g. shape of waterbody, around inlet) • lapping of water against exposed turf edges • use of inappropriate soils around the edge of the waterbody (dispersive soils and the associated tunnel erosion) • loss of vegetation. 	<p>Discuss scour of waterbody batters with asset owner and engineering and environmental health department to identify and document any potential current and historical issues.</p> <p>Complete a site inspection to check for evidence of scour around the margins of the waterbody and assess the scale of the problem and cause of scour.</p> <p>Following the investigation tasks listed above a decision needs to be made regarding whether the scour issues require rectification or not. This decision will be dictated by the amount of scour, risk of further scour and the public safety risk. Where rectification is undertaken, in most cases this will not require detailed assessment but rather will involve in situ stabilisation.</p>	<p>Where scour exists and has stabilised or is not considered a risk to local government, then no management action is required. Monitor the scour zones via regular visual inspection.</p>	<p>Rectification of significant scour will be dictated by the investigations and may require specialist input from a soil scientist and/or stormwater engineer. Rectification responses may include:</p> <ul style="list-style-type: none"> • reinforcing the eroded areas (e.g. rock protection) • directing inflows to rock-lined channels that feed down the batters to the waterbody • replacing topsoil in scoured zones and re-establishing the vegetation • modifying hydraulic control structure (i.e. inlet and outlet pipes and weirs). <p>If the soil is problematic, seek advice from the soil laboratory for rectification options to meet the specification. In some cases, in situ rectification may be possible (e.g. treating with gypsum followed by placing of non-dispersive topsoil and grass seeding). If not, remove and replace the soil.</p>
<p>Relevant supporting information</p>			
<p>Nil</p>			

Figure 4.15 Blocked waterbody outlet



Photo: Ralph Williams, DesignFlow

Figure 4.16 Leaking waterbody outlet structure



Photo: Ralph Williams, DesignFlow

Figure 4.17 Waterbody where siltation has reduced the water depth, resulting in the growth of aquatic macrophytes



Photo: Maree Manby, Redland City Council

Figure 4.18 Inundation of low-lying land adjacent to a waterbody



Photo: Julian Wakefield, Sunshine Coast Council

Figure 4.19 Waterbody with coarse sediment accumulation around the inlet



Photo: Colin Bridges, Gold Coast City Council

Figure 4.20 A poorly flushed waterbody with irregular inflows



Photo: Jack Mullaly, Logan City Council

Figure 4.21 Waterbody with scoured batters adjacent to inlet structure



Photo: Colin Bridges, Gold Coast City Council

4.3.5 Flora and fauna

Managing flora and fauna is an important component of managing waterbodies and needs to be undertaken with consideration of the surrounding riparian and wetland fringes and broader catchment. Healthy flora and fauna are an essential element of a healthy waterbody. Healthy flora and fauna increase the amenity provided by the waterbody. Unhealthy and problematic flora and fauna often generate public complaints. It is an issue in its own right but can also be symptomatic of broader waterbody issues such as water quality. The issues associated with flora and fauna include:

- aquatic weeds
- terrestrial weeds
- deterioration in health of native aquatic and terrestrial vegetation
- introduced or nuisance fauna
- deterioration in health of native fauna.

Table 4.5 details the management of flora and fauna including:

- methods to investigate and monitor each issue
- management actions – actions that can be implemented rapidly and cost effectively
- rectification actions – actions that require planning, design and budget to implement
- relevant supporting information.

Figures 4.22 and 4.23 provide photographs to help with identifying different flora and fauna issues.

Table 4.5 Waterbody flora and fauna issues and associated management and rectification actions

Issue – Aquatic weeds			
Description	Investigations/ monitoring	Management actions	Rectification actions
<p>The persistence of aquatic weeds within the waterbody may be due to:</p> <ul style="list-style-type: none"> • uncontrolled weed infestations in the upstream catchment • excess sediment accumulation within the waterbody • high nutrient concentrations present within the waterbody • die back of native vegetation allowing weeds to colonise • accidental or illegal introduction (e.g. ornamental ponds or aquarium species such as <i>Salvinia</i>) • seed dispersal (e.g. animals, wind) • lack of regular maintenance • colonisation amongst desirable vegetation making removal difficult. 	<p>Discuss aquatic weed issues with asset owner, engineering and environmental health departments to identify and document any issues.</p> <p>Complete a site inspection to determine presence, proportion, species etc. of weeds</p> <p>Undertake risk assessment.</p> <p>Seek advice from a weed specialist for long term weed removal or control strategies. This will require:</p> <ul style="list-style-type: none"> • confirming the weed species present • identifying the cause/s of the weed infestation • considering the biological characteristics of the weed species • determining long term weed management options. 	<p>The control of declared weeds is mandated under the legislation. Therefore, these weeds must be dealt with as part of the regular maintenance schedule.</p> <p>Refer to <i>Maintaining Vegetated Stormwater Assets (Water by Design, 2012a)</i> for general advice about managing weeds. Management actions may include:</p> <ul style="list-style-type: none"> • regular harvesting using aquatic weed harvester • chemical control (Note: Seek advice from weed specialist if chemical control is being considered. The potential impacts of chemical herbicides on the aquatic ecosystem should be considered) • biological control agents such as the <i>salvinia weevil (Cyrtobagous salviniae)</i> and <i>water hyacinth weevil (Neochetina eichorniae)</i> (Note: Specialist advice should be sought from the CSIRO division of entomology). 	<p>If the risk is deemed unacceptable and the aquatic weed infestation cannot be controlled by management alone, rectification actions include:</p> <ul style="list-style-type: none"> • completely removing the weed species using control methods listed in <i>Maintaining Vegetated Stormwater Assets (Water by Design, 2012a)</i> • draining and drying out the waterbody in order to desiccate the weed species. Obtain specialist advice about the required drying out period • establishing and maintaining healthy submerged and emergent macrophytes within the waterbody • establishing and maintaining healthy riparian vegetation on waterbody margins to improve shading and reduce sources of nutrients. <p>Generally a combination of the above actions is required to manage and/or eradicate infestations.</p>
<p>Relevant supporting information</p> <p>Water by Design (2012a), Refer to Biosecurity Queensland (DAFF, 2013a) website (http://www.daff.qld.gov.au/4790.htm), Australian Weeds Committee (2012), Sainty and Associates Pty Ltd (n.d.), DEEDI (2011b)</p>			

Issue – Terrestrial weeds

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>The persistence of terrestrial weeds along waterbody edges or adjacent to the waterbody may be due to:</p> <ul style="list-style-type: none"> • uncontrolled weed infestations in the upstream catchment • discontinuous or fragmented perimeter vegetation • die back of native vegetation allowing weeds to colonise • accidental or illegal introduction • seed dispersal (e.g. animals, wind) • lack of maintenance • contaminated fill and/or mulch (on batters) • sediment deposition following flood events • poorly draining edges which result in sodden conditions conducive to weed (e.g. Typha) growth. 	<p>Discuss terrestrial weed issues with asset owner, engineering and environmental health departments to identify and document any current and historical issues.</p> <p>Complete a site inspection to determine presence, proportion, species etc. of weeds.</p> <p>Undertake risk assessment.</p> <p>Seek advice from a weed specialist for long term weed removal or control strategies. This will require:</p> <ul style="list-style-type: none"> • confirming the weed species present • identifying the cause/s of the weed infestation • considering the biological characteristics of the weed species • determining long term weed management options. 	<p>The control of declared weeds is mandated under the legislation. Therefore, these weeds must be dealt with as part of the regular maintenance schedule.</p> <p>Refer to <i>Maintaining Vegetated Stormwater Assets</i> (Water by Design, 2012a) for general advice about managing weeds.</p> <p>Management actions include:</p> <ul style="list-style-type: none"> • chemical control (Note: Seek advice from weed specialist if chemical control is being considered. The potential impacts of chemical herbicides on the aquatic ecosystem should be considered) • regular inspection and application of clean mulch around waterbody perimeters. 	<p>If the risk is deemed unacceptable and the terrestrial weed infestation cannot be controlled by management alone, rectification actions include:</p> <ul style="list-style-type: none"> • completely removing the weed species using control methods listed in <i>Maintaining Vegetated Stormwater Assets</i> (Water by Design, 2012a) • establishing and maintaining healthy riparian vegetation on waterbody margins. <p>Generally a combination of the above actions is required to manage and/or eradicate infestations.</p>

Relevant supporting information

Water by Design (2012a), Australian Weeds Committee (2012), Sainty and Associates Pty Ltd (n.d.). DEEDI (2011b)

Issue – Deterioration in health of native aquatic and terrestrial vegetation

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Deterioration in the health of native aquatic and terrestrial vegetation in and around waterbodies can lead to a decrease in amenity values and a loss of habitat and ecological function, as well as being symptomatic of other waterbody issues.</p> <p>Deterioration in the health of native aquatic and terrestrial vegetation can be due to:</p> <ul style="list-style-type: none"> • inappropriate water levels • variable water levels • disease • competition from weeds • damage by fauna, particularly birds • erosion of batters • poor water quality • overspray of herbicides for weed control • extreme weather events (e.g. flood, drought) • use of non-endemic vegetation not suitable for the location. 	<p>Discuss the deterioration in health of native aquatic and terrestrial vegetation with asset owner, engineering and environmental health departments to identify and document any current and historical issues.</p> <p>Complete a site inspection to determine the extent and severity of the deterioration in health of native aquatic and terrestrial vegetation.</p> <p>Undertake a risk assessment.</p> <p>Seek advice from a vegetation specialist to determine the cause of the deterioration in health of the vegetation.</p>	<p>The management actions undertaken will depend upon the cause of the deterioration in health of the native aquatic and terrestrial vegetation. For information on:</p> <ul style="list-style-type: none"> • inappropriate or variable water levels, refer to Table 4.4 • competition from weeds, refer to 'Aquatic weeds' or 'Terrestrials weeds' in this table • damage by fauna, particularly birds, refer to 'Introduced or nuisance fauna' in this table • erosion of batters, refer to 'Scour of batters' in Table 4.4 • poor water quality, refer to Table 4.2. 	<p>If the risk is deemed unacceptable, actions to rectify the deterioration in health of native aquatic and terrestrial vegetation must be undertaken. The actions undertaken will depend on the cause of the problem. For information on:</p> <ul style="list-style-type: none"> • inappropriate or variable water levels, refer to Table 4.4 • competition from weeds, refer to 'Aquatic weeds' or 'Terrestrials weeds' in this table • damage by fauna, particularly birds, refer to 'Introduced or nuisance fauna' in this table • erosion of batters, refer to 'Scour of batters' in Table 4.4 • poor water quality, refer to Table 4.2.
<p>Relevant supporting information</p> <p>DERM (2011)</p>			

Issue – Introduced or nuisance fauna

Description	Investigations/ monitoring	Management actions	Rectification actions
<p>Introduced and/or nuisance fauna (e.g. Ibis, ducks, exotic fish) can lead to a decrease in amenity values and a decrease in water quality.</p> <p>The presence of introduced or nuisance fauna may be due to:</p> <ul style="list-style-type: none"> • their presence in nearby environments • a readily available food source • suitable habitat • dumping of domestic fauna. 	<p>Discuss the introduced or nuisance fauna with asset owner, engineering and environmental health departments to identify and document any current and historical issues.</p> <p>Complete a site inspection to determine the extent and severity of the introduced or nuisance aquatic fauna.</p> <p>Undertake a risk assessment.</p> <p>(Note: The capture, removal or destruction of animals is governed by strict ethical considerations and should only be undertaken by qualified staff, in accordance with NHMRC (2004))</p>	<p>The management actions undertaken will depend on the type of introduced or nuisance fauna and the cause. Actions may include:</p> <ul style="list-style-type: none"> • reduction in food sources • signage to discourage feeding of wildlife. <p>See Table 4.2 for further details on management actions for the presence of exotic fish species.</p>	<p>If the risk is deemed unacceptable, actions to rectify the introduced or nuisance fauna must be undertaken. The actions undertaken will depend on the type of fauna and the cause of the problem. Actions may include:</p> <ul style="list-style-type: none"> • removing, moving on or culling introduced or nuisance fauna by an appropriate contractor in accordance with NHMRC (2004) (permit may be required) • where repeated dumping of domestic fauna occurs, community education should occur to build education and understanding of the issue • removing habitat (may require permit). <p>See Table 4.2 for further details on rectifying the presence of exotic fish species</p>

Relevant supporting information

NHMRC (2004), DEEDI (2011b)

Issue – Deterioration in health of native fauna

Description	Investigations/monitoring	Management actions	Rectification actions
<p>The deterioration in health of native fauna can lead to decrease in amenity and lead to public complaints. It can also be symptomatic of other issues within the waterbody.</p> <p>The deterioration in health of native fauna may be due to:</p> <ul style="list-style-type: none"> • predation and competition • disease • poor water quality • lack of food and habitat. 	<p>Discuss the deterioration in health of native fauna with asset owner, engineering and environmental health departments to identify and document any current and historical issues.</p> <p>Complete a site inspection to determine the extent and severity of the deterioration in health of native fauna.</p> <p>Undertake a risk assessment.</p> <p>Where the cause of the deterioration in health of native fauna is not immediately apparent, seek specialist advice.</p> <p>Where disease or poor water quality is suspected, consider testing of dead animals and water quality to determine cause.</p> <p>(Note: The capture, removal or destruction of animals is governed by strict ethical considerations and should only be undertaken by qualified staff, in accordance with NHMRC (2004))</p>	<p>Management actions include:</p> <ul style="list-style-type: none"> • removing carcasses of dead animals • capture and treatment of unwell animals • where predation by non-native fauna is suspected, refer to 'Introduced or nuisance fauna' in this table • where poor water quality is suspected, refer to Table 4.2. 	<p>If the risk is deemed unacceptable, actions to rectify the deterioration in health of native fauna must be undertaken. The actions undertaken will depend on the cause of the problem. For information on:</p> <ul style="list-style-type: none"> • predation and competition by non-native fauna, refer to 'Introduced or nuisance fauna' in this table • poor water quality, refer to Table 4.2 <p>Undertake testing of dead animals to determine if disease is the cause. The response will be dependant on the disease and a specialist should be consulted.</p> <p>When lack of habitat resources is the suspected cause, it may be possible to reintroduce aquatic or terrestrial habitat by restoring vegetation cover and structural components.</p>
<p>Relevant supporting information</p> <p>NHMRC (2004)</p>			

Figure 4.22 Waterbody with aquatic weeds (Salvinia)



Photo: Colin Bridges, Gold Coast City Council

Figure 4.23 Waterbody with terrestrial weeds



Photo: Julian Wakefield, Sunshine Coast Council

4.4 MANAGEMENT ACTIONS

Section 4.3 detailed how to identify common waterbody issues, investigate them and select appropriate management and rectification actions. Many of these actions are simple, and the skills are likely to already exist within many local governments. Other actions however, are more complex and require specialist knowledge and skills. This section explores these more complex actions and provides useful advice about how and where to obtain more information. The actions addressed in this section are:

- providing appropriate access for maintenance
- dewatering a waterbody
- modifying waterbody configuration
- repairing erosion
- managing silt and organic matter
- repairing leaking waterbodies
- promoting mixing of waterbody waters
- managing weeds
- redesigning waterbodies to high ecological value wetlands
- recirculating water through treatment systems
- in situ water treatment with floating wetlands
- removing a waterbody.

