



# Lend Lease

East Lake

Stormwater Management

Final

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0	16 Aug 2013	Draft	MM/SR	JC	JW
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## Executive Summary

This report has been prepared to support the Development Application (DA) of the East Lake at the Western Precinct of the Lend Lease site at Jordan Springs. The assessment focuses on the permanent stormwater management component of the Lake. It includes calculations of the required detention volume in the lake to provide peak flow mitigation and an assessment of water quality. To meet the detention and water quality requirements, a lake of approximately 3 hectares is proposed.

A maintenance procedure has also been prepared to outline the appropriate wetland management strategies for the Lake.

This report is to be read in conjunction with the following stormwater management DA drawings:

■ **Table 1 Drawing list**

Drawing number	Drawing title
EN04189-ECC-DG-0001	COVER SHEET AND DRAWING INDEX
EN04189-ECC-DG-0006	GENERAL NOTES
EN04189-ECC-DG-0011	EAST LAKE LAYOUT PLAN
EN04189-ECC-DG-0012	EAST LAKE DETAILED SPILLWAY PLAN
EN04189-ECC-DG-0016	BULK EARTHWORKS PLAN
EN04189-ECC-DG-0021	EAST LAKE SECTIONS – SHEET 1
EN04189-ECC-DG-0022	EAST LAKE SECTIONS – SHEET 2
EN04189-ECC-DG-0026	EAST LAKE DETAILED SECTIONS
EN04189-ECC-DG-0028	EAST LAKE DETAILED SPILLWAY SECTIONS

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The sole purpose of this report and the associated services performed by Jacobs is to determine the stormwater management requirements in accordance with the scope of services set out in the contract between Jacobs and Lend Lease. That scope of services, as described in this report, was developed with the Client.

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## 1. Introduction

The purpose of this report is to support the East Lake stormwater management DA drawings. The main purpose of the Lake is to provide detention, water quality treatment and improve the aesthetic qualities of the area.

The emphasis in this report and associated drawings will be on the Lake area inside the water edge line but will include details of the proposed spillway at the outlet of the Lake. For all areas above the permanent water line, reference is to be made to the landscaping and subdivision drainage plans by others.

## 2. Site description

The proposed East Lake will be located south of the Village 5 residential area. When built, the Lake will occupy an area of approximately 3 ha and contain a permanent water body of approximately 46 ML. Stormwater collected in the drainage system of the proposed upstream residential areas will enter the Lake via culverts under Road 21 and other drainage inlet discharge points from Villages 2 and 5.

The Lake will comprise of a deep water zone, and a macrophyte zone which will consist of reed beds along the southern edges and the north east and north west corners of the Lake. The Lake will provide detention, facilitate nutrient suspended solids removal and provide a habitat for wildlife.

The Landscape drawings of the Lake provide the outline of the Lake, the proposed landscaping around the Lake, trees, footpaths, drainage headwalls, and other structures.

## 3. Stormwater detention

A hydrological assessment has been undertaken to determine peak flow rates for existing conditions at the location of the proposed Lake at its downstream end. This was followed by an assessment of peak flow rates for a fully developed catchment which generated an increase in peak flows. The detention volume of the Lake and its outlet have been designed to provide sufficient peak flow mitigation such that the peak flows from the fully developed catchment do not exceed current peak flow rates. The detention volume is situated above the permanent water level in the Lake. **Appendix A** provides a more detailed description of the methodology, parameters used and results of the hydrological and detention basin modelling. A Stream Erosion Index (SEI) assessment has not been undertaken at this stage given detention will provide peak flow mitigation and adequate erosion protection will be provided at the basin outlet.

## 4. Water quality

The water quality objectives for the East Lake are to achieve the target reductions of pollutant loads generated from a fully developed catchment upstream of the Lake. The design criteria and target reductions for new urban areas were obtained from the Penrith City Council's *Water Sensitive Urban Design (WSUD) Policy* (December 2013).

A water quality assessment was undertaken using the eWater MUSIC model to estimate the reduction in water pollution by the proposed Lake. The main purpose of the modelling was to demonstrate that the proposed water quality management controls (East Lake/water quality pond) would meet the water quality objectives of reducing the annual pollutant loads generated from the future urbanised catchment. **Appendix B** provides a more detailed description of the methodology, parameters used and results of the water quality modelling.

The results of the modelling indicate that the proposed size of the Lake would meet these objectives.

