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6.0 LAKES, PONDS AND WETLANDS

6.1 BACKGROUND

The purpose of this Chapter is to identify the key issues that must be addressed when a development proposal involves lakes, ponds and/or constructed wetlands and to highlight existing policies, standards and guidelines governing such facilities.

The functional requirements of lakes, ponds and constructed wetlands are that they must be designed, operated and maintained in order to:

- act as sustainable facilities;
- provide the desired level of stormwater treatment without introducing additional risks;
- meet agreed objectives (eg visual amenity, recreational function, provision of habitat);
- ensure that discharges from the facility are of such quality that Environmental Values of downstream receiving waters are protected or enhanced (ie relevant Water Quality Objectives are met); and
- facilitate routine service/maintenance requirements that are manageable, cost efficient, and minimise environmental impacts.

It is recognised that some constructed lakes and ponds in the City of Brisbane have had a poor track record in meeting relevant Water Quality Objectives. Reasons for this have included:

- the Water Quality Objectives that were set as performance targets for the facilities may have been incorrectly applied, for example protection of aquatic ecosystems objectives were applied within a pond rather than the downstream watercourse; and/or
- the ponds or lakes were poorly designed (eg undersized, little pre-treatment, etc).

A principal objective of this Chapter is to provide guidance on definitions, the selection of the appropriate Water Quality Objectives (ie water quality-related performance targets), and how to locate detailed design guidelines.

For the purposes of this guideline the following definitions apply:

- A **Lake** is a large body of open water with the primary function of providing visual and/or recreational amenity. The terminology will not apply if stormwater treatment is proposed to be a significant function of the water body.
- A **Pond** is an artificial body of open water designed primarily as a water quality treatment device (which may also have a water quantity management function).
- A **Constructed Wetland** is an area which:
  - has been constructed for the primary function of water quality treatment;
  - is transitional between land and water systems;
  - is either permanently or periodically inundated with shallow water; and
  - either permanently or periodically supports the growth of aquatic macrophytes (eg marsh, swamp, fen, bog).

Once again, this Chapter should not be seen as prescriptive and a hindrance to innovative ('non-standard') design of lakes, ponds and wetlands. It is a guide to what Council believes are the key issues that must be managed and refers users to what Council believes are currently the best references on the subject. As Figure C1.4 indicates, strict compliance with this guideline is only one way of meeting the performance criteria in the *City Plan*.

6.2 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

The designated EVs of a water body determine the appropriate WQOs (see Chapter 2 of Part C of this document). Definition of the values in the water body and downstream receiving waters is a vital task, which must be completed, early in the planning process. Consultation and agreement on relevant WQOs and where they apply should be sought with Council's development assessment team at an early stage as this issue has major ramifications for subsequent design of water bodies.

Clear distinction is required as to whether any WQOs will apply within the water body or just within the receiving waters downstream of the constructed water body. For example, if a constructed water body such as a lake with recreational and visual amenity values is to be incorporated into a residential development, then the WQOs relevant to the type of recreation (eg swimming, boating or visual use) will apply within the water body as well as for receiving waterways (eg creeks, rivers) downstream from the lake.

However, if the open water body is to be considered only as part of the stormwater treatment system then it will be known as a pond (see above definitions), and there may be no Environmental Values applied to the pond itself. In these cases, Environmental Values and WQOs will apply to the downstream receiving waters only. Note that there may be times when a pond will also have a secondary recreational purpose (eg visual amenity). In that case, WQOs relevant to the type of recreation will also apply to the waters within the pond.

It is important that the design process recognises this distinction. For example, where a water body is to be a pond, landscaping and/or structural features would typically be required to avoid inappropriate recreational use of the 'polluted waters' being treated in the pond (eg swimming). Visual screening may also be required. Furthermore, it may not be appropriate for the pond to feature in the marketing of the development (ie as a 'pristine lake'), as long term visual amenity cannot be guaranteed due to poor water quality in the pond and inevitable accumulation of pollutants and maintenance requirements.

It is also recognised that a single facility may include several components with different objectives. For example, an urban lake may have an upstream constructed wetland, sedimentation pond and trash rack(s) to treat stormwater. In such a case, WQOs may apply to waters in the lake but not in the wetland.

Water Quality Objectives applicable to design and construction must be determined with reference to Chapter 2 of Part C of this document and the *Guideline on Identifying and Applying Water Quality Objectives in Brisbane City* (BCC, 2000).

6.3 STATE GOVERNMENT LEGISLATION

The construction of a lake, pond or constructed wetland may require State Government approval under one or more of the following pieces of legislation. Relevant approvals are listed in the table below.