4.4.1 Providing appropriate access for maintenance

Easy access to a waterbody is critical for undertaking maintenance activities such as sediment removal or weed harvesting and control. Access should be provided to the:

- main water
- inlets and outlets
- the perimeter of the waterbody.

Ideally maintenance access should be provided in accordance with Table 4.6

Some waterbodies will not contain the appropriate maintenance access. Maintenance access can be expensive to construct, particularly if retrofitting it to an existing waterbody. Before constructing maintenance access to a waterbody, consider how regularly the maintenance access will be used. A waterbody in good condition with limited pressures may require only very irregular access into the waterbody itself, and may not justify the expense of a concrete or rock access ramp.

Where accesses are to be constructed, landscape integration should be considered to soften the impact. Shared paths could be considered to provide public trails as well as maintenance access.

Table 4.6 Maintenance access requirements

Access Provided	Purpose	Design Specifications
Stable access ramp into the waterbody	For machine/boat access into or onto the waterbody	<ul style="list-style-type: none"> • appropriate to the machinery required to maintain the waterbody • concrete or rock • maximum grade of 1:4 • minimum width of 4 m • equipped with a barrier suitable to the location to restrict public access
A stable, well drained dewatering pad	For dewatering of removed sediments	<ul style="list-style-type: none"> • large enough to store wet material extracted from waterbody until it can dry and be removed • where the waterbody contains an inlet pond, dewatering pad should be located adjacent to the inlet pond
Access for trucks to waterbody	For removal of sediment and weeds	<ul style="list-style-type: none"> • hardstand vehicular access
Access to the entire perimeter of waterbody	For vegetation and mosquito management	<ul style="list-style-type: none"> • trafficable trails
Access to inlets, outlets and other hydraulic structures	For managing hydraulic structures	<ul style="list-style-type: none"> • stable surface that minimises vehicle rutting • minimum 2.5 m width

4.4.2 Dewatering a waterbody

In some instances it will be necessary to lower the water level, drain or dewater a waterbody in order to undertake other maintenance or rectification activities such as removing sediment or repairing a waterbody's impermeable liner.

Prior to dewatering a waterbody, be sure to consider:

- acid sulfate soils – acid sulfate soil maps should be reviewed, and if the waterbody is in a high risk area, on-ground investigation (e.g. test pitting) must be undertaken. If acid sulfate soils are present, engage the help of a specialist to develop and implement a management plan prior to dewatering
- approvals – investigate whether any approvals are required prior to discharging water particularly in relation to spread of aquatic weeds or pests
- any potential fish kills or species die off that may result from dewatering

- removing and relocating fauna
- whether the system is online or offline from a watercourse and its connection to the broader wetland and catchment
- where to discharge the water after dewatering, including consideration of options for re-use (e.g. rural fire fighting)
- the effect of dewatering on environments sensitive to environmental flows
- presence of invasive species or toxins.

Prior to dewatering, all inlets to the waterbody should be blocked to prevent inflows. Where the waterbody is offline, this can be done by simply blocking the inlet. Where the waterbody is online, a bypass must also be established. This could include constructing a diversion channel, or partitioning the inlet off from the majority

of the waterbody, and pumping any inflows to the waterbody outlet. When blocking inlets be sure not to cause upstream flooding.

Dewatering can be undertaken either by pumping, or gravity. Some waterbodies will contain a dedicated maintenance valve which allows the water level to be controlled and the waterbody to be free-drained. It is possible to drain a waterbody by gravity by breaching the waterbody wall or bund, however, be aware that a structurally sound bund must be reinstated if the waterbody is not being removed. This may be an expensive task.

When dewatering a waterbody by pumping out the water it may be possible to discharge it onto adjacent vegetated areas. This will help to remove sediments and solids from the water before entering downstream waterways. Be sure that:

- the area where water is discharged is not susceptible to erosion
- any contaminants in the water do not present a risk to human health
- the water does not create a flooding or a drainage nuisance.

Regardless of the method used to dewater the waterbody, many waterbodies will have an uneven base, which will form isolated pools which must each be drained individually.

In some instances a waterbody may be fed by groundwater. In these cases, the rate of draining must be greater than the rate of groundwater inflow to the waterbody. The works must be undertaken promptly to avoid artificially lowering the local groundwater (even temporarily), and to reduce dewatering costs.

If a waterbody contains a large amount of organic matter (either accumulated organic matter or fresh plant material) and the waterbody remains dewatered for more than a short period of time, the organic matter may start to decompose releasing odours.

4.4.3 Modifying waterbody configuration

When managing waterbodies it may be necessary to modify the configuration (shape, size or bathymetry) of a waterbody. The configuration of a waterbody may be modified to:

- reduce the risk of injury or drowning because of inappropriate batters or edges to the waterbody
- reduce mosquito habitat
- improve the hydraulic efficiency of the waterbody (improve flushing, reduce stratification and eliminate dead pockets).

Modifying the configuration of a waterbody may include activities such as:

- re-profiling the edges
- modifying the profile of the base of the waterbody
- removing islands
- filling parts of the waterbody (including reconnecting islands to the waterbody bank).

The waterbody should generally be dewatered (see Section 4.4.2) prior to modifying its bathymetry, although in some cases it may be possible to modify by placing and configuring rock material from the edges.

Before modifying a waterbody's bathymetry, obtain and comply with any necessary approvals and standards.

Achieving a cut and fill balance is desirable when modifying the configuration of a waterbody as this will avoid costs associated with importing or disposing of fill offsite. If the activity being undertaken necessitates the disposal of material from the site, the potential for soil contamination will need to be considered.

It is not unusual for sediment in urban waterbodies to become contaminated with heavy metals and other toxic substances. The disposal of contaminated sediment is expensive and should be undertaken in accordance with legislative requirements.

If soil is imported to the site, it must:

- be uncontaminated (e.g. no toxic materials or weeds)
- preferably be clay type material
- not be dispersive.

When modifying the configuration of a waterbody it is important to make sure that the clay liner is not damaged (this will ensure that the waterbody continues to retain water). Where excavation occurs this is particularly important and the clay liner may need to be reinstated. Clay liners can be constructed from:

- compacted clay sourced on-site
- proprietary liners such as bentonite sheets
- imported clay.

Over time all waterbodies will accumulate some silt or organic material at the base. Accumulated material will typically appear as an unconsolidated layer lying upon the sediment or clay base.

The unconsolidated layer generally ranges in depth between 25-500 mm (but may range in depth up to 1 m in some waterbodies) and must be managed in areas where work is taking place as it is unlikely to compact/stabilise sufficiently if left in situ with no treatment. If large quantities of unconsolidated silt or organic matter are present, options include:

- removing the unconsolidated silt or organic matter
- stabilising the unconsolidated silt or organic matter in situ – specialised methods exist such as mixing in very low percentages of cement to improve the properties of silt and make it workable.

Where planting is proposed, topsoil should be laid at a minimum depth of 150 mm over all clay liners to provide a substrate for aquatic macrophytes to grow in. Topsoil should be in accordance with AS4419 (2003) *Soils for Landscaping and Garden Use*.

Design Tips

When modifying a waterbody's configuration to reduce the risk of unsafe edges, consider the guidance supplied in Appendix A of *Rectifying Vegetated Stormwater Assets* (Water by Design, 2012b)

Design Tips

When modifying a waterbody's configuration to reduce mosquito habitat, ensure that:

- the waterbody edge is free draining across all operating water levels (i.e. the profile of the base does not contain any isolated areas where water can pool during times of reduced water level)
- a minimum (shallowest) grade of 2% of waterbody batters below the maximum possible water level to allow free draining areas.

Design Tips

When modifying a waterbody's configuration to remove dead spots, consider the following techniques:

- round-off sharp corners surrounding dead spots
- infill dead pockets to create terrestrial or wetland plant dominated areas
- fill in deep isolated pools.

Design Tips

When modifying a waterbody's configuration to improve hydraulic efficiency:

- achieve a length to width ratio of 3:1 or greater
- consider reconnecting islands to bank flow paths and reduce total waterbody volume.

4.4.4 Repairing erosion

In some instances it will be necessary to repair erosion within waterbodies. Erosion can occur within waterbodies for a variety of reasons. Small amounts of erosion can, in the long term, extend and turn into a large problem, including channelling of flows, undermining of headwalls and pipes, compromising the integrity of bunds and clay liners and impacting on plant health. The response will depend on the type of erosion. Table 4.7 details possible responses to repair common types of erosion. Refer to *Rectifying Vegetated Stormwater Assets* (Water by Design, 2012b) if erosion is recurring or severe.

Table 4.7 Responses to repair common types of erosion

Erosion Type	Response
Erosive lateral flows down waterbody batters	If dispersive soils are present, treat (ameliorate) soils and formalise inflows with stable channels down batters.
High flows around outlet structures	Reinforce or redesign outlet as required. Refer to the <i>Queensland Urban Drainage Manual</i> (DEWS, 2013) for typical responses.
Wind induced wave actions acting on batters	Where the fetch length of the waterbody is short (<500 m): <ul style="list-style-type: none"> • treat (ameliorate) or replace dispersive soils • re-profile batters • place good quality, non-dispersive topsoil (AS4419, 2003 compliant) on batters • heavily revegetate on batters. Where the fetch length of the waterbody is long (>500 m): <ul style="list-style-type: none"> • implement structural response such as revetment walls.
Poorly structured or dispersive soils on waterbody batter/s (Figure 4.24)	Treatment options include mixing dispersive sub-grade with gypsum and capping with non-dispersive topsoil. Revegetation can then occur (e.g. hydroseeding) (Figure 4.25).

Figure 4.24 Erosion of a waterbody batter caused by dispersive soils



Photo: Ralph Williams, DesignFlow

Figure 4.25 Revegetation of a waterbody batter



Photo: Ralph Williams, DesignFlow

4.4.5 Managing silt and organic matter

Silt and organic matter may need to be removed from a waterbody for a number of reasons. In most cases it is to improve water quality. Managing silt and organic matter can entail either removing the matter or stabilising it in situ.

Removing silt and organic matter can occur either while the waterbody is full of water (and thus the silt or organic matter is saturated) or after the waterbody is dewatered. Sediment and organic matter can be removed from a waterbody while full of water by:

- suction dredging via barge
- suction dredging from waterbody edge (smaller waterbodies only)
- suction dredging using specialised equipment such as a 'sludge rat'
- mechanical extraction from waterbody (Figure 4.26).

Figure 4.26 Mechanical extraction of silt, organic material and weeds from a waterbody



Photo: Colin Bridges, Gold Coast City Council

Disposing of the sediment or organic matter while saturated is best avoided as it is difficult to transport and can leak on public roads, and it significantly adds to the cost of both transport and disposal. It is recommended that sediment or organic matter is dewatered prior to disposal. Methods for dewatering include:

- drying on-site in a dedicated dewatering area
- dewatering within suction trucks (some suppliers only)
- dewatering on-site using geotextile bags.

Dewatering the waterbody enables the sediment and organic matter to be removed in a drier form via mechanical means (i.e. excavation).

In some cases it may not be necessary to remove accumulated silt or organic matter to solve the waterbody issues. In these situations, stabilising the matter in situ may be a viable alternative. Silt and organic matter can be stabilised in situ in waterbodies by:

- capping – see the *Townsville Constructed Lakes Guideline* (DesignFlow, 2010) for further details on sediment capping
- amelioration – additive such as concrete may be added in small quantities (using specialised equipment) to turn otherwise unstable and unworkable silt into a stable, workable material (Figure 4.27). Seek specialist assistance.

Figure 4.27 Stabilising silt by ameliorating it with concrete



Photo: Ralph Williams, DesignFlow

4.4.6 Repairing leaking waterbodies

Leakage from waterbodies generally occurs via either the impermeable liner or a component of the outlet (e.g. pit, embankment). The method used to fix the leaking waterbody is dependent on where the waterbody is leaking from. An alternative option to repairing the leak is to redesign the leaky waterbody into an ephemeral wetland, further information on this is provided in Section 4.4.9.

A major challenge with fixing leaking waterbodies, particularly those leaking from the impermeable liner is that it can be very difficult to locate the leak. Implementing an effective solution can also be difficult. It is therefore possible to waste a large amount of time and resources attempting to fix a leaking waterbody with no success.

The first step in fixing a leaking waterbody is to identify the source of the leak. There are certain indicators that can be used to help locate the source of the leak. For example, an obvious wet or lush green area downstream

of the wall is a likely sign of a leak in that vicinity. Similarly, checking outlet structures for cracks, leaking valves or seepage can help to identify if the outlet structure is the source of the leak.

Monitoring waterbody water level over a period of time can quantify the extent of the leakage. Seasonal variations may be indicative of groundwater interactions (i.e. when the groundwater level is high the waterbody is not likely to leak and when the groundwater level is low waterbody leakage is more likely). If groundwater monitoring wells are available in close proximity to the waterbody, monitor groundwater levels together with waterbody levels.