## 5. Maintenance

The proposed Lake will comprise of a deep water zone and a macrophyte zone which will consist of reed beds on the southern side and around the perimeter of the Lake on the northern side. It will facilitate nutrient and suspended solids removal and provide a habitat for wildlife. Water quality ponds and wetlands provide a very

effective means of treating stormwater in urban areas. However, ongoing maintenance is essential in maintaining the water quality performance of the Lake.

A maintenance procedure has been prepared to outline the maintenance and operational requirements associated with the East Lake.

**Appendix C** provides a more detailed description of the required maintenance regime, noxious weeds management and routine inspections of the Lake.



## Appendix A. Hydrologic and detention basin assessment

### A.1 Introduction

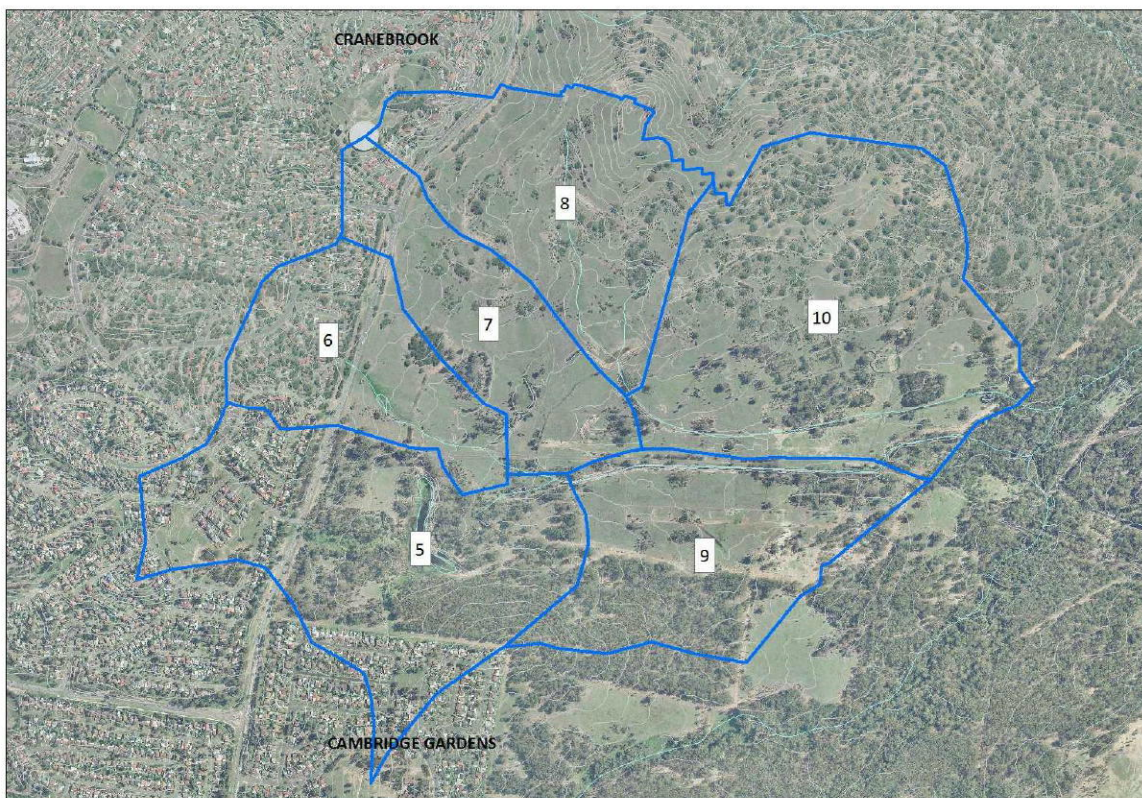
This section summarises work undertaken to assess detention requirements for the development the catchments upstream of the proposed East Lake. It provides details of the hydrological modelling work undertaken using the XP-RAFTS model to assess the existing and developed cases, in order to determine the detention volume requirements. It also provides details of HEC-RAS modelling undertaken to determine the basin outlet configuration that considered downstream flooding impacts.

### A.2 Study area

The study area includes a total catchment area of 292 hectares draining to the proposed East Lake, which is located in the south-east corner of the Western Precinct. The Jordan Springs Lake is located within the study area and this captures an area of 109 hectares. The existing catchment areas are predominantly undeveloped, with some urban development on the western fringes of the catchment.