TABLE C6.1
APPLICABLE STATE GOVERNMENT LEGISLATION
(LAKES, WETLANDS AND PONDS)

Department	Legislation	Activity
Department of Natural Resources (DNR)	*Water Resources Act 1989*, Riverine Protection Permit	A Permit is required for modification of a freshwater (or non-tidal) watercourse through actions such as the removal of vegetation, excavation or filling. Note that a 'watercourse' can include a drainage channel that was once a natural waterway.
DNR	*Water Resources Act 1989*, Water Works Licence	A Licence is required for construction in a watercourse.
DNR	*Water Resources Act 1989*, s38	A Licence is required for construction works to 'conserve' water (eg a feature that includes water storage).
DNR	*Water Resources Act 1989*	A Licence is required for a 'Referable Dam' - where a barrier is 10 metres or more in height and creates a reservoir storage capacity of more than 20,000 m^3, or is more than 5 metres in height and creates a reservoir storage capacity of 50,000 m^3 or more.
Environmental Protection Agency (EPA)	*Harbours Act* (continued in effect by the *Transport Infrastructure Act 1994)*, s86	Approval is required for construction works on tidal lands (relevant for works in tidal creeks).
EPA	*Environmental Protection Act 1994* and *Environmental Protection Regulations 1998*	A Licence is required for dredging material from the bed of any waters.
Department of Primary Industries (DPI)	*Fisheries Act 1994,* s113 s116	Approval is required for activities that could affect the movement of fish (eg drop structures, culverts, GPTs). The requirement includes ephemeral and continuously flowing open drains and waterways.
DPI	*Fisheries Act 1994*, s51	A Permit is required to remove, destroy or damage marine plants or any other vegetation on tidal lands (eg mangroves).
DPI	*Fisheries Act 1994*, s90	A Permit is required to release non-indigenous fish (eg into a pond or wetland for mosquito control).

Note: These legislative requirements should always be checked with relevant State Government Departments, as the legislation may have been amended (or interpretations may have changed).

In addition there is the General Environmental Duty under the Queensland *Environmental Protection Act 1994* which requires all person in the State to take "*…all reasonable and practicable measures are taken to minimise or prevent environmental harm*".

6.4 KEY ISSUES/DESIGN CRITERIA

6.4.1 Introduction

The construction of a lake, pond or constructed wetland has the potential to create positive and negative impacts in upstream and downstream environments. The assessment of the development proposal must therefore consider the magnitude of these potential impacts and how the potential impacts are to be mitigated. The onus is placed on the proponent to demonstrate that the proposal is sustainable using reasonable maintenance requirements, complies with relevant State Government legislation (see above), has acceptable impacts upon upstream and downstream hydrology and hydraulics, and that it will have a net benefit to the community.

The Sections below outline the key water quality design requirements for constructed water bodies.

6.4.2 General Requirements for Constructed Water Bodies

A development proposal that includes a lake, pond or constructed wetland, must be accompanied by a detailed assessment report prepared by a suitably qualified professional. The level of detail required in the report will be commensurate with the degree of risk associated with the proposal.

The report must provide (as a minimum) details of the following:

- the broad functional objectives for the facility (eg recreational lake, habitat provision, water quality treatment device), and how the facility is to be integrated with surrounding land uses;
- the Environmental Values and Water Quality Objectives for waters in the facility and downstream receiving waters;
- an assessment of the impacts of the proposal on the upstream and downstream environment and proposed mitigation measures (eg environmental and flooding impacts);
- an assessment of public safety risks and management measures;
- an assessment of whether the catchment is of an adequate size to fill the water body and maintain the desired water levels;
- a performance monitoring plan for the facility (where required - see Chapter 13 of Part C of this document); and
- a maintenance plan (see Chapter 14 of Part C of this document).

The report should be supported by sufficient analysis and/or computer modelling (eg hydrologic and pollutant export modelling) to give stakeholders confidence that the development's objectives will be satisfied. Note that for large water bodies (ie recreational lakes and regional wetlands) two or three dimensional hydrodynamic and water quality modelling may be required[1]. Applicable modelling references are listed in Section 6.6.

[1] The primary objectives of such modelling are to demonstrate that 'short circuiting' will not occur and that minimum detention times will be met. Three dimensional modelling would be unusual for Brisbane. Examples of current two dimensional hydrodynamic models include SMS, MIKE21, and DEFLT FLS. As a general rule, such modelling would be required when the proponent is using designs that are not in accordance with preferred references listed in Section 6.6.

The final ownership of the water body is a critical issue that needs to be clarified early in the development of the proposal. If public ownership is proposed, this issue must be negotiated with Council on a case by case basis. In addition, the criteria for 'hand-over' of the asset must be developed and agreed (see Chapter 15 of Part C of this document). If the water body is to be kept in public ownership in the short or long term, Council may require a bank guarantee to be kept with an accompanying agreement/deed between Council and the owner. Such a guarantee and deed could be called upon if Council needed to take over the management of the asset to ensure compliance with reasonable and relevant performance criteria.