Repairing leaking liners

Prior to embarking on waterbody liner rectification, field investigations should be completed to determine if this is the primary cause. This is likely to require the installation of shallow monitoring wells around the edge of the waterbody, and subsequent water level monitoring of both waterbody and groundwater. These monitoring wells can be simple 50 mm diameter PVC pipe installations backfilled with sand around the pipe opening. Refer to the *Townsville Constructed Lakes Design Guideline* (DesignFlow, 2010) for a typical installation.

Where the waterbody liner is determined to be the source of the leak, possible fixes include:

- Distributing bentonite across the water surface in order for it to settle and seal the leaks. Note: This is considered a highly unreliable method for sealing waterbodies.
- Dewatering waterbody, removing unconsolidated silt and organic matter and then rotary hoeing the bentonite layer into the consolidated base material. When the waterbody is refilled, the bentonite will absorb water, swell and seal base. Note: This method is considered to be a more reliable strategy than distributing bentonite across the water surface.
- Dewater waterbody and lay geotextile clay liner on the base of waterbody to seal base. Whilst this method is commonly used to seal waterbodies, it is expensive and results can be variable due to difficulties sealing the interface between the geotextile clay liner and the outlet structures (e.g. outlet pit)
- Dewater waterbody, desilt and reconstruct compacted clay liner, similar to the method used when constructing stormwater treatment wetlands.

Care must be taken to fully seal areas such as pipes perforating impermeable liners as these can be common sources of leakage.

Repairing leaking embankments

Where the waterbody embankment is determined to be the source of the leak, the problem may be solved by:

- installing a cut-off wall
- sealing the face of the embankment.

Installing a cut-off wall is done by:

1. determining the general location of the leak within the waterbody embankment
2. digging a vertical trench along the embankment in the vicinity of the leak
3. filling the trench with compacted clay (or clay mixed with bentonite) to form an impenetrable barrier.

Sealing the face of the embankment is done by dewatering the waterbody, desilting and then reconstructing compacted clay liner as typically done when constructing stormwater treatment wetlands. Clay liner is constructed on the internal (wet) side of the embankment and generally has a minimum depth of 300 mm. A protective topsoil layer should be provided over the clay liner to minimise any potential cracking from drying out.

Further information is provided by various Australian State governments in the form of advice to landholders on sealing leaking farm dams. For example, see *Leaking Farm Dams* (DPI, 2004) and *Treatment of Leaky Dams* (DA, 2006).

Repairing leaking hydraulic structures

Hydraulic outlet structures can leak in any number of ways. Common leaks include:

- faulty maintenance valves (for draining waterbody)
- poorly sealed pipes
- faulty weir plates
- damaged pipes and pits.

Fixing leaking structures such as these will be site specific, and specialist advice is generally required to have the greatest chance of success.

Where tunnel erosion occurs adjacent to an installed pipe due to improperly compacted materials or pipe leakage, it may be necessary to reinstall the pipe with a cut-off wall and/or seepage collars. Seek specialist advice.

4.4.7 Promoting mixing of waterbody waters

Promoting mixing within waterbodies is used to minimise stratification. Mixing also keeps the waterbody oxygenated, sediments healthy and thus decreases the risk of nutrient release and related algal growth occurring within the waterbody. Oxygen enters the water via diffusion at the water's surface. Increasing turbulence at the water surface can increase the uptake of oxygen within waterbodies.

Well designed waterbodies promote oxygenation via wind forced mixing. This can be achieved by orientating the waterbody appropriately to the prevailing wind direction and establishing a smooth, flat base within the waterbody. Once a waterbody has been constructed it is much harder to promote additional wind mixing. Wind mixing can be encouraged by:

- altering the shape or size of a waterbody (see Section 4.4.3) (e.g. removing an island) to increase the fetch length of the waterbody in the prevailing wind direction
- modifying the bathymetry of the waterbody (see Section 4.4.3) to create a smooth flat base as this promotes more turbulent mixing at the waterbody surface.

One of the most effective ways to promote mixing is to retrofit the waterbody with a recirculation system that is able to circulate water from poorly mixed areas to well mixed areas. This has been shown to be effective in large waterbodies such as the Gold Coast Botanic Gardens. Do some simple calculations and try to move the volume of water in dead pockets out every 2-3 days. For example, a 2 m deep, 20 m² section of dead water equates to 40 m³ or 40,000 L of water. For this water to be pumped out in 3 days (72 hours, or 4320 min), it would take a pumping rate of about 10 L/min.

Proprietary devices are also available that enhance mixing within waterbodies. Effective mixing systems promote both convection (movement of water within the waterbody) and oxygenation (via turbulence at the water surface).

For this reason, systems such as fountains which are not designed to establish convection are usually ineffective at promoting mixing and preventing stratification.

Effective mixing devices are typically one of two types:

- floating or submersible pump systems – these pump water from the base of the waterbody and distribute it on the surface to promote both convection and oxygenation
- aerators – these release air bubbles at the base of the waterbody to promote both convection and oxygenation.

Proprietary mixing devices can be expensive to purchase and operate. In most circumstances, the size and configuration of the mixing system will need to be custom designed for the waterbody to ensure that they are effective.

Solar powered proprietary mixing devices are also available. These are often an attractive option as they have substantially reduced running costs (Figure 4.28).

Figure 4.28 Solar water circulation system close up



Photo: Karen McNeale, Redland City Council

4.4.8 Managing weeds

Weed management is a critical component of looking after waterbodies effectively. Consult *Maintaining Vegetated Stormwater Assets* (Water by Design, 2012a) for detailed information on managing weeds in waterbodies. Note that while the information provided pertains to constructed stormwater treatment wetlands and sediment basins it is equally applicable to waterbodies.

4.4.9 Redesigning waterbodies to high ecological value wetlands

In many instances, redesigning a waterbody to a wetland is an option to reduce long term maintenance costs and create a more sustainable system, particularly where external pressures such as nutrient loadings are high and the waterbody experiences water quality problems. It can also be used to repurpose a leaking waterbody.

Redesigning a waterbody to a wetland may take several forms:

- redesigning the entire waterbody into a wetland
- redesigning a strip or band across the main flow path within the waterbody into a wetland
- redesigning a dead pocket within a waterbody into a wetland
- redesigning a leaking waterbody into an ephemeral wetland.

The first three options should be designed in accordance with the wetland chapter of the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (Water by Design, 2006) and the *Wetland treatment systems* section of the *Wetland Management Handbook: Farm Management Systems* (DEEDI, 2011b). Note that this guidance is tailored towards designing wetlands to treat stormwater. When redesigning a waterbody into a wetland, the primary purpose is to reduce maintenance and create a more sustainable asset. Stormwater treatment is likely to be a secondary consideration. Priority should be given to designing the most sustainable, easily maintained wetland possible.

Figure 4.29 Inside a detention basin configured as an ephemeral wetland



Photo: Jack Mullaly, Logan City Council

Redesigning a leaking waterbody into an ephemeral wetland should also be undertaken in accordance with the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (Water by Design, 2006), with the following considerations:

- in South East Queensland, an ephemeral wetland dominated by *Melaleuca* species to mimic the natural *Melaleuca* wetlands of South East Queensland is likely to be a low maintenance, sustainable solution
- creating a sustainable, biodiverse terrestrial ecosystem similar to that described in Blanche (2010)
- modification of the outlet structure to achieve appropriate inundation duration (the existing outlet arrangement of the waterbody is likely to result in inundation for longer than an ephemeral wetland can sustain)
- careful selection of outlet structure to prevent blockage.

Figure 4.29 depicts the understory of an ephemeral detention basin which presents many of the same features that could be incorporated into the conversion of a tree dominated waterbody to an ephemeral wetland.

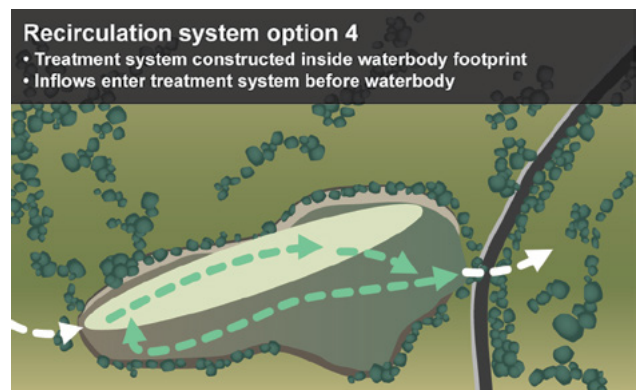
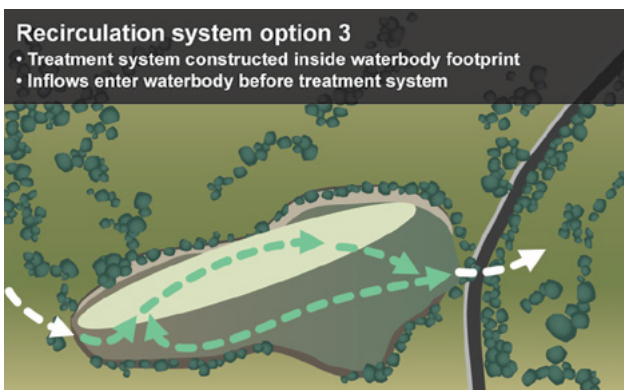
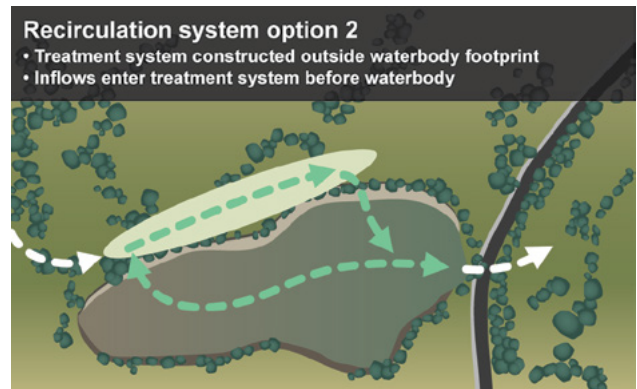
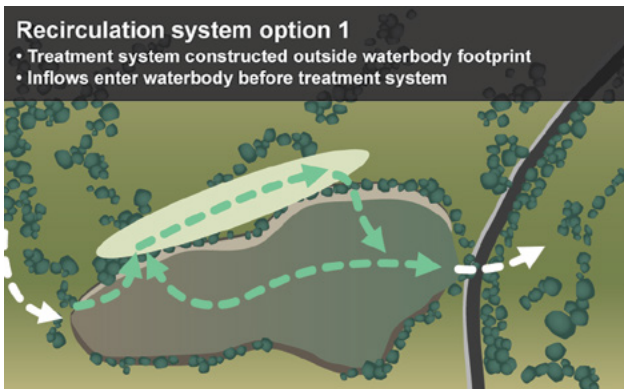
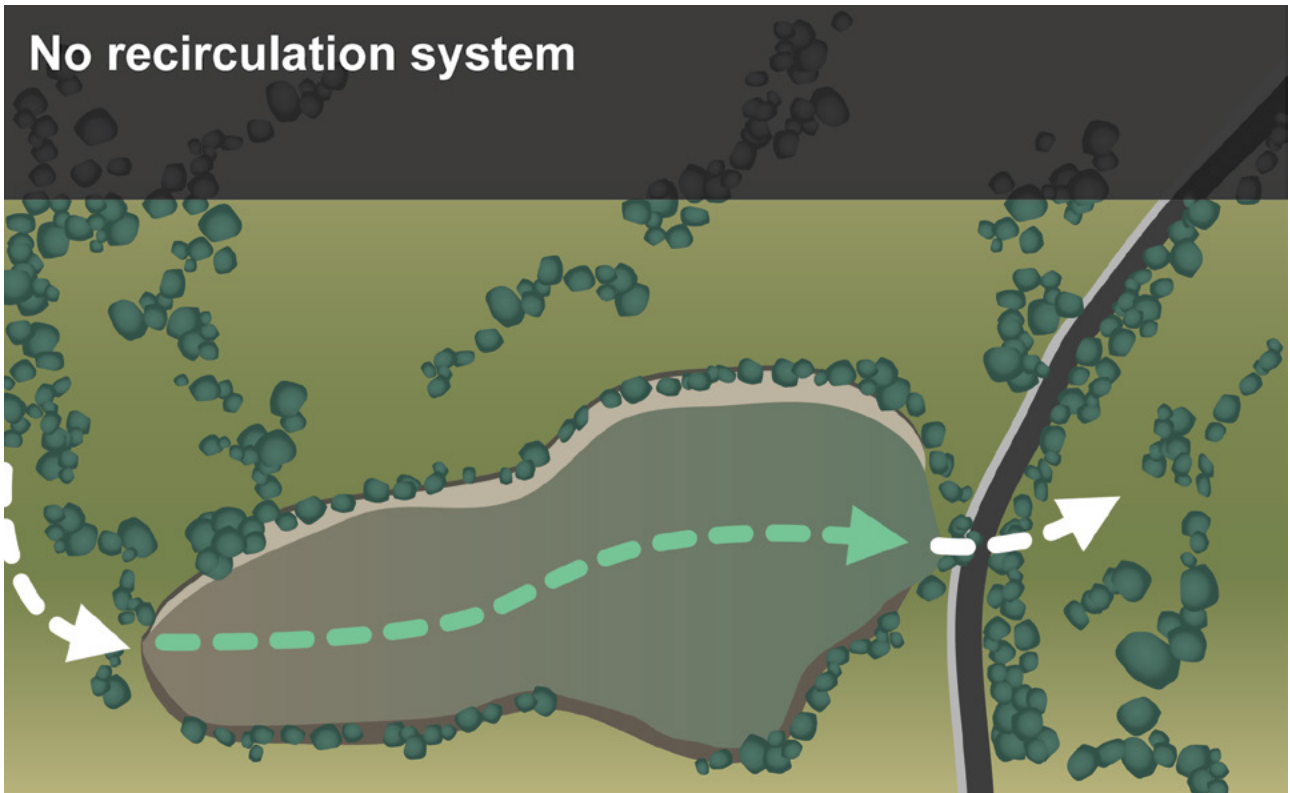
4.4.10 Recirculating water through treatment systems

Recirculating waterbody water through treatment systems can be used to manage water quality in waterbodies. Most often, constructed wetlands are proposed, however bioretention systems and mechanical systems such as sand filters and ultra-filtration could also be used.