The study area, showing the catchment boundary used in this assessment is shown in **Figure A.1**.

#### ■ Figure A.1 Study area showing catchment boundary



### A.3 Objective

The objective of the assessment is to mitigate the peak flows under the developed conditions such it is less than the existing peak flow for a range of design storms from 2 to 100 year average recurrence intervals (ARI). The assessment has used the XP-RAFTS model to provide the required detention volume and outlet configuration.



## A.4 Design criteria (hydrology and detention) and model set up

### A.4.1 Catchment areas

The study area has been divided into 6 sub-catchments which are shown in **Figure A.1**. Delineation of the catchments was undertaken as part of the *St Marys Western Precinct Plan – Water, Soils and Infrastructure Report* (May, 2009). Some minor improvements were made to the catchments following a review of this work. The catchment characteristics as modelled in XP-RAFTS are provided in **Table A. 1**.

■ **Table A. 1 Sub catchment details (refer to Figure A.1)**

Sub-catchment	Total area (ha)	Existing		Developed		Slope (%)
		Pervious sub area(ha)	Impervious sub area (ha)	Pervious sub area(ha)	Impervious sub area (ha)	
5	64.24	50.95	13.28	50.95	13.28	1.89
6	32.00	24.30	7.70	12.68	19.32	2.11
7	28.70	26.80	1.90	9.37	19.33	2.22
8	48.00	46.70	1.30	14.92	33.08	1.41
9	43.18	43.18	0.00	30.50	12.68	1.37
10	77.88	77.88	0.00	41.05	36.83	1.53

The pervious and impervious sub area values estimated for each sub catchment are based on the following assumptions:

- No development will occur in the park areas therefore percentage impervious does not change;
- Areas allocated for urban development will have varying impervious percentages between 50-70%. For the purpose of the assessment 70% has been adopted for all areas which is conservative and is consistent with previous hydrologic assessment undertaken for the Jordan Springs Lake; and
- Existing urban areas external to the site will be unchanged from existing, i.e. 50% impervious.

### A.4.2 Rainfall intensities and loss parameters

Design rainfall Intensity-Frequency-Duration (IFD) data was generated for the site location following the procedure outlined in Australian Rainfall & Runoff (ARR, 1987). The design rainfall data was used in the RAFTS model and a suite of storm durations were input for each ARI rainfall event. The site IFD data is shown in **Table A. 2**. The site IFD data is very similar to IFD values provided in Penrith City Council's *Stormwater Drainage for Building Developments* guidelines.

■ **Table A. 2 Site IFD rainfall data**

Duration (min)	2yr ARI	5yr ARI	10yr ARI	20yr ARI	50yr ARI	100yr ARI
20	52.82	69.66	79.08	91.89	108.85	121.9
30	42.83	56.47	64.09	74.46	88.19	98.75
60	29.05	38.28	43.43	50.44	59.72	66.86
90	23.04	30.31	34.36	39.89	47.19	52.81
120	19.48	25.6	29	33.65	39.79	44.51
180	15.33	20.12	22.78	26.41	31.21	34.89
360	10.16	13.3	15.04	17.42	20.56	22.97
720	6.75	8.81	9.95	11.51	13.57	15.15

An initial and continuing loss model was applied to the XP-RAFS model. Loss parameters used in the model are outlined in **Table A. 3**.

■ **Table A. 3 Loss parameters**

Land use	Initial loss (mm)	Continuing loss (mm)
Impervious	1.0	0.5
Pervious	10.0	2.5

The loss parameters are consistent with previous work undertaken by SKM for Jordan Springs. A Bx factor of 1.0 was adopted in the model which is also consistent with previous modelling.

#### A.4.3 Roughness coefficients

Manning's 'n' values adopted in the model for different land uses are provided in **Table A. 4** for the existing and developed case. These values are consistent with previous assessments undertaken.

■ **Table A. 4 Roughness values**

Land use	Manning's 'n' value
Impervious	0.015
Pervious - urban	0.04
Pervious - rural	0.07

#### A.4.4 Channel routing

Channel routing was applied in the XP-RAFS model to represent the change in flood attenuation that would occur as a result of the proposed East-West channel. The proposed channel details were obtained from the latest design drawings.

### A.5 Model Results

The XP-RAFS model was run for a range of durations from 15 minutes to 18 hours to assess and compare the existing peak flows to the developed peak flows with and without detention at the catchment outlet.