6.4.3 Lakes and Ponds

One of the key issues associated with lakes and ponds is the maintenance of adequate water quality in the facilities (assuming both types of facility have some Environmental Values associated with captured water[2]).

Water quality in a lake or pond is a function of catchment characteristics, hydrologic regime, climate, depth, pre-treatment and internal processes (chemical, physical and biological). The assessment of water quality must take a holistic view of all these processes.

Management of inflows to the water body should be addressed in the Site Based Stormwater Management Plan (SBSMP), as outlined in Chapter 3 of Part C of this document.

The management of risks associated with public safety in and around constructed water bodies is also a key issue. Design elements such as the depth, bank slope, public access and outlet design must incorporate public safety considerations.

In addition to the issues listed in Section 6.4.2, the assessment of lakes and ponds should include consideration of the following:

- treatment of inflows via gross pollutant traps, nets, trash racks, swales, sedimentation basins, wetlands or other types of SQID;
- definition of the shape, location and depth of the water body to minimise the potential for stratification, stagnation or 'short circuiting';
- for ponds with a treatment function, high flow bypass requirements need to be considered, as high flow velocities may cause scouring of deposited materials thereby reducing the effectiveness of the pond;
- maximisation of hydrologic effectiveness for ponds (eg detention time, volume of wetland relative to flow regime);
- maximisation of hydraulic efficiency for ponds (eg the establishment of uniform flow, an optimal discharge relationship at the outlet structure);
- maximisation of treatment efficiency for ponds (eg macrophyte contact time);
- management of groundwater impacts such as leakage, contamination, rising water tables and salinity;

[2] For ponds, water quality in the device may only have to be suitable for passive recreation, that is, provide visual amenity (eg no algal blooms) and not produce malodours (eg from decaying vegetation).

- protection against noxious/feral fish species;
- provision for faunal movement along the waterway corridor (ie both terrestrial and in-stream movement);
- consideration of the nature of contaminants (eg speciation of nutrients, particle size) and how they behave in the facility (eg releases of nutrients from anoxic sediments);
- water level control for maintenance or during drought periods;
- management of the impact on the downstream flow regime and the frequency and quality of releases for environmental or other purposes;
- safe and cost-effective maintenance of the water body including removal of excessive growths of floating macrophytes, control of noxious water weeds, desilting, mosquito control, litter removal and periodic drainage;
- edge treatments for the water body and minimisation of the potential for instability or erosion by wave action (particularly on long fetches) or water level changes; and
- management of public safety with regard to access to the water body, depth, bank grading, screening, fencing and signage.

If the lake or pond has recreational and aesthetic Environmental Values, maintenance of good water quality within the water body is required at all times. In addition to the points above, this includes an assessment of the following:

- treatment of the base and sides of the water body prior to inundation (this may include the removal of vegetation or contaminated material to minimise the potential for the release of nutrients or contaminants into the water body);
- design to minimise the potential for stratification, either passively through shaping of the bathymetry, or actively through aeration or recirculation; and
- prevention of eutrophication through control of nutrient inputs (via source controls and/or upstream treatment) or in-lake management measures (eg destratification, biological controls, sediment chemistry manipulation).

6.4.4 Constructed Wetlands

As with lakes and ponds, management of inflows to the water body and catchment processes should be addressed in the Site Based Stormwater Management Plan (SBSMP), as outlined in Chapter 3 of Part C of this document.

In addition to the general design issues listed in Section 6.4.2, the design of a constructed wetland should include consideration of the following:

- maximisation of hydrologic effectiveness (eg detention time, volume of wetland relative to flow regime);
- maximisation of hydraulic efficiency (eg the establishment of uniform flow, an optimal discharge relationship at the outlet structure);
- maximisation of treatment efficiency (eg macrophyte contact time);
- provision of adequate wetland pre-treatment and high flow bypass;
- minimisation of organic loading;
- provision of safe and cost-effective maintenance;
- protection of wetland plants from the scouring effects of high flows;