The use of treatment wetlands incorporated as part of waterbody recirculation systems is often linked to attempts to manage cyanobacterial blooms in waterbodies. It should be noted that there is little evidence to suggest that constructed wetlands directly remove cyanobacterial cells from water. Treatment wetlands function to improve water quality and thereby reduce the likelihood of cyanobacterial and algal blooms occurring within the waterbody.

Constructed wetlands or bioretention systems can be configured in multiple ways as part of a waterbody recirculation system as shown in Figure 4.30.

Figure 4.30 Possible configurations of vegetated stormwater treatment systems for recirculating waterbody water



Where a recirculation system is considered for use in a waterbody that is oversized for its catchment, locating the treatment system within the existing footprint of the waterbody is desirable as this decreases the overall volume of the waterbody and hence increases hydraulic efficiency and overall resilience of the waterbody to algal and cyanobacterial blooms.

Where a wetland is proposed as part of a waterbody recirculation system it should be designed in accordance with the *Water Sensitive Urban Design Technical Design Guidelines for South East Queensland* (Water by Design, 2006) and the recirculation systems advice provided in the *Townsville Constructed Lakes Design Guideline* (DesignFlow, 2010) and the *Water by Design Urban Lakes Discussion Paper* (2012c).

Due care must be given to the design of wetlands that will receive both stormwater inflows and recirculated waterbody flows. For example, the residence time required in a recirculation wetland is typically longer than for stormwater treatment, and the outlet configuration of the wetland must be appropriately designed to achieve the desired wetland performance.

Recirculating wetlands are also likely to operate over extended periods of time. Due care should be taken when selecting plants for the expected operating conditions.

Bioretention systems can also be used in a waterbody recirculation system. Bioretention systems should be designed in accordance with the *Bioretention Technical Design Guideline* (Water by Design, 2012d). Note that bioretention systems will grow algae on the filter media surface and block if continually loaded with recirculated water. A waterbody recirculation system using a bioretention system for treatment will require multiple bioretention cells so that individual cells can be rested periodically to dry, preventing algal growth. This will require additional pumping and distribution systems compared to a recirculation system using a constructed wetland.

4.4.11 In situ water treatment with floating wetlands

Floating wetlands are growing in popularity as a potential tool for managing water quality in waterbodies. As an emerging technology there still needs to be more research undertaken to fully understand the performance they can be expected to deliver.

Many local governments in South East Queensland are currently trialling floating wetlands in urban waterbodies. Further data can be expected to be available in the future.

Floating wetlands can be either purchased as

proprietary off the shelf products, or constructed from simple materials. Both options present their advantages and disadvantages.

Regardless of the option chosen, the key functional elements of floating wetlands are:

- buoyancy – even under fully grown vegetation
- lightweight – to allow for easy handling and movement, and contribute to buoyancy
- durable – the floating wetland must be long lasting to allow for plants to establish
- bird protection – birds will roost in floating wetlands damaging vegetation. Netting or other protection must be robust to prevent damage by birds, particularly during the establishment phase of vegetation
- support for vegetation – ideally the stems of vegetation should sit slightly above the water surface. Vegetation can be either supported by a growing media, or suspended in the water column similar to a hydroponic system
- anchor points and cable fixing – to allow position and secure floating wetlands within waterbodies.

4.4.12 Removing a waterbody

In some circumstances, removing a waterbody may be the best outcome for a local government and the community. There are several ways to remove a waterbody. Some methods include:

- removing an embankment and restoring as a waterway
- infilling waterbody and restoring as a waterway
- disconnecting drainage to waterbody (when located offline), infilling waterbody and restoring usable land
- converting to a stormwater treatment system (Figure 4.31)
- converting to a stormwater detention system (Figure 4.32).

Figure 4.31 A waterbody converted into a stormwater treatment system



Photo: Andrew O'Neill, Water by Design

Figure 4.32 A waterbody converted into a stormwater detention system by inserting a pipe through the embankment



Photo: Jack Mullaly, Water by Design

Prior to removing a waterbody, consider the following to ensure unexpected adverse outcomes are avoided:

- What is the community's expectation from the waterbody?
- Does the waterbody have a flood or conveyance function?
- Does the waterbody have flora or fauna that rely on the ecosystem?
- Does the waterbody have weeds that must be managed? How will this be done?
- Does the waterbody need to be dewatered before being removed? How will this be done?
- How will the waterbody area be stabilised prior to removing?
- How will the sediments be managed?

4.5 WORKED EXAMPLE

This worked example demonstrates how a hypothetical local government may go about using information provided in this module to select the correct maintenance or rectification action for a waterbody, and then implement that action.

4.5.1 Setting

Sunnyside Council is a small to medium sized local government in South East Queensland. It contains several creek systems and one river. The lower reaches of these catchments are typically urban. The upstream reaches are a combination of rural, forest and conservation. There are a large number of waterbodies in Sunnyside Council. Approximately 70% are on private land, with the remaining 30% on Council land.

Due to a series of prominent incidents in Council managed waterbodies, including a fish kill, Sunnyside Council recently undertook to improve how it manages its waterbodies. The two main aims of this were to achieve acceptable environmental outcomes and avoid unnecessary cost to the community.

Module 3, Section 3.8 explained how Sunnyside Council:

- investigated their waterbody roles, responsibilities and resources
- identified and characterised their waterbodies
- prioritised their waterbodies
- managed the financial aspect of looking after their waterbodies.

In this Section we see how Sunnyside Council used the 'waterbody issues and actions tables' (Table 4.1 to Table 4.5) to identify a problem with one of their waterbodies, investigate it, then identify and implement an appropriate response.

4.5.2 Identifying the problem

Sunnyside Council received several public complaints regarding mosquitoes from residents living near a waterbody at Cockatoo Crescent. The complaints described a recent increase in mosquito numbers, particularly noticeable in the late afternoon, believed to be associated with the waterbody.

From the work Sunnyside Council undertook prioritising their waterbodies, the Cockatoo Crescent waterbody was identified as a high priority waterbody with large pressure from the surrounding catchment. Located in a high profile park, it was also highly valued by the community.

Sunnyside Council used Table 4.1, *Waterbody health and safety issues and associated management and rectification actions*, to investigate and identify the problem.

The first step was to investigate the problem (Figure 4.33)

Figure 4.33 Step 1 – Investigating the problem

Issue – Human health risk due to large mosquito populations			
Description	Investigations/monitoring	Management actions	Rectification actions
<p>The presence of large mosquito populations</p> <p>health risk (as mosquitoes transmit many pathogens including protozoa, nematodes and viruses) and a nuisance to local residents.</p>	<p>Discuss safety with asset owner and environmental health department to identify and document any issues.</p> <p>Undertake site inspection to check for evidence of mosquito breeding sites around the margins of the waterbody and also in any isolated shallow pools in the near vicinity. Check for evidence of litter which may support mosquito breeding.</p> <p>Undertake risk assessment.</p> <p>Record whether or not:</p> <ul style="list-style-type: none"> the mosquito problem is associated with the waterbody (or the surrounding ecosystems) simple management actions can be implemented to reduce populations a mosquito control plan should be prepared and rectification actions implemented. <p>Where a mosquito control plan is required then an audit of the mosquito species and population density both within waterbody and adjacent habitats is required.</p>	<p>Simple management actions may include:</p> <ul style="list-style-type: none"> implementing a regular litter removal program spraying with ecologically friendly larvicides (Seek advice from environmental health experts within local government if the use of chemical control agents is deemed necessary. Not recommended as a long term strategy due to insecticide resistance, cost and possible inability to apply to all areas). 	<p>Where rectification is required, a mosquito control plan should be prepared in accordance with the <i>Mosquito Management Code of Practice for Queensland</i> (Local Government Association of Queensland, 2002)</p> <p>Rectification options may include:</p> <ul style="list-style-type: none"> draining isolated pockets of pooled water filling in uneven areas where stagnant water accumulates increasing depth in open water areas to >60 cm to limit mosquito breeding increasing the slope of submerged batters (see 'Risk of injury or drowning' in this table for further discussion of waterbody batter slope) increasing the diversity of plants (both emergent and submerged) in the waterbody improving waterbody circulation and flushing introducing mosquito predators (native fish).
<p>Relevant supporting information</p> <p>Local Government Association of Queensland (2002), Queensland Health (2002), Water by Design (2012a), Water by Design (2012b)</p>			

STEP 1



The Stormwater and Flood Plain Management department (recently appointment as responsible for managing waterbodies) consulted with the Parks Maintenance department and Pest Management department, and together undertook a site inspection to determine whether:

- the mosquito problem was associated with the waterbody
- there were any simple management actions that could be implemented.

Sunnyside Council inspected the waterbody in the late afternoon and quickly determined that there was indeed a mosquito problem.

They undertook an inspection of the perimeter of the waterbody and located an isolated pool of open water approximately 200 m² in size and 20 cm deep. It was determined to be mosquito breeding habitat. No other suitable habitat was found so it was determined to be the primary source of the mosquito problem.

As this was the first known mosquito outbreak at the Cockatoo Crescent waterbody, further investigations were undertaken. Sunnyside Council determined that the isolated pool of water was not a normal feature of the waterbody. Due to a prolonged period of dry weather, evaporation had lowered the water level to the point where the uneven base of the waterbody caused the shallow isolated pool of water to develop in a location normally more than 70 cm deep and connected to the rest of the waterbody.

4.5.3 Deciding on management and rectification actions

Having identified the source of the mosquito outbreak, the next step was to determine the appropriate management or rectification action(s) (Figure 4.34)

From Table 4.1, possible actions included:

- regular spraying with larvicides
- draining isolated pockets of pooled water
- filling in uneven areas where stagnant water accumulates
- increasing depth in open water areas to >60 cm to limit mosquito breeding
- improving waterbody circulation and flushing
- introducing mosquito predators (native fish).

Sunnyside Council chose to fill the uneven area where water ponded to remove the mosquito habitat, and replant with fringing ephemeral vegetation to create ephemeral wetland. Table 4.8 explains why this option was chosen.

Table 4.8 Rationale for choosing to fill mosquito habitat

Possible Action	Chosen (Yes/No)	Reason
Regular spraying with larvicides	No	Council wanted a long term solution which did not involve chemical use in a high profile park.
Draining isolated pockets of pooled water	No	Would have required dewatering waterbody.
Filling in uneven areas where stagnant water accumulates	Yes	Could be undertaken without dewatering waterbody. Enabled the creation of a small pocket of ephemeral wetland. Long term solution.
Increasing depth in open water areas to >60 cm to limit mosquito breeding	No	Would have required removal of materials offsite and dewatering of waterbody. Could have compromised waterbody liner.
Improving waterbody circulation and flushing	No	Would have required major works to bathymetry.
Introducing mosquito predators (native fish)	No	Considered to already exist within main body of waterbody and would inhabit the breeding area once water levels rose again.

Figure 4.34 Step 2 – Management and rectification actions

Issue – Human health risk due to excessive mosquito populations			
Description	Investigations/monitoring	Management actions	Rectification actions
<p>The presence of large mosquito populations represents both a potential human health risk (as mosquitoes transmit many pathogens including protozoa, nematodes and viruses) and a nuisance to local residents.</p>	<p>Discuss safety with asset owner and environmental health department to identify and document any issues.</p> <p>Undertake site inspection to check for evidence of mosquito breeding sites in the margins of the waterbody and also in any isolated shallow pools in the near vicinity. Check for evidence of litter which may support mosquito breeding.</p> <p>Undertake risk assessment.</p> <p>Record whether or not:</p> <ul style="list-style-type: none"> the mosquito problem is associated with the waterbody (or the surrounding ecosystems) simple management actions can be implemented to reduce populations a mosquito control plan should be prepared and rectification actions implemented. <p>Where a mosquito control plan is required then an audit of the mosquito species and population density both within waterbody and adjacent habitats is required.</p>	<p>Simple management actions may include:</p> <ul style="list-style-type: none"> implementing a regular litter removal program spraying with ecologically friendly larvicides (Seek advice from environmental health experts within local government if the use of chemical control agents is deemed necessary. Not recommended as a long term strategy due to insecticide resistance, cost and possible inability to apply to all areas). 	<p>Where rectification is required, a mosquito control plan should be prepared in accordance with the <i>Mosquito Management Code of Practice for Queensland</i> (Local Government Association of Queensland, 2002)</p> <p>Rectification options may include:</p> <ul style="list-style-type: none"> draining isolated pockets of pooled water filling in uneven areas where stagnant water accumulates increasing depth in open water areas to >60 cm to limit mosquito breeding increasing the slope of submerged batters (see 'Risk of injury or drowning' in this table for further discussion of waterbody batter slope) increasing the diversity of plants (both emergent and submerged) in the waterbody improving waterbody circulation and flushing introducing mosquito predators (native fish).
<p>Relevant supporting information</p> <p>Local Government Association of Queensland (2002), Queensland Health (2002), Water by Design (2012a), Water by Design (2012b)</p>			

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Waterbody Management Guideline

Module 5

Extension and Engagement

VERSION 1 SEPTEMBER 2013

waterbydesign



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5.1 INTRODUCTION

5.1.1 Purpose of module 5

The purpose of this module, '*Extension and Engagement*', is to provide local government extension officers with practical and relevant information and resources to use when engaging landholders about waterbody management on private property.

5.1.2 How to use module 5

This module is divided into seven key sections. Figure 5.1 describes how to use each section. Section 5.8 is the worked example, an easy to follow step by step layout of all the information presented in this module.

Figure 5.1 How to use module 5

Section 5.2	
Local Government Extension Programs	This section explains what an extension program is and the benefits it can provide as well as outlining a generic process for an extension program.
Section 5.3	
Secure Participation	This section outlines a process for engaging and motivating landholders to join an extension program.
Section 5.4	
Site Assessment	This section provides guidance on how to carry out the first site visit and assessment including a list of useful questions to ask the landholder.
Section 5.5	
Identify the Issues and Actions	This section outlines the common issues found in waterbodies and provides advice on how to identify the source of the issue and how to choose the most appropriate management action.
Section 5.6	
Set Priority Issues and Actions	This section provides some practical advice for how to set priority issues and actions.
Section 5.7	
Implement Waterbody Plan	This section advocates a long term adaptive management approach to the implementation of the waterbody management plan.
Section 5.8	
Worked Example	This section uses a hypothetical example to demonstrate the process of managing waterbodies on private property through an extension program.