A comparison of peak flows for the 2 year and 100 year events is shown in **Table A. 5**.

■ **Table A. 5 Peak flows**

Design storm (ARI)	Peak flow existing (m <sup>3</sup> /s)	Peak flow developed (m <sup>3</sup> /s) no detention	Peak flow developed (m <sup>3</sup> /s) with detention
2 year	9.8	24.9	8.9
100 year	29.6	60.4	27.0

The results in **Table A.5** indicate that the developed peak flow with detention is less than the existing peak flow for the 2 year and 100 year events. The reduction in peak flows is 9% and 13% respectively. There is also a significant reduction in developed peak flows with the detention basin when compared to the unmitigated peak flows.

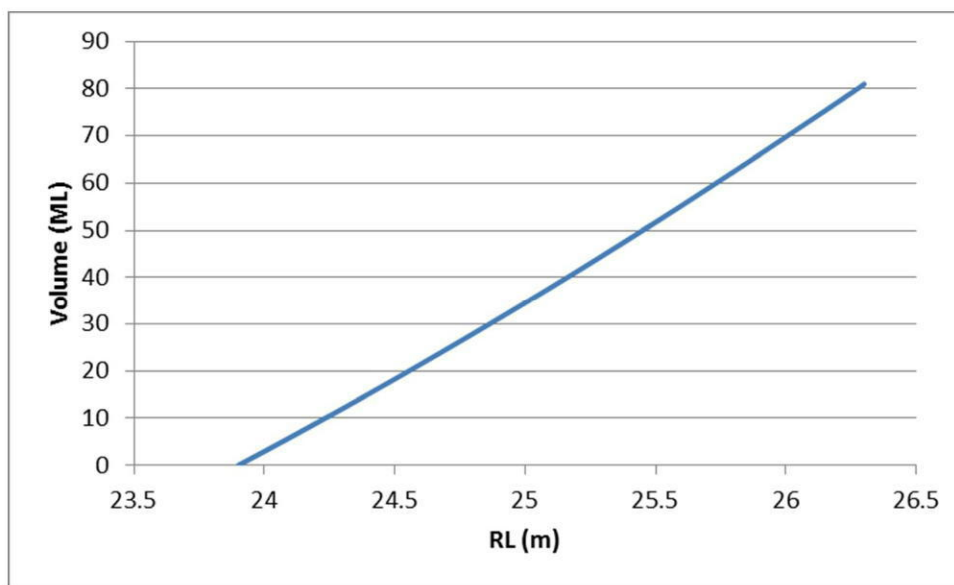
The results indicate that a minimum detention volume of approximately 55,000 m<sup>3</sup> (55 ML) at East Lake provides adequate detention for the proposed developments with an acceptable freeboard. Details of the detention basin are provided in **Section A6**.

## A.6 Detention basin details

### A.6.1 Basin geometry

A stage-volume relationship of the basin was developed from the 3D (12d) model of the proposed lake shape and dimensions. The derived relationship is shown in **Figure A. 2**.

#### ■ Figure A. 2 Stage-Volume relationship for East Lake

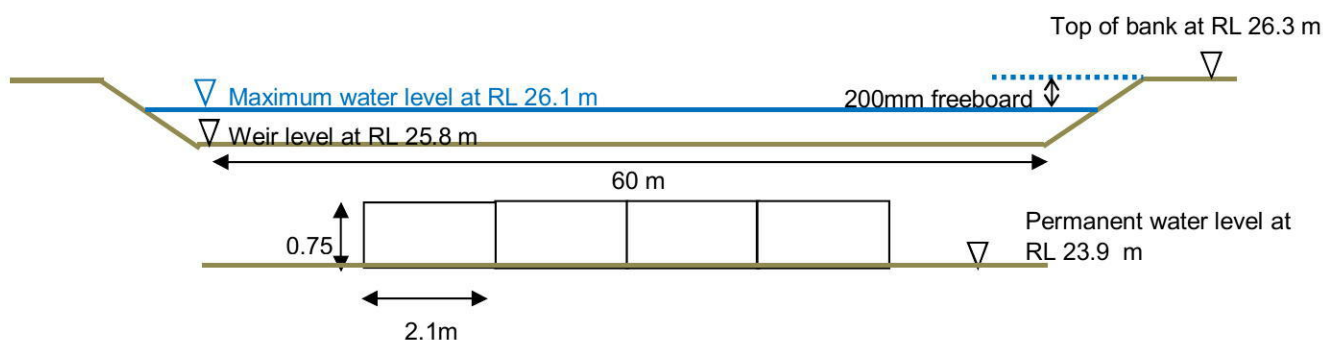


### A.6.2 Outlet configuration

Model runs have been undertaken assuming the details shown below and the outlet configuration shown in **Figure A. 3**:

- 4 x box culverts, 2.1m width x 0.75m height with an upstream invert level of 23.9m
- 60m weir at an elevation of 25.8m. The elevation and width of the weir has been determined from HEC-RAS modelling of the basin weir and downstream channel and floodplain for the 100 year ARI event.

#### ■ Figure A. 3 Outlet configuration



Results for the 2 year and 100 year design events are summarised in **Table A. 6**.

■ Table A. 6 Detention details

Design storm (ARI)	Detention volume required (ML)	Proposed Maximum stage (m)	Maximum depth over weir (mm)
2 year	27.7	25.0	0
100 year	55.0	26.1	300

The 100 year ARI maximum stage and depth of flow over the weir has been obtained from HEC-RAS modelling of the basin weir and downstream channel. The HEC-RAS model better simulates the impact of downstream flooding conditions on the behaviour of the detention basin compared to the XP-RAPTS model. **Figure A2** and **Table A6** indicate that the minimum required detention volume of 55ML has been satisfied.

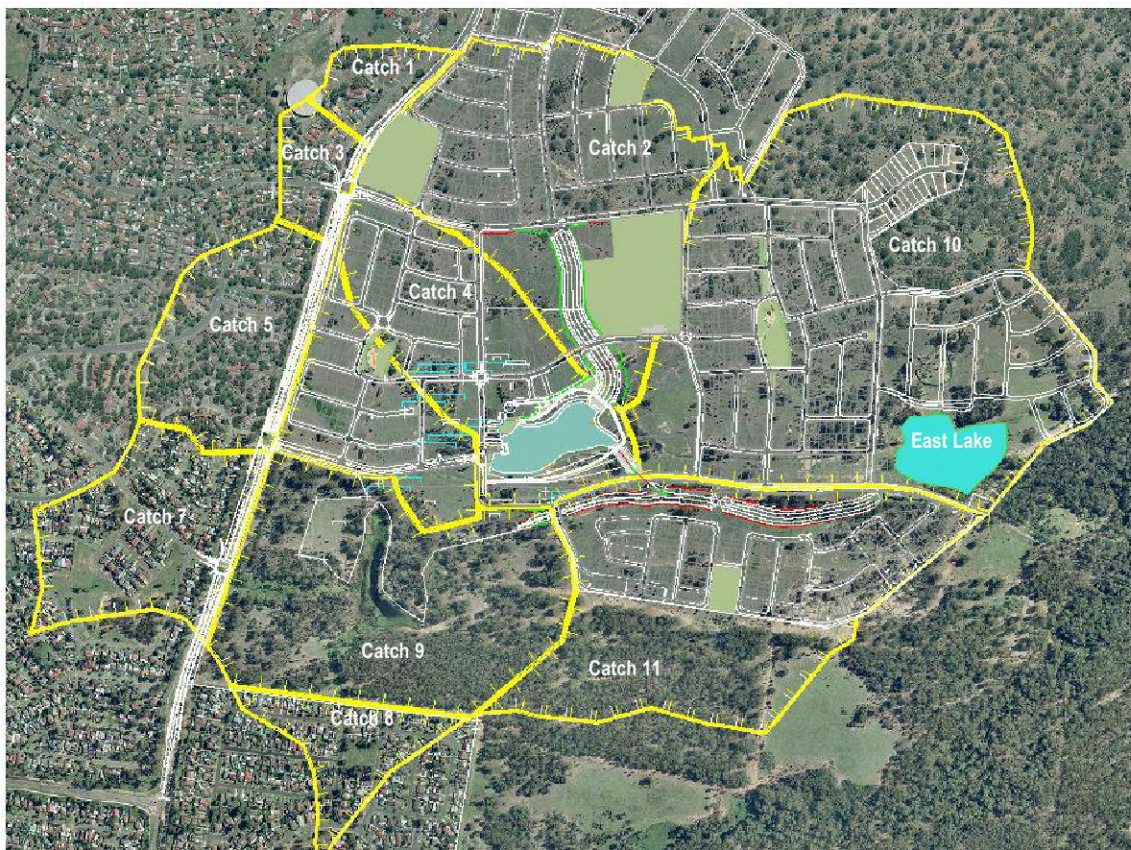


## Appendix B. Water quality assessment

### B.1 Purpose

The purpose of this report is to provide a water quality assessment of the proposed East Lake. The runoff generated from the proposed development area requires water quality treatment prior to being discharged into the Regional Park.