- a pre-treatment device to collect litter and vegetative matter;
- siting the wetland upstream (rather than within) natural wetlands with significant ecological values;
- an inlet zone or sediment basin designed to promote the settlement of coarser sediments which can be easily removed;
- a flow distribution device downstream of the inlet zone which promotes uniform flow (eg a permeable weir or submerged berm);
- banded zones of vegetation perpendicular to the primary flow path to minimise the potential for short circuiting;
- a macrophyte zone morphology which has a flat base in cross section to maximise macrophyte contact;
- use of Queensland native plants during macrophyte species selection (refer to CCIR, 1999);
- macrophyte species selection based upon an understanding of pollutant removal performance and local ecological benefits/impacts;
- a permanent pool of approximately 10% to 15% of total storage to increase detention time while maintaining a diverse ephemeral habitat along the periphery of the wetland;
- a length to width ratio in the open water area of greater than 3, with flow velocities less than 0.2 m/s;
- multiple cells within the wetland's macrophyte zone with uniform flow distribution between each cell, and no 'short circuiting';
- location of outlet structures to permit water level control and promote habitat diversity (eg a riser or siphon outlet);
- a macrophyte planting strategy including plant selection, site preparation, supply of planting stock, planting procedures, water level control during establishment and establishment period maintenance (note that wetland plants may need to be ordered 12-18 months before planting);
- minimisation of the loading of organic matter through pre-treatment, sizing of open water areas and the use of wetting and drying cycles to promote the rate of organic degradation;
- management of safety issues such as banks slopes, and the provision of safety rails, a barrier, screening and/or signage;
- potential for multiple uses (any secondary uses should not compromise the primary function, for example, the use of habitat islands which support large bird populations can increase pollutant loads and decrease wetland treatment performance);
- management of impacts on groundwater (eg leakage, contamination, rising water tables and salinity); and
- the control of mosquitos through grading, water depth control, preventing stagnation, litter removal and/or predation.

6.5 PROCESS

The recommended process for creating a lake, pond or constructed wetland from the planning stage through to implementation is described as follows:

Step 1
Establish a vision for the proposed water body including a statement of how it will be incorporated in the surrounding area. For example, a vision could be that "a recreational lake is proposed as the central focus for a residential development".

Step 2
Determine the desired Environmental Values within the facility, around it and in the downstream receiving waters (eg creeks and rivers). Identify target pollutants and select appropriate Water Quality Objectives (refer Chapter 2 of Part C of this document) in consultation with the relevant Council development assessment teams. Agreed EVs and corresponding WQOs are to be documented.

Step 3
Assess the proposal's environmental impact. This task includes consideration of ecological impacts and licensing requirements. Given the impacts constructed water bodies typically have and the type of developments they are normally associated with, and Environmental Management Plan (EMP) would be required that explains how the various impacts will be managed.

Step 4
Carry out concept design in consultation with the key stakeholders. This includes consideration of the design issues raised in Sections 6.4.2, 6.4.3, and 6.4.4.

Step 5
Undertake pollutant export modelling to develop the concept and to ensure that the proposal can meet relevant WQOs as well as other objectives (eg water quantity management objectives). As modelling is a relatively complex task, a suitably qualified professional must undertake this task.

Step 6
Undertake detailed design in consultation with key stakeholders. These will include relevant Council staff from the maintenance, open space (parks), waterways and natural environment areas. Other stakeholders may include community groups and the local Councillor.

The design must be undertaken using a multi disciplinary team and in accordance with best practice (refer reference list below). Assessment of water quality, ecological, drainage or flooding issues must be undertaken by suitably qualified experts.

Step 7
Prepare a water quality/performance monitoring program and Maintenance Plan where needed (see Chapters 13 and 14 of Part C of this document, respectively).

Step 8
Where responsibility for the facility is to be transferred to Council, undertake the asset hand-over steps outlined in Chapter 15 of Part C of this document.

6.6 REFERENCES

Preferred References

1. Centre for Catchment and In-stream Research, 1999. *Wetlands Indicator Plant Species List (draft)*. Griffith University, Brisbane.
2. Cooperative Research Centre for Freshwater Ecology, 1998. *Design Guidelines: Stormwater Pollution Control Ponds and Wetlands*. Cooperative Research Centre for Freshwater Ecology, Melbourne.
3. Cooperative Research Centre for Catchment Hydrology, 1998. *Managing Urban Stormwater Using Constructed Wetlands: Industry Report 98/7*. Cooperative Research Centre for Catchment Hydrology, Melbourne.
4. Department of Land and Water Conservation, NSW, 1998. *The Constructed Wetlands Manual, Vol 1 & 2*. Department of Land and Water Conservation, NSW.
5. Victoria Stormwater Committee, 1999. *Urban Stormwater: Best Practice Environmental Management Guidelines.* CSIRO, Melbourne.
6. Martin, J.L., McCutcheon, S.C., and Schottman, R. W. (1999). *Hydrodynamic and Transport for Water Quality Modelling*. Lewis Publications, Boca Raton.

Additional References

1. NSW EPA, November 1997. *Treatment Techniques: Managing Urban Stormwater.* EPA, NSW.