5.2 LOCAL GOVERNMENT EXTENSION PROGRAMS

5.2.1 Introduction

Local government extension programs are an effective way to build a relationship between the community and their local government. These relationships form the foundation for collaboratively working towards the common goals of improved property health and therefore improved catchment health. Extension programs support landholders by providing access to helpful, experienced and skilled officers who can deliver practical advice based on best available scientific knowledge and local experience. Extension officers support landholders from the start of a project through to completion. A 'learning by doing' approach to waterbody management is adopted that is easy to understand and implement.

Extension programs can deliver **multiple benefits** to both the landholder and local government such as to:

- build relationships and trust between local government and the community
- improve community education, understanding and engagement with waterways and the environment
- empower landholders and communities to implement proactive and practical solutions to conserve, protect and improve their properties
- provide cost effective strategies that support local economic growth
- maximise efficiency of local government resources.

5.2.2 Establishing an extension program

Although extension programs may vary in scope and structure, at the core of all programs is the fundamental principle of building partnerships between local governments and landholders to enable and empower the conservation, protection and enhancement of ecosystems on privately owned properties. It is important that a holistic view is taken when designing a program that addresses both land and waterbody based environmental issues. It is also important to link the benefits of the extension program to the bigger picture of the local government's strategic objectives and goals, for example, Waterway Recovery Goals, Water Quality Objectives or Ecosystem Health Monitoring Program Report Card Grades. Linking the outputs of the extension program to these bigger strategic goals will

aid the building of a business case for the continuation and expansion of the extension program. The following sections provide examples of how extension programs incorporate a waterbody focus into their work.

Waterways Extension Program – Redland City Council

Redland City Council established the Waterways Extension Program (WEP) in response to the poor ecological health grades received by Redland's waterways in the Healthy Waterways Ecosystem Health Monitoring Program (EHMP, 2008). The WEP has a unique focus on water and delivers stream bank, farm dam and wetland enhancement projects. The WEP uses water quality monitoring data to focus work in the high priority areas.

For more information, visit: www.redland.qld.gov.au

Backyards for Wildlife – Moreton Bay Regional Council

The Moreton Bay Regional Council Backyards for Wildlife Program recognises the collective impact that smaller properties can have on surrounding and downstream environments. This program supports landholders of smaller properties (less than one hectare) which have high conservation values such as a waterbody located on or adjoining the property.

For more information, visit: www.moretonbay.qld.gov.au/backyardsforwildlife

Land for Wildlife – South East Queensland

Land for Wildlife originated in Victoria in 1981. In South East Queensland, Land for Wildlife is hosted by the community based, not for profit organisation 'SEQ Catchments'. This program has produced the Land for Wildlife Notes which include information on 'Healthy Dams' and 'Wildlife Friendly Dams' (Land for Wildlife Notes, 2011). The SEQ Catchments Water Quality Monitoring Team encourages Land for Wildlife members to get involved with monitoring the water quality of their waterbodies by supplying equipment and providing technical advice.

For more information, visit: www.seqcatchments.com.au/programs/land-for-wildlife

Southern Rivers Catchment Management Authority (SRCMA) – New South Wales

The Bega Dairy Partnerships Program aims to improve the environmental sustainability of dairy operations in the Bega River Catchment. Bega Cheese and SRCMA have worked cooperatively with farmers on a voluntary basis to implement a diverse range of initiatives. Key environmental benefits of this project include improved river health via enhanced water quality, environmental flows and habitat restoration. Benefits to farmers include financial gains through improved soil health, water use efficiency and pasture productivity. Each of these practices provides a mix of environmental and business benefits. More than 85% of Bega Cheese suppliers are participating in at least one aspect of the Bega Cheese Environmental Management System initiative.

For more information, visit www.southern.cma.nsw.gov.au

Fish Friendly Farms – New South Wales

Fish Friendly Farms is a New South Wales Department of Primary Industries program that encourages farmers to protect fish habitat on and off their properties through sustainable agricultural practices. Through educational field days, workshops and publications the program encourages the following seven actions for enhancing waterway health:

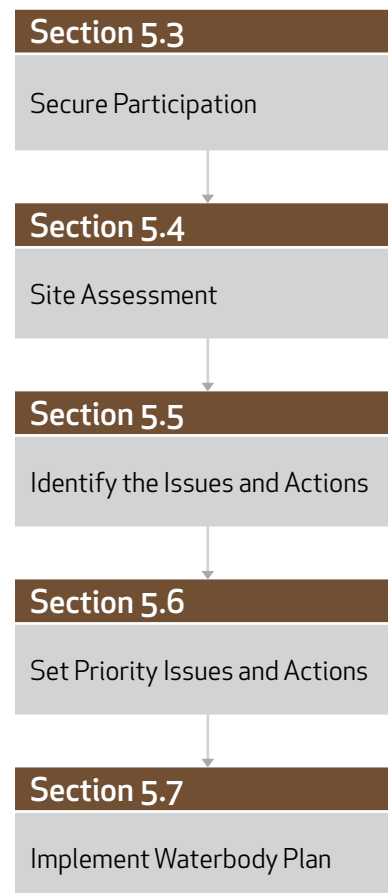
1. have large woody debris (snags) in streams
2. grow native vegetation on the stream bank
3. install fish friendly crossings
4. control or treat agricultural runoff
5. provide water for stock off-line
6. control the opening of floodgates
7. protect wetlands.

For more information, visit www.dpi.nsw.gov.au/fisheries/habitat/rehabilitating/fish-friendly-farms

5.2.3 The extension program process

The first step of any extension program is to secure participation from landholders. Once a landholder has signed up to an extension program, a plan for that property and waterbody must be created. The waterbody plan will begin with a site visit and assessment where the issues will be identified and possible management actions noted. This assessment will result in a list of issues and actions for the property. It is important to work through this list with the landholder and set both short term and long term priorities to enable implementation of the plan. This process is shown in Figure 5.2.

Figure 5.2: Process of an extension program



When carrying out the extension process on a property and creating the waterbody plan it is important to remember the following:

- **Assess each waterbody on a case by case basis**
Each waterbody is unique with its own characteristics and set of influencing factors.
- **Align the goals for the waterbody with the waterbody's purpose**
For example, if a waterbody is used for recreation or as a water source for animals then it is necessary to set stringent goals on the health and safety aspects of that waterbody.
- **Consider any downstream impacts when designing the waterbody plan**
A waterbody is not an individual, isolated ecosystem but sits within a catchment and connects to and influences this much larger system.
- **Be innovative and pragmatic with management actions**
Landholders are, by and large, resource and time limited and need simple and effective solutions that are practical to implement.

• **Know your limitations**

Understand what management actions can be feasibly implemented and which management actions are beyond the scope of an extension program and require external expertise. Table 5.1 provides a list of possible scenarios that may fall outside the scope of an extension program and identifies where to direct a landholder for further assistance.

There are very useful resources available that can inform and support extension programs and provide valuable information for managing waterbodies on private properties. These resources include:

- [Wetland Management Handbook: Farm Management Systems \(FMS\) guidelines for managing wetlands in intensive agriculture, 2008](#)
- [Grazing for Healthy Coastal Wetlands: Guidelines for managing coastal wetlands in grazing systems, 2011](#)
- [Guidelines and template for preparing a wetland management plan: For primary producers \(grazing, dryland cropping\) in Queensland's inland catchments, 2012](#)

Table 5.1: When and where to go for further help

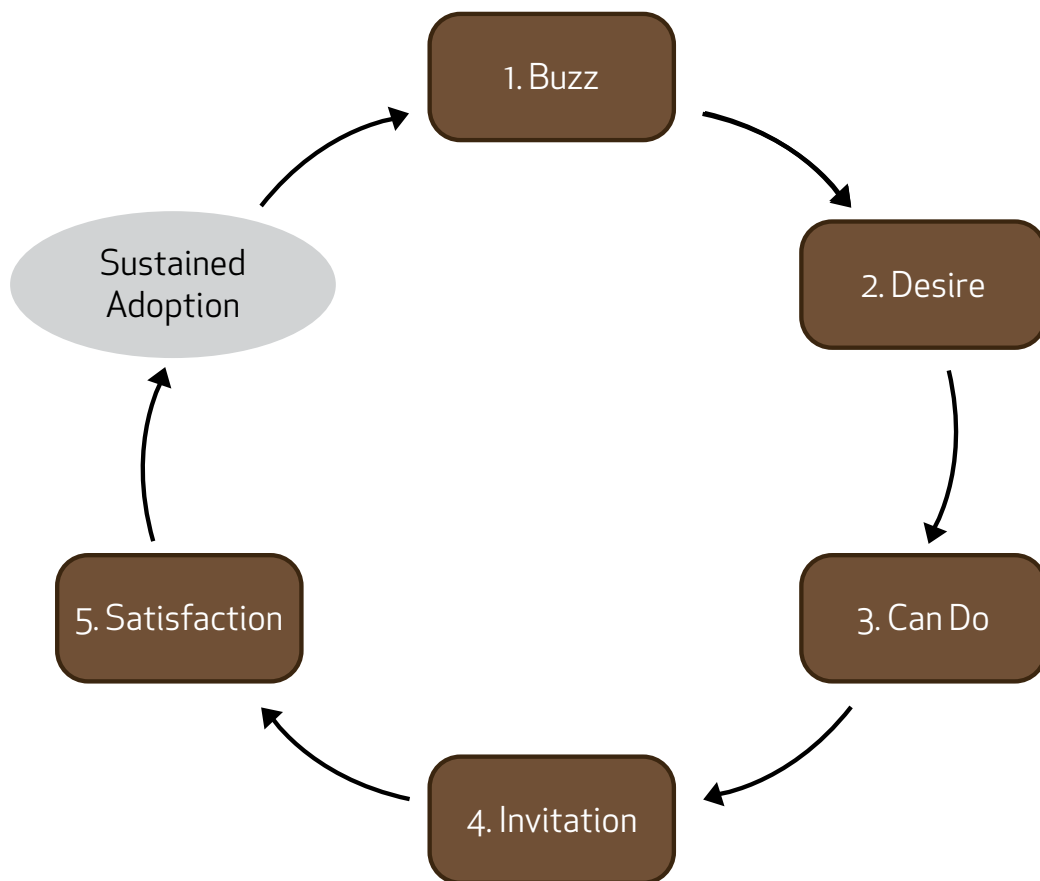
Scenario	Refer to
Operational works development application required for works such as excavating, landscaping, filling of land etc.	Local government's planning and development area.
Landholder wants to construct a farm dam	Local government's planning and development area.
Structurally damaged waterbody i.e. fractured dam walls	A dam or civil engineer should be consulted.
Waterbody located on acid sulfate soils	State environment departments provide extensive advice on identifying and managing acid sulfate soils. The Queensland Acid Sulfate Soils Investigation Team can provide general and technical advice on acid sulfate soils.
Waterbody located on dispersive clays	The Tasmanian Department of Primary Industries and Water has published ' <i>Dispersive soils and their management: guidelines for landholders, planners and engineers and technical reference manual</i> '.

5.3 SECURE PARTICIPATION

The first and most important part of an extension program is to engage and motivate the landholders. However, presenting the science, knowledge and logic behind why a landholder should join an extension program will not guarantee buy in and commitment from landholders. Knowing something isn't necessarily enough to cause change and promote participation. Landholders need to feel something to rouse their motivation. Dan and Chip Heath's book *Switch: How to Change Things When Change Is Hard* provides valuable insight into the nature of change and outlines the key factors that an extension program should address in order for change to occur in a community. The Heath brothers explain (using the analogy of a logical rider trying to direct an emotional elephant down a new path) that for a change to have an effect it needs to speak to the logical side (provide the 'rider' with clear direction), speak to the

emotional side (motivate the 'elephant' to move) and finally it needs to provide an environment that makes the change easier (shape the 'path' to ease the journey of the 'elephant' and 'rider'). In other words, to encourage participation in an extension program clear direction needs to be provided (e.g. provide horses with off-line watering points), motivation for action roused (Redland's community are proud landholders who cherish their beautiful waterways) and the environment adapted (to join, simply sign this one page form). Les Robinson from *Enabling Change* builds on the Heath brother's work and elaborates that there are five factors necessary to motivate participation in a new group, activity or behaviour (Robinson, 2009). Figure 5.3 outlines these five factors of buzz, desire, can do, invitation and satisfaction. For sustained participation all five of these factors need to be present.

Figure 5.3 Five factors to create motivation



5.3.1 Buzz

For the most part, conversation is how people make decisions. Peer-peer conversations are vital for triggering change in human behaviour. Nothing happens without conversation, or at least interaction, between peers. What people say about an extension program determines whether their peers believe it is useful, credible and offers advantages over what they currently do. When people experience a new behaviour or program that really works, they talk about it, creating more buzz, increasing other people's desire, lowering their fears, and so creating a virtuous circle. It is therefore important to showcase success stories from extension programs. Field days on working properties are great for this. Similarly, encouraging networks among landholders will help open communication channels and generate 'buzz'. For example, let landholders know if one of their neighbours is participating in an extension program and put them in touch with that neighbour. By encouraging this peer-peer conversation the fears of unconverted landholders will be lowered and their motivation will be spurred.

5.3.2 Desire

To stimulate landholder's interest and passion in an extension program, listen to their fears, worries and frustrations and frame the program's activities as solutions to those dissatisfactions. For example, instead of framing the program's message as 'Correctly managing your waterbody will reduce the adverse impacts on downstream environments' frame it as a solution to the landholder's dissatisfactions i.e. 'Join other Redland residents in looking after their farm dams for the wellbeing of their livestock, properties and families'.

5.3.3 Can do

To enable landholders to participate in an extension program it is important that it is simple and easily accessible. The barrier to motivation which encourages change is often a fear of failure, embarrassment, humiliation or losing certainty or control. What often prevents people from participating in new activities is people's fears of perceived risks. It is important to address and mitigate these fears when promoting an extension program to landholders. This relates to the Heath brother's idea of 'Shape the Path'. Create an environment that minimises the barriers and makes change doable.