- Figure B. 1 Location of the proposed East Lake and the associated upstream catchments



### B.2 Stormwater quality management objectives

The stormwater quality management objectives for the proposed development are to provide sufficient water quality treatment to reduce the Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN) loads from the proposed development catchments. The objectives that have been used were obtained from Penrith City Council's *Water Sensitive Urban Design (WSUD) Policy* document (Penrith City Council, 2013). These criteria and water quality objectives for new urban areas are described on **Table B. 1**.



■ Table B. 1 Stormwater treatment objectives for new urban areas

Pollutant	Pollutant load reductions
Total Suspended Solids (TSS)	85% reduction in the post development mean annual load
Total Phosphorus (TP)	60% reduction in the post development mean annual load
Total Nitrogen (TN)	45% reduction in the post development mean annual load
Gross Pollutants (greater than 5mm)	90% reduction in the post development mean annual load

### B.3 Water quality strategy

The water quality treatment strategy for the proposed development includes:

- Conveying runoff by swales, where possible.
- Initial treatment of the proposed development areas with Gross Pollutant Traps (GPT)
- Capturing runoff in the East Lake where treatment would occur through natural processes prior to discharging into the Regional Park.

The topography of the site means that runoff from some existing upstream catchments would flow to the lake and would therefore also receive treatment.

### B.4 Water quality MUSIC modelling

A stormwater quality assessment was undertaken using the MUSIC model (Version 6) to estimate the reduction in water pollution by the proposed Lake. The main purpose of the modelling was to demonstrate that the proposed GPTs and East Lake would meet the water quality objectives of reducing the annual pollutant loads generated from the future urbanised catchment. Whilst swales provide additional water quality treatment, they have not been considered in the modelling. This is considered to be a conservative approach.

The MUSIC modelling was undertaken following the procedures and recommendations in Penrith City Council's *WSUD Technical Guidelines* (Penrith City Council, 2014). The following section provides information on the MUSIC modelling inputs and process.

#### B.4.1 Climate

Pluviograph data for use in the model was obtained from the Bureau of Meteorology for station AWS 67113 at Penrith Lakes for the period January 1999 to December 2008. The ten year period was entered to the MUSIC model and the model was run at six minute time steps.

#### B.4.2 Soils

Site specific soil testing has been undertaken to confirm soil conditions in the location of the Lake.

Average laboratory testing results were found to be 0.0013 mm/hr while average field test results were 1.4 mm/hr. This is a significant difference that may be caused by the methodology of testing or variations in the soils or local fractures. Further site tests are likely to be undertaken once the lake is excavated to determine the most appropriate permeability value to be adopted in the range of 0.0013 to 1.4mm/hr. If the lake is to be lined with clay lining or a geosynthetic clay liner, the permeability would be reduced to nil. The water quality model has assumed a conservative design of 0.1mm/hr permeability. A more representative permeability would be in the order of 0.36mm/hr or higher.

### B.4.3 Pollutants

In deriving data for pollutants generated by the urban catchments, data from Penrith City Council's *WSUD Technical Guidelines* (Penrith City Council, 2014) was used.

For the forested catchment areas, the *Draft NSW MUSIC Modelling Guidelines* (Sydney Metropolitan Catchment Management Authority, 2010) were reviewed. The recommended typical values for TSS, TP and TN were adopted as the Event Mean Concentrations (EMC) in the MUSIC model.

The values are given in **Table B. 2** and **Table B. 3**

■ **Table B. 2 EMC values adopted for the urbanised catchments**

Pollutant	Base EMC (mg/L)	Storm EMC (mg/L)
TSS	15.8	141
TP	0.14	0.25
TN	1.29	2.0

■ **Table B. 3 EMC values adopted for the forested catchments**

Pollutant	Base EMC (mg/L)	Storm EMC (mg/L)
TSS	6.0	39.8
TP	0.03	0.08
TN	0.30	0.89

### B.4.4 Catchment areas

The total catchment area flowing to the East Lake is approximately 292 ha. The total developed area flowing to the East Lake, including existing urban areas is approximately 185 ha. A breakdown of the catchment characteristics is provided in **Table B. 4**.