Quick Tips to minimise the barriers for participants:

- Focus on **do-able** solutions
- Use **positive** proactive language
- Start with projects that are **achievable** in a short time frame
- Choose projects that are **measurable**, easy to understand and do
- Promote the popularity and **inclusion** aspects of the program i.e. the 'good neighbour effect'
- Lower fears by outlining the **supportive** framework of your program i.e. our friendly and experienced extension officers will provide you with all the help and assistance you need
- Encourage participants to have **control** and ownership over the project i.e. involve the landholder in developing the vision, goals, plan and priority activities for their property
- Choose **familiar** and comfortable activities and goals
- **Award** good participants by trusting them with more responsibility and more ambitious project
- **Celebrate** success!

What to avoid:

- Avoid focusing on the issues and problems.
- Avoid using negative language which promotes negative buzz.
- Avoid starting with projects that are overly ambitious or difficult to understand.
- Avoid using language that will exclude and make your participants feel singled out i.e. you should...
- Avoid overly complicated sign up processes and procedures i.e. reduce the red tape.
- Avoid using a compliance approach.
- Avoid forcing your participant to undertake lots of boring tasks like excessive reporting.

5.3.4 Invitation

Even if landholders are interested in an extension program it may only be the enthusiastic few who will take the initiative and participate. To reach beyond these enthusiastic few and engage the 'un-converted' it is necessary to send landholders a personal invitation to join the extension program. Even though landholders may think the program is interesting the majority will still need to be invited, ideally by someone they know.

Consider how best to pitch and deliver the invitation to engage the target audience. An invitation will carry more persuasion if it comes from a credible inviter. Avoid generic invitations that do not come from an identifiable individual. A good inviter wins people's attention and commitment by authentically showcasing the benefits of participating in the program. Testimonials from participants of the program are a good way to achieve this, particularly if the testimonial comes from a well respected, passionate and relatable member of the community.

An invitation should also include a 'hook'. This will be something intriguing or surprising that grabs the audience's attention. This can be achieved by asking an intriguing question or two, or by introducing a surprising element. For example, why not hold a 'DIY Floating Wetlands Construction Competition' or a 'Master Chef - The Bush Tucker Challenge' to engage and excite the community about management of waterbodies.

Les Robinson suggests that an invitation should have the following ten elements:

1. Grab your communities' attention
2. Introduce your credible inviter
3. Hook their motivations with an inspiring personal story
4. Sketch the problem
5. State the vision
6. Sketch how your program will work practically and be supported
7. State how you'll lower their personal doubts and fears
8. Don't forget some enticing instant gratification extras
9. Request a general sign of approval for your program
10. Issue a precise call to action

An Example Invitation:

Are you passionate about the Lockyer Valley? Do you love the land and lifestyle that Lockyer Valley provides you with? *G'day, I'm Darren Lockyer and for generations my family have depended on the land and water of the Lockyer Valley for our livelihoods. The farm dams on my land used to provide a secure and healthy source of water to my family. These days though it is a different story. Increasing levels of pollution from land erosion, chemical fertilisers and animal wastes have pushed my farm dams to their tipping point. One day my children will inherit my land, just as I did from my father. I want to make sure that the land they inherit is healthy enough to provide them with the lifestyle and livelihood that I and my fathers have enjoyed. To do this I knew I needed to improve the health of my farm dams. Thankfully, the Waterways Extension Program was there to help with great practical advice and assistance based on sound scientific knowledge. I had access to friendly and experienced officers who were there to help whenever I needed it. Upon joining the Waterways Extension Program I received a free starter's pack with all of the information I needed and I even had some free water sampling of my farm dam carried out! Do you believe we can make a difference today, to provide our children with the future they deserve? Then start by contacting a Waterways Extension Program officer today at: example@email.com*

5.3.5 Satisfaction

At each stage of involvement in an extension program, participants should experience satisfactions. It is important that each activity is enjoyable and new behaviours generate satisfactions. It is equally important to publicly acknowledge participants' successes, celebrate their achievements and reward their efforts, no matter how small. Most people are self-doubting so unless attention is drawn to their successes, they often discount them. Never miss a chance to celebrate a success. Name the participant, make sure their peers are listening, and tell them exactly what they did well. If possible provide a small reward or token. Small, frequent satisfactions are better than big infrequent satisfactions. By experiencing satisfaction from participation in an extension program not only will landholders continue to participate but this will also go towards generating more positive buzz for the program through peer-peer conversations.

5.4 SITE ASSESSMENT

During the first site visit, assess the property and waterbody to identify the issues and management actions. The issues and actions can be assessed within the five categories of water quality, biodiversity, health and safety, amenity and aesthetics and hydrology and hydraulics. It is vital to understand the history and current functioning of the waterbody before goals can be set. Therefore, gather as much information as possible during the first site visit to ensure appropriate plans and goals are set. To gather this information, observation will only go so far. Asking the right questions will prove crucial to understanding the waterbody.

Ask the right questions

It is vital to talk to the landholder about both the current and historic landuse of the surrounding waterbody. Similarly, speak to other locals or neighbours who may be aware of past events that might explain the current status of the waterbody. For example, look for stories about localised flooding events, upstream development or interesting past landuse, i.e. was the property previously used as a poultry farm or abattoir? Similarly, ask the landholder how the waterbody functions with seasonal variability. For example, how does it behave during the dry winter months and during wet summer months? A waterbody can rarely be considered as an individual, isolated ecosystem. Rather, waterbodies usually sit within a broader wetland and catchment and are connected to this much larger ecosystem. It is therefore important to identify the catchment and sub-catchment that the waterbody sits in and consider how the waterbody was formed and interacts within these catchments and how it affects the natural hydrology of the catchment.

Questions to ask to understand the waterbody:

- What is the current and past landuse?
- Have there been any significant past events in the surrounding landscape?
- What catchment and sub-catchment does the waterbody sit in?
- How was the waterbody formed?
- What waterway is downstream of the waterbody?
- What features are upstream of the waterbody?
- How does the waterbody behave during dry winter months and drought periods?
- How does the waterbody behave during wet summer months and flooding periods?
- What is the current use of the waterbody?
- What was the waterbody originally used for?

This exercise will not only provide vital information about the waterbody and property but may also build the understanding of the landholder as they seek the answers to these questions.

5.5 IDENTIFY THE ISSUES AND ACTIONS

For a waterbody to be healthy and provide value, it needs to have good:

- water quality
- biodiversity
- health and safety
- amenity and aesthetics
- hydrology and hydraulics.

The following sections discuss each of these five areas in detail describing indicators to look out for and providing case studies to showcase some of the different management actions available. Module 4 *Maintenance and Operations* also provides further detail on issues and management actions for waterbodies.

5.5.1 Water quality

Good water quality is fundamental to all other elements of a waterbody functioning well. For example, good water quality tends to be clear and weed free which improves the waterbody's aesthetics, promotes biodiversity and prevents occurrence of algal and cyanobacterial blooms therefore improving the health and safety of the waterbody. High levels of sediment and nutrients in waterbodies are the two major causes of poor water quality.

Sediment

High sediment loads entering a waterbody cause high turbidity. High turbidity blocks sunlight reaching submerged vegetation and causes difficulties for animals which rely on sight to feed (Figure 5.4). High turbidity encourages the growth of floating vegetation and can lead to the occurrence of problematic algal blooms and weed infestation (Figure 5.5). If the waterbody is used for watering stock, high turbidity and poor water quality can reduce the health of livestock. Research (Petty and Poppi, 2008) has shown that cattle grazing in muddy paddocks have a lower live weight gain and spend less time grazing than those in dry paddocks. Research in Canada by Willms (2002) has also shown that animals gained up to 23% more weight drinking clean water compared to dam water.

Resuspension of sediment from the bottom of a waterbody can also cause turbidity issues. Resuspension can occur for a number of reasons for example rain events or lack of submerged vegetation to stabilise the sediment. Aquatic animals which feed from the bottom sediments of a waterbody may also disturb and resuspend the sediment. An example is the introduced Carp species. Carp increase the water's turbidity by uprooting vegetation and stirring up sediments during feeding. This in turn reduces light penetration, which can make it difficult for native fish that rely on sight to feed. Reduced light can also decrease plant growth, and suspended sediments can smother plants and clog fishes' gills. Carp feeding habits can also undermine banks leading to the collapse of banks and vegetation. However, factors such as hoof erosion or exposed banks are much more important factors in bank erosion and should be prioritised before Carp control measures. Protection and restoration of riparian vegetation can minimise the risk of damage by Carp.

High sediment loads are a relatively easy issue to identify because muddy, brown water is easy to recognise. The turbidity of a waterbody can be measured using a turbidity sensor or the water's clarity can be measured using a Secchi disc.

Erosion of surrounding soil is a significant source of sediment to waterbodies. Erosion can occur via:

- upstream erosion of gullies lacking vegetation with exposed and unstable banks (Figure 5.6)
- hoof erosion both upstream and around the waterbody (Figure 5.7)
- sheet erosion from exposed soil on surrounding land (Figure 5.8)
- erosion of the waterbody's banks through trampling or exposed soil (Figure 5.9).

Figure 5.10 outlines where these types of erosion occur within the landscape.

Figure 5.4 High turbidity makes it difficult for animals that rely on sight to feed



Photo: Jack Mullaly, Healthy Waterways

Figure 5.5 A waterbody with high turbidity and floating waterplants



Photo: Jack Mullaly, Healthy Waterways

Figure 5.6 Upstream gully erosion



Photo: Lockyer Valley Regional Council

Figure 5.7 Hoof erosion



Photo: Lockyer Valley Regional Council

Figure 5.8 Hill slope and sheet erosion



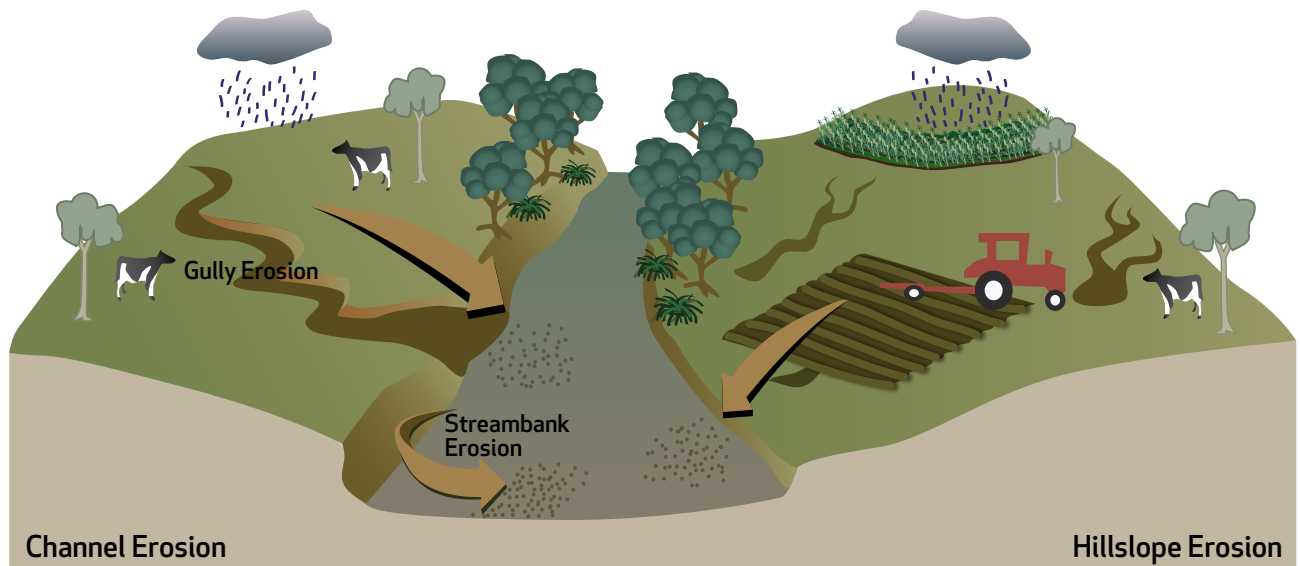
Photo: Sunshine Coast Council

Figure 5.9 Waterbody bank erosion



Photo: Healthy Waterways

Figure 5.10 Types of erosion



Practical and Innovative Solutions: DIY floating wetlands to remove nutrients and sediment

Floating wetlands are a relatively new technology for removing pollutants from the water column. They work by providing a floating surface for plants and vegetation to grow upon (Figure 5.11). The plants in a floating wetland have their roots suspended in the water column where a biofilm forms (Figure 5.12). It is within these biofilms that microbes and bacteria trap and digest organic matter and nutrients including suspended solids, nitrogen and phosphorus. Floating wetlands can be an expensive option if an expert is consulted. Owing to the simplicity of the concept of floating wetlands it is possible to build a 'DIY' (do it yourself) version for implementing on a private property (Figure 5.13). Relatively cheap and easily available materials such as stormwater pipes, wire netting and cable ties can be used to build a floating wetland. DIY floating wetlands provide a practical and cost effective option for landholders. In addition DIY floating wetlands can be an effective way to engage community through organising workshops and demonstrations (Figure 5.14). To learn how to build a floating wetland visit www.redland.qld.gov.au

Figure 5.11 The plants of a DIY Floating wetland



Photo: David Brown, Redland City Council

Figure 5.12 The roots of a DIY Floating wetland



Photo: David Brown, Redland City Council

Figure 5.13 DIY Floating wetland with protective bird netting



Photo: Jack Mullaly, Healthy Waterways

Figure 5.14 DIY Floating Wetlands can provide opportunity for community engagement



Photo: David Logan, Healthy Waterways

Case Study – Upstream gully erosion in Redlands Catchment

The landuse of this rural property is predominately grazing of horses. A small farm dam is located on the property and lies directly downstream of a well-used gully crossing for the horses.

Issue

The frequent use and trampling by the horses had caused the gully crossing to become degraded and eroded (Figure 5.15). The gully crossing was particularly vulnerable to erosion following wet weather when the horses caused significant damage and hoof erosion to the wet ground (Figure 5.16). The gully crossing was polluting the downstream dam with sediment and nutrient loads as well as lessening the aesthetics of the property.

Action

The Redland City Council Waterways Extension Program provided the landholder with materials and expert advice to help with the construction of a permanent pipe crossing and a gravel path for the horses to cross the gully without causing erosion.

Why?

In rain events, soil disturbed by horses would be transported into the dam and eventually into the creek adjoining the property. The permanent pipe crossing and gravel path covers exposed soil (Figure 5.17) and allows the flow of water in a rain event (Figure 5.18).

Outcome

Environmentally, there was a significant reduction in sediment entering the dam and hence the waterway. Aesthetically, the construction of the pipe crossing and path improved the visual look of the property.

Figure 5.15 Before - hoof erosion caused by the horses



Photo: Danielle Crawford, Redland City Council

Figure 5.16 Before - gully crossing is eroded and degraded



Photo: Danielle Crawford, Redland City Council

Figure 5.17 After - exposed soil is covered reducing erosion



Photo: Dale Watson, Redland City Council

Figure 5.18 After - pipe allows flow of water without causing erosion



Photo: Dale Watson, Redland City Council

For further information on sustainable horse management see:

- The Horse Management on Small Properties booklet J, Myers and S, Myers, (2010).

For more information on managing stock water see:

- Property planning: Using off-stream watering points, Fitzroy Basin Association. Peck, G. (2006).
- Stock and Waterways: a manager's guide, Land and Water Australia. Staton, J. and O'Sullivan, J. (2006).

Nutrients

The two key nutrients in waterbodies are nitrogen and phosphorus. These nutrients occur naturally in the environment but when found in high levels they can cause a multitude of problems in a waterbody. High nutrient levels can increase the occurrence of algal blooms (Figure 5.19). Algal blooms cause aesthetic, health and safety problems (particularly if toxic in nature) and lower water quality when they start to die and decay (Figure 5.20). As decaying blooms are broken down by organisms, the increase in respiration to achieve this breakdown will exert a significant demand on the dissolved oxygen supply of the water. This can lower dissolved oxygen levels to the point where fish kills may occur. Fish kills bring a range of problems such as lowered biodiversity, public complaints and disposal issues.

Sources of nutrients to a waterbody may include:

- fertilisers
- animal wastes (Figure 5.21)

Figure 5.19 A waterbody experiencing an algal bloom



Photo: Kate MacKenzie, Sunshine Coast Council

Figure 5.21 Manure is a common source of nutrients on farm properties



Photo: David Brown, Redland City Council

- on-site sewage treatment facilities (i.e. septic systems)
- sediment (nutrients in particulate form).

Algal blooms and weed infestations indicate high nutrient levels. Discoloured water and floating scum signifies the occurrence of an algal bloom. Multiple management actions such as aeration and recirculation systems, floating wetlands, enzymes to kick start nutrient cycling and chemicals that bind and settle out nutrients can be used directly on a waterbody. However, these are reactive management actions and should only be used in the short term. To effectively address high nutrient levels the issue must be combated at its source. Actions such as best management practice of animal waste, repairing of leaky septic systems and sewer pipes and appropriate application of fertilisers will be of greater effect for managing nutrients in a waterbody. For further information on management actions to improve water quality see Section 4.3.2 of Module 4 'Maintenance and Operations'.

Figure 5.20 An algal bloom caused by high nutrient levels



Photo: Karen Waite, Moreton Bay Regional Council

Case Study – Nutrient source control through correct animal waste management in the Redlands Catchment

A waterbody is located adjacent to a property which has a large number of horses on it. A drainage line runs through the property and feeds directly into the waterbody.

Issue

The landholder was struggling to completely manage the large volume of horse manure produced by the horses. Some manure was being bagged and sold but not on a large enough scale to manage all of the manure. The remaining manure was left unmanaged and served as a pollution source to the adjacent waterbody (Figure 5.22).

Action

The Redland City Council Waterways Extension Program worked with the landholder to improve his pasture and significantly improve the water quality of the waterbody. In the short term a manure compound was provided for the property to contain and control the manure (Figure 5.23). In the long term the landholder was trained in how to compost his manure and reapply it to the pasture.

Why?

One major issue for any horse owner on a small acreage property is manure management. Providing a designated site to store the manure and training the landholder in how to compost manure enabled the landholder to effectively manage the manure and improve the pasture coverage and health.

Outcome

There has been a significant reduction in nutrients entering the waterbody adjoining the property. An additional benefit was the improvement of the landholder's pasture. This has encouraged the landholder to continue working with the Waterways Extension Program.

Figure 5.22 Before - unmanaged manure left in exposed stockpiles



Photo: Dale Watson, Redland City Council

Figure 5.23 After - a manure compound for storing and composting manure



Photo: Danielle Crawford, Redland City Council

5.5.2 Biodiversity

Diverse habitat supports high biodiversity (Figure 5.24). Waterbodies with low biodiversity are less stable and more vulnerable to weed infestation (Figure 5.25).

Creating diverse habitats within waterbodies can be achieved through simple actions. A study of wetlands in Delaware, US showed that adding woody logs to waterbodies increased the diversity of insect communities (Alsfeld, 2009). A diverse insect community will provide a food source for a wider range of predators such as waterfowl and frogs. The same study also showed the benefits of varied microtopography (small scale variations in the height and roughness of the ground and vegetation). Providing ridges or furrows in the surrounding land as opposed to flat surfaces will enhance the landscape. Similarly, the addition of rocks or pontoons will promote a more dynamic habitat for encouraging biodiversity. Planting native vegetation around a waterbody with rocks interspersed will create habitat for animals, particularly frogs. Frogs eat lots of insects and can help reduce the number of problematic insects such as mosquitoes.

Figure 5.24 A high biodiversity waterbody



Photo: Julian Wakefield, Sunshine Coast Council

Quick tips for promoting waterbody biodiversity

- **Plants** - Planting a mixture of native vegetation in and around a waterbody will create a diverse ecological community
- **Trees** - Planting native trees provide shade and habitat for animals
- **Logs** - Introduce coarse woody debris such as hard woody logs to waterbodies
- **Rocks** - Create frog friendly habitat by placing rocks around waterbodies
- **Ridges and furrows** - Create a variety of microtopography features such as land surface ridges and furrows
- **Buffer** - Create a buffer zone around the waterbody to protect and enhance biodiversity, refer to the [Queensland Wetland Buffer Planning Guideline, 2011](#), for information on how to design an appropriate buffer zone
- **Fencing** - Fencing around a waterbody and native vegetation will exclude feral pests who prey on native species and will also exclude domestic animals who can trample and damage important habitat
- **Nest boxes** - Provide safe nesting areas for wildlife species that depend on tree hollows for shelter
- **Shallow water** - Shallow water areas are ideal bird and fish feeding habitats

Figure 5.25 A low biodiversity waterbody



Photo: Karen Waite, Moreton Bay Regional Council

Case Study – Increasing biodiversity by revegetating a drainage line in the Redlands Catchment

A drainage line runs along this rural grazing property before crossing the property to flow into a waterbody adjoining the property.

Issue

The drainage line had been cleared of vegetation (Figure 5.26). This meant that there was no natural barrier to pollutants, such as manure and sediment, being washed from the property directly into the waterbody.

Action

In the short term, manure compounds were constructed and erosion control measures put in place. In the long term, the drainage line was revegetated with native vegetation (Figure 5.27).

Why?

Addressing the manure and sediment source directly reduces the pollutant loads entering the waterbody. The vegetated drainage line now acts as a filter for nutrients and sediments contained in runoff from the surrounding land, preventing them from entering the waterbody.

Outcome

There has been a significant reduction in nutrients and sediment entering the waterbody adjoining the property. In addition to the water quality improvements, the established native vegetation along the drainage line provides habitat for a number of small birds and reptiles. This builds the resilience of the waterbody and improves the aesthetics of the property.

Figure 5.26 Before - unvegetated drainage line with exposed soil



Photo: Danielle Crawford, Redland City Council

Figure 5.27 After - revegetated drainage line



Photo: Dale Watson, Redland City Council

5.5.3 Health and safety

Health and safety issues will vary in concern depending on the location and purpose of a waterbody. If a waterbody is used for primary contact recreation, such as swimming, or for watering animals then it is vital that any potential risks are managed and minimised.

The most common health and safety risks associated with waterbodies are:

- contact with cyanobacteria
- contact with microbial pollution
- injury or drowning.

Ask the landholder questions to indicate the presence of toxic blooms or microbial pollution. Questions could include 'have any livestock that access the waterbody shown signs of illness?' or 'have any family members who use the waterbody for swimming shown symptoms of illness such as vomiting or skin rashes?'

Cyanobacteria

Certain species of cyanobacteria produce toxins that are harmful to humans and animals. These toxins are a potential hazard in waters used for human and animal drinking water supplies, aquaculture, agriculture and recreation (Ressom *et al.*, 1993). Production of toxins is unpredictable, making it difficult to identify the toxicity of waters (Falconer *et al.*, 1999). The most common toxic cyanobacteria species in Australia are:

- *Microcystis aeruginosa*, *Anabaena circinalis*, *Cylindrospermopsis raciborskii*, and *Aphanizomenon ovalisporum* in fresh water
- *Nodularia spumigena* and *Lyngbya majuscula* in estuarine and coastal marine water.

Table 5.2 provides a list of potentially toxic types of cyanobacteria and how they affect mammals.

The following advice, as adapted from the National Health and Medical Research Council *Guidelines for Managing Risks in Recreational Water*, should be provided to the landholder if a cyanobacterial bloom is identified on the property:

- Avoid areas with visual signs of cyanobacterial or algal blooms for example if the water is discoloured or floating scum is present.
- Where scums and discoloured water are both present, avoid waterskiing because of the potential for substantial exposure to sprays containing algae and cyanobacteria.
- Wetsuits may result in a greater risk of rashes, because cyanobacterial or algal material trapped inside the wetsuit will be in contact with the skin for long periods.
- After coming ashore, shower or wash yourself down to remove any cyanobacterial or algal material.
- Wash and dry all clothing and equipment with clean water after any contact with cyanobacterial or algal blooms and scum.
- If you experience any health effects, whatever the nature of your exposure, seek medical advice promptly.

Reactive management actions such as introducing algaecides to a waterbody, for example barley straw or copper-based algaecides, or introducing activated carbon for toxin removal will only manage the current bloom and will not prevent the reoccurrence of a bloom in the future. Preventative management actions will be far more beneficial. Techniques to prevent cyanobacterial blooms should focus on the two main drivers of blooms; high nutrient levels and low flows or flushing. Refer to Section 4.3.2 of Module 4 'Maintenance and Operations' for further information on reactive and preventative management actions for cyanobacterial blooms.

Table 5.2 General cyanobacterial related illness (NHMRC, 2008)

Cyanobacteria type	Primary area effected in mammals
<i>Microcystis</i> , <i>Anabaena</i> , <i>Planktothrix (Oscillatoria)</i> , <i>Nostoc</i> , <i>Hapalosiphon</i> , <i>Anabaenopsis</i> , <i>Nodularia</i> , <i>Aphanizomenon</i> , <i>Cylindrospermopsis</i> , <i>Umezakia</i> , <i>Raphidiopsis</i>	Liver
<i>Anabaena</i> , <i>Aphanizomenon</i> , <i>Lyngbya</i> , <i>Cylindrospermopsis</i> , <i>Planktothrix (Oscillatoria)</i> , <i>Aphanizomenon</i>	Nervous system
<i>Lyngbya</i> , <i>Schizothrix</i> , <i>Planktothrix (Oscillatoria)</i>	Skin and gastrointestinal tract

Microbial pollution

A microbe is a tiny life form or microscopic organism that cannot be seen by the human eye. Microbial pollution is the presence of harmful microbes in water at levels which can produce undesirable effects to human health. Poor animal waste management and leaky septic systems or sewer pipes can be a source of microbial pollution to a waterbody. Exposure to pathogens in waterbodies can occur through direct contact with polluted water during recreation, accidental ingestion of polluted water or the inhalation of small water droplets. Polluted water can cause a variety of gastrointestinal diseases, collectively known as gastroenteritis. Symptoms of gastroenteritis may include vomiting, diarrhoea, stomach-ache, nausea and headaches. Diseases and conditions affecting the eyes, ears, skin and the upper respiratory tract can also be contracted when certain pathogens come into contact with broken skin or the delicate membranes in the ear, nose, and lungs. Refer to Table 5.3 for some common illnesses associated with pathogens.

Studies (Journeaux, 2005) have shown that cattle are five times more likely to defecate in waterbodies than surrounding paddocks and the concentration of sediment, nitrogen and *E. Coli* bacteria have been shown to be 20 to 30 times higher downstream of stock access sites than upstream.

If a waterbody is used for recreation it is important to ensure that microbial pollution is prevented.

Top tips for preventing microbial pollution:

1. Make sure manure stockpiles are safely secured and are not located adjacent to or upstream of a waterbody.
2. Prevent animals such as cows or horses from having direct access to the waterbody (this stops the animals from defecating directly into the waterbody).
3. Test on-site sewerage facilities, such as sewer pipes and septic tanks, regularly for leaks and illegal connections.

Injury or drowning

If a waterbody is easily accessible and/or used for recreational purposes then water depth is something that needs to be considered, particularly if small children reside on the property. Water depth coupled with poor water clarity has contributed to drowning and near-drowning (Quan *et al.*, 1989). This is particularly evident if there is a significant increase in water depth from the edge of a waterbody. Shallow edges around a waterbody, which gradually increase in depth, reduce risk of drowning and injury and also have the added benefit of providing important feeding habitat for fish and birds and encouraging growth of submerged vegetation.

Table 5.3: Pathogens, illnesses and symptoms

Pathogen	Common illnesses and symptoms
Bacteria (e.g. <i>Campylobacter</i> , <i>Escherichia coli</i>)	Infections of cuts and wounds, gastroenteritis (including diarrhoea and abdominal pain)
Viruses (e.g. Rotaviruses, Hepatitis A)	Gastroenteritis, respiratory infections
Parasites (e.g. <i>Cryptosporidium</i> , <i>Giardia</i>)	Gastroenteritis, (including dysentery, diarrhoea and abdominal pain)

Case Study - Barley straw trial for treating toxic cyanobacterial bloom in the Redlands Catchment

A horse riding property with a large farm dam (approximately 1300 m²) which is used as a water source for the horses.