■ **Table B. 4 Catchment areas and characteristics (refer to Figure B. 1)**

Catchment	Area (ha)	Land use
1	4.7	Existing urban residential catchment at Cranebrook
2	39.8	Proposed urban residential catchment with some area being used as playing fields.
3	5.0	Existing urban residential catchment at Cranebrook
4	26.4	Proposed urban residential catchment and Jordan Springs Lake
5	16.8	Existing urban residential catchment at Cranebrook
6	14.0	Proposed urban residential catchment
7	18.4	Existing urban residential catchment at Cranebrook
8	8.2	Existing urban residential catchment at Cambridge Gardens
9	37.7	Regional Park to be retained
10	43.2	Proposed urban residential catchment with some area of the Regional Park to be retained
11	77.9	Proposed urban residential catchment and Jordan Springs Lake with some area of the Regional Park to be retained
<b>Total</b>	<b>292 ha</b>	

#### B.4.5 Rainwater tanks

The effect of rainwater tanks has been included in the model. The number of tanks in use has been estimated based on the requirement for properties over 400m<sup>2</sup> requiring rainwater tanks. The rainwater tanks would be used for irrigation of landscaped areas only. The irrigation demand on tanks has been taken from Council's *WSUD Technical Guidelines* (Penrith City Council, 2014). Rainwater tanks would not be plumbed to dwellings for internal use. The parameters used for modelling the rainwater tanks were are shown in **Table B.5**.

■ **Table B.5 Rainwater tanks**

Parameter	Value
Estimated total number of tanks	1071
Size of each tank	2 kL
Estimated tank dimensions (length x width)	2210 mm x 700 mm
Average daily internal demand	-
Average annual irrigation demand	75 kL/yr/lot

#### B.4.6 Treatment nodes

Treatment would be provided by GPTs and the East Lake, all of which have been included in the MUSIC model. The GPTs included in the MUSIC model are two CDS units (one of which is already constructed upstream of Jordan Springs Lake) and a Humeguard device. The GPT removal rates used in the model were selected from Council's *WSUD Technical Guidelines* (Penrith City Council, 2014) and the manufacturer documentation, and are outlined in **Table B. 6**.

■ **Table B. 6 GPT removal rates**

Pollutant	CDS Unit	Humeguard
Gross pollutants	95%	85%
TSS	70%	0%
TP	30%	0%
TN	0%	0%

The East Lake has been modelled as a water quality pond. The design parameters used in the model to represent the Lake are outlined in **Table B. 7**. The values of surface area and volume were obtained from 3d modelling of the proposed Lake.

■ **Table B. 7 East Lake design parameters**

Parameter	Value
Surface area	29,400m <sup>2</sup> or 2.94ha
Extended detention depth	0.5m
Volume	46,554m <sup>3</sup>
Exfiltration rate	0.1mm/hr – conservative estimate based on soil test results



#### B.4.7 Model layout

A screenshot of the MUSIC model is shown overleaf in **Figure B. 2**.

A portion of the undeveloped catchment 11a shown in **Figure B.2** (approximately 50%) may bypass the East Lake once the detailed drainage design is developed for the CC stages of the project. The water quality modelling in this report has assumed that the undeveloped catchment discharges into the Lake which is a conservative assumption that produces conservative results.

### B.5 Results

The MUSIC model includes GPTs and the East Lake which has a proposed surface area of 2.94 ha, an estimated volume of 46.5ML. The model also includes the already constructed Jordan Springs Lake which provides water quality treatment to some upstream areas of the catchment.

The results for the MUSIC modelling are given in **Table B. 8**. This shows the annual pollutant loads for TSS, TP and TN generated by the upstream catchments. The residual annual loads after treatment are also shown. The percentage reduction in annual pollutant loads is deduced and compared to the water quality criteria.

The results indicate that the proposed Lake will provide sufficient water quality treatment for the runoff generated from the developed upstream area. Although the MUSIC modelling suggests 100% of gross pollutants would be trapped by the treatment train, a reduction of 90 to 95% is considered more realistic as some floatable pollutants may not be captured during times of high flow.