Issue

Due to high nutrient levels in this dam, cyanobacterial blooms occur regularly throughout the year (Figure 5.28). These potentially toxic blooms prevent the landholder from using the dam to water the horses. This lack of a safe water source on the property adds to the running cost of the business as the landholder needs to buy water from external sources.

Action

The Redland City Council Waterways Extension Program is working with the landholder to reduce sediment and nutrients entering the dam. In the short term barley straw is being trialled as an algaecide so that the landholder might be able to use the water for his business (Figure 5.29).

Why?

Studies from Britain have shown barley straw to be an effective method of algal control. Rotting barley straw has been shown to produce a natural algaecide that prevents growth of certain algae and cyanobacteria. However, Australian studies have generally not supported the original research in Britain. This property provides a good location to trial the barley straw method. Barley straw is a cost effective and practical option for the landholder.

Outcome

Although the results of the barley straw trial have not been analysed, the anecdotal evidence would suggest that the barley straw has reduced the reoccurrence of toxic cyanobacterial blooms (Figure 5.30, 5.31). Prior to using the water for horses it should be tested for toxins.

Figure 5.28 Before - waterbody experiencing cyanobacterial blooms



Photo: Vianne Law, Redland City Council

Figure 5.29 Installation of barley straw



Photo: Vianne Law, Redland City Council

Figure 5.30 Waterbody with barely straw



Photo: David Brown, Redland City Council

Figure 5.31 Six months after installation of barley straw



Photo: David Brown, Redland City Council

5.5.4 Amenity and aesthetics

The profile and amenity of a waterbody plays an important role in how the community will perceive and value it. Community will take pride and ownership of a healthy waterbody that delivers values. Generally the community will assess the health of a waterbody based on its visual aspects. It is therefore important for a waterbody to be free of any issues such as weed infestation (Figure 5.32) and litter (Figure 5.33) that will degrade the waterbody's profile and amenity.

Not all factors degrading a waterbody's amenity are visual. Other factors like odour and pests (e.g. mosquitoes) will also cause the community to devalue a waterbody. Visual indicators (e.g. litter) and community complaints are common indicators of amenity and aesthetic issues.

Figure 5.32 Weeds in a waterbody



Photo: Maree Manby, Redland City Council

Figure 5.33 Litter in a waterbody



Photo: Colin Bridges, Gold Coast City Council

Case Study – Profile and amenity in the Redlands Catchment

This case study presents a unique situation, in that there is a dam surrounded by four properties, with each property having a land area of 2051 m². The dam is not connected to a natural drainage line and surface runoff from the surrounding four properties is the dam's main source of water.

Issue

The dam does not get flushed out during heavy rainfall events. As a result, any nutrients or sediment that enter the dam during the rain event will remain within the dam until they have been utilised. High nutrients and turbidity have made the dam vulnerable to weed infestation (Figure 5.34). The invasive weed Mexican waterlily had become dominant in the dam.

Action

Over the past few years the Redland City Council Waterways Extension Program (WEP) has been reactively treating the Mexican waterlily (Figure 5.35).

As a long term action WEP has worked with all the landholders to revegetate the dam edge and introduce floating wetlands to the dam (Figure 5.36).

Why?

Mexican waterlily is a notoriously hard plant to completely eradicate from a waterbody. Like most weeds high nutrients accelerate the growth rate of Mexican waterlily allowing it to quickly reach levels that are difficult to control. Revegetating the dam edges will help to reduce the nutrients within and entering the dam in the long term. The biofilms present on the roots of the floating wetland remove nutrients and sediment from the water column of the dam (Figure 5.37).

Outcome

The dam's nutrient levels are reducing which will help reduce the spread of the Mexican waterlily.

The collaborative working relationship between the WEP officer and the landholders has resulted in a positive outcome around education and capacity building on aquatic weeds. As a result, one of the landholders spotted *Salvinia molesta* and manually removed it whilst it was at a controllable stage.

The landholders continue to work with WEP to improve water quality in the dam. In the future more planting will be carried out on the dam edges. Water sampling has been undertaken over a ten month period and will continue into the future. In addition, depending on future monitoring results and funding, more floating wetlands may be deployed.

Figure 5.34 Before – Mexican waterlily infestation



Photo: David Brown, Redland City Council

Figure 5.35 After – Mexican waterlily removed



Photo: Dale Watson, Redland City Council

Figure 5.36 After - installation of floating wetlands with protective bird netting



Photo: David Brown, Redland City Council

Figure 5.37 After - floating wetlands with bird netting removed



Photo: David Brown, Redland City Council

5.5.5 Hydrology and hydraulics

Hydrology and hydraulics refers to how water behaves and moves within a waterbody. The volume and frequency of water moving into and out of a waterbody and how long the water resides in the waterbody are important determining factors of the functioning of a waterbody. The hydrology and hydraulics of a waterbody is largely a function of:

- the size, shape, landuse and topography of the catchment

- the design of the waterbody (e.g. size, shape, construction type, inlet and outlet arrangement).

There are very limited numbers of practical, easy to achieve methods of improving hydrologic and hydraulic function within a waterbody. More intensive fixes do exist and are discussed in Section 4.3.4 of Module 4 'Maintenance and Operations.'

Practical and Innovative Solutions:

Solar water circulation system

Low flows in and out of a waterbody can result in thermal stratification particularly during the warmer seasons. See Section 1.4.2 of Module 1 'Waterbodies in Our Landscape' for further information on thermal stratification. Stratification favours cyanobacteria that are able to regulate their buoyancy and move between the stratified layers. Stratification can also result in significant release of phosphorus from sediments increasing the nutrient levels in the waterbody. Encouraging water circulation within a waterbody is one way to combat thermal stratification. Aeration systems are often used to introduce oxygen into the water column and promote circulation of the water. However, these systems can be costly to run if powered by fuel. Solar powered water circulation systems provide a more sustainable solution (Figure 5.38, 5.39).

Figure 5.38 Solar water circulation system from behind



Photo: Karen McNeale, Redland City Council

Figure 5.39 Solar water circulation system



Photo: Karen McNeale, Redland City Council

5.6 SET PRIORITY ISSUES AND ACTIONS

Having carried out a site assessment, identified the issues and then mapped out all of the practical management actions that need to be implemented, the result may be a colossal 'to-do' list. The trick here is to divide and conquer. Work with the landholder to discuss what actions they would most like to start with. Be sure to start with actions that can be achieved in the short term and can show some real tangible outcomes. Every time an action is completed and ticked off the list be sure to acknowledge and celebrate this achievement with the landholder. This can be accomplished through achievement certificates or even a simple verbal well-done. This will motivate the landholder to continue with the 'to-do' list.

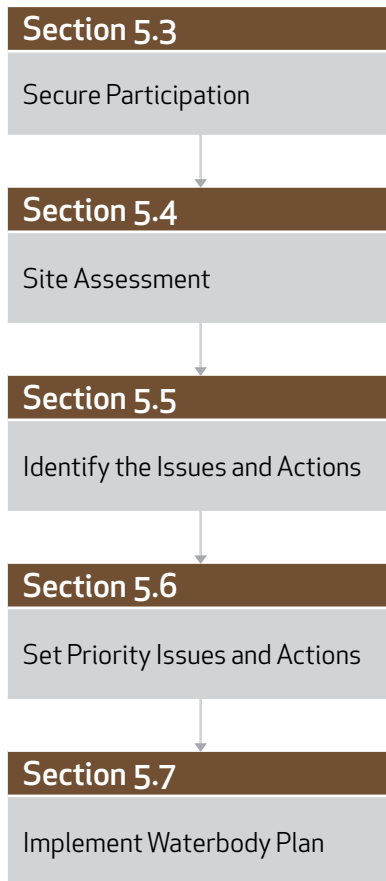
5.7 IMPLEMENT WATERBODY PLAN

Considering restraints in resources of both the extension program and the landholder, full implementation of the waterbody plan may take some time. It is therefore important to take a long term approach to managing waterbodies. Observe the waterbody and the effectiveness of the management actions over time. Learn from successes and failures, and tailor future management actions accordingly. Keep the landholder engaged and encouraged throughout this time by celebrating successes and acknowledging hardwork. Working together, the goal of a healthy waterbody and improved property and ecosystem will be achieved.

5.8 WORKED EXAMPLE

This worked example outlines the practical application of an extension program process (Figure 5.40) to a hypothetical local government area and landholder's property.

Figure 5.40 Extension program process



5.8.1 Setting

Sunnyside Council manages the Sunnyside Catchment. The lower reaches of this catchment are urban with the upstream reaches of the catchment being predominantly rural with some conservation and forested areas. The farming practices include equine, dairy, beef, poultry and crop. A large number of waterbodies exist across the Sunnyside Catchment. Over 70% of these waterbodies are located on private property, mainly in the upper catchment. During high rainfall events the majority of the waterbodies reconnect to the Sunnyside River which discharges into Sunnyside Bay. The Sunnyside Council 'Rural Waters Extension Program' works with landholders in the upper catchment to improve the health of their waterbodies and minimise the downstream impacts on Sunnyside Bay.

5.8.2 Securing participation

Sunnyside Council 'Rural Waters Extension Program' understands that a landholder's land is their business. The extension program therefore describes its work as 'giving landholder's the edge in their business'. The program promotes the environmental and business benefits gained from the practices they encourage. This promotes positive buzz around the program. The program also establishes networks and partnerships among their participants. This includes pairing suitable landholders together which generates discussion and promotes sharing of knowledge and experiences. By creating these partnerships the landholders have access to a peer support network which lowers the landholder's fears about participating and shows that the program is doable and beneficial. Each year the Program runs the 'People's Choice Awards' to celebrate successes and acknowledge the hard work of the participants. The program participants nominate and vote for landholders within different categories, such as, 'Most Supportive Neighbour' or 'Newcomer of the Year'. To keep satisfaction ongoing throughout the year, the Program also has a 'Landholder of the Month' award where the winner receives a token certificate and polo shirt with the Program's name and logo embroidered, as well as being acknowledged in the Program's monthly newsletter.

5.8.3 Site assessment

Charlie Smith, a cattle farmer, was tired of seeing the productivity of his land steadily decline. He heard from a neighbour that the 'Rural Waters Extension Program' had really experienced and friendly staff who might be able to provide some ideas on how to solve Charlie's problem. Charlie looked up the Program online and called the number on the website. He was put through to a friendly extension officer who arranged with Charlie an appropriate time and date to visit Charlie on his property. The site visit took place within a few days of Charlie making the call. Charlie gave Sarah, the extension officer, a tour of his property. Charlie lamented that his land just wasn't the same as it used to be. Charlie pointed out the sparse pasture and bare exposed soil and complained that his water supply had an unnatural green glow and wasn't fit for watering his animals. Sarah listened attentively to Charlie's frustrations and asked lots of practical and insightful questions about his property. After Charlie had concluded his property tour, Sarah and Charlie sat down together and talked about their shared vision for Charlie's property.

5.8.4 Identify issues and actions

Once Charlie and Sarah had set the goals and vision for the property, they discussed all the steps they would need to take to reach this vision. From Charlie's property tour and the answers he provided, Sarah had compiled a list of issues and actions. Sarah recognised the visual indicators of an algal bloom in Charlie's waterbody. From investigating the waterbody and property Sarah discovered stockpiles of manure located near the waterbody. From asking Charlie the right questions Sarah had also discovered that in previous years the

fields adjacent to the waterbody had been ploughed perpendicular to the waterbody. Sarah therefore identified that the waterbody was suffering from a legacy issue of high nutrient and sediment loading from the ploughing and also had an ongoing constant supply of nutrients from the upstream manure stockpiles. Sarah would therefore need to think of both long term and short term actions to address the issues. Table 5.4 shows the list of issues and actions that Sarah created for the property.

Table 5.4 List of issues and actions

Issue	Short Term		Long Term	
	Action	Expected Outcome	Action	Expected Outcome
High nutrient levels	Compound the manure stockpiles	Manure is no longer a source of nutrients to the waterbody	Create and introduce DIY floating wetlands to the waterbody	Nutrient and sediment uptake from the waterbody
High sediment levels	Prevent stock access to the waterbody	Reduced hoof erosion and reduced nutrient supply from animals defecating into the waterbody	Revegetate the waterbody edge with native vegetation	Vegetation acts as a filter for sediment protecting the waterbody and improves biodiversity
Erosion	Reapply composted manure to the sparse pasture	Improved pasture cover and less exposed soil	Revegetate the drainage line that runs into the waterbody	The vegetation will slow and filter the water running off the property and reduce erosion and capture sediment
Cyanobacterial blooms	Add a solar powered recirculation system to the waterbody	Prevents stratification and encourages flushing of the waterbody preventing build up of cyanobacterial cells	Plant tall native vegetation around the waterbody to shade the waterbody	The shade will regulate the waterbodies temperature preventing stratification and will reduce the sunlight and hence photosynthetic activity of algae and cyanobacteria

5.8.5 Set priority issues and actions

Sarah and Charlie worked through the list in Table 5.4 and discussed resources, capacity and what issues were of most importance to Charlie. Sarah kept in mind to focus on short term actions in the initial stages so that Charlie could see tangible benefits within short time periods and be encouraged to continue with the list. From listening to Charlie, Sarah knew that his biggest frustration was that his pasture was not as productive as it used to be and that it would be beneficial to focus on actions that would address this frustration. Together Sarah and Charlie made a short list of three key priorities that they would focus on (Table 5.5).

Table 5.5 Priority actions

Charlie's Top Three Priorities
1. Compound the manure stockpiles
2. Reapply composted manure to the sparse pasture
3. Prevent stock access to the waterbody

5.8.6 Implement waterbody plan

Charlie and Sarah set to work on completing their priority tasks. The 'Rural Waters Extension Program' supported Charlie by having Sarah as his dedicated extension officer and by financially supporting Charlie to purchase the manure compound and fencing supplies. Charlie was also teamed up with another like minded landholder who had experienced similar issues with livestock waste management. As each action was completed Sarah congratulated Charlie and complemented his dedication and hard work. Charlie even won 'Newcomer of the Year' at the annual awards and upon his completion of an off-line watering system was awarded 'Landholder of the Month'. Together Sarah and Charlie have completed their first three priorities and have already moved onto tackling bigger actions like revegetating the waterbody edge and constructing DIY Floating Wetlands.

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