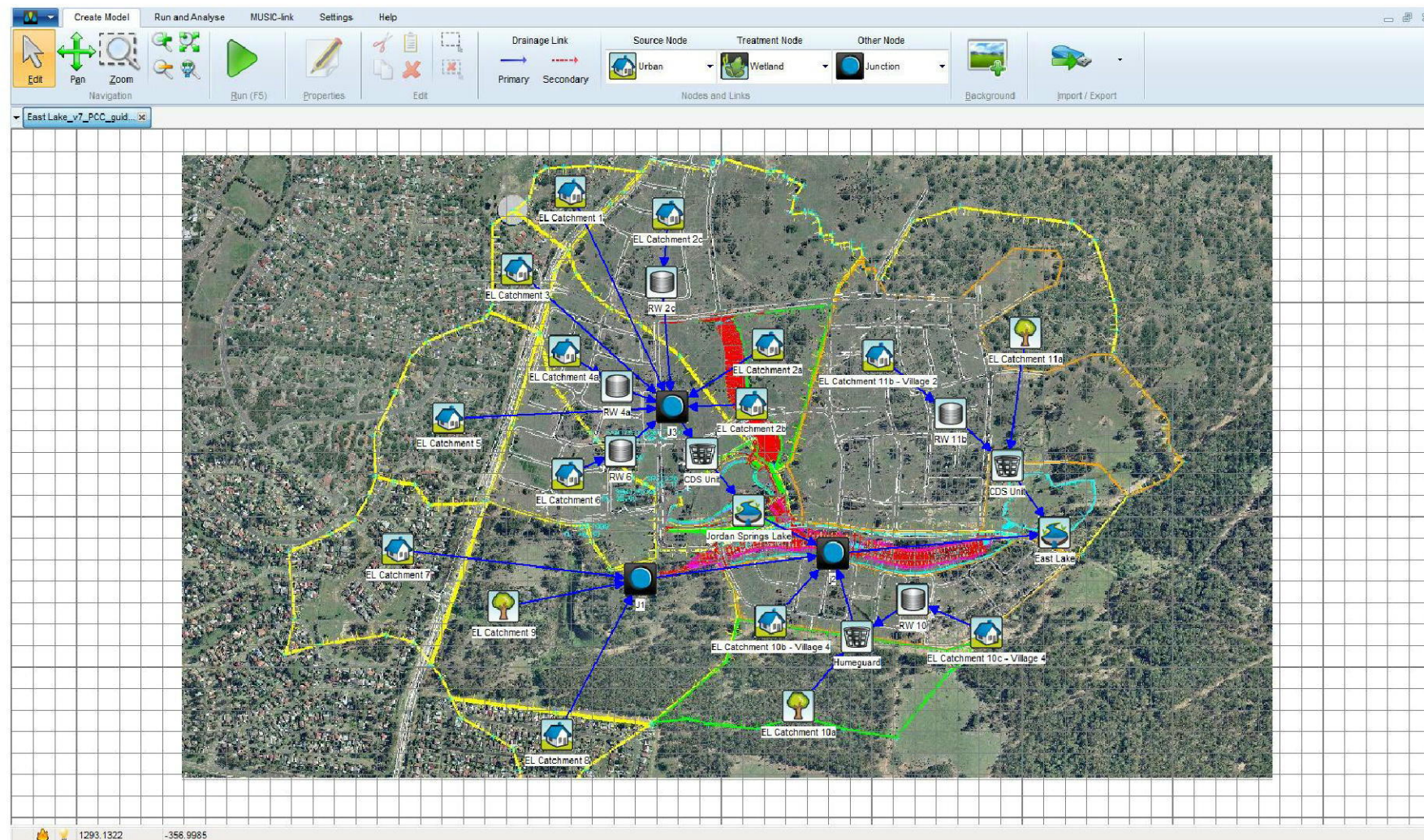
■ **Table B. 8 Pollutant loads and reductions achieved by the Lake system**

Pollutant	Average annual loads (kg/yr)	Residual annual loads (kg/yr)	Reduction (%)	Water quality reduction criteria (%)
TSS	92,800	10,900	88.3	85
TP	154	46.8	69.6	60
TN	1,150	585	49	45
Gross Pollutants	18,900	0	100	90

A sensitivity test adopting a 0 mm/hr exfiltration rate in East Lake was undertaken using the MUSIC model. The results showed there would be a minor decrease in the pollutant reduction rates achieved however the water quality targets would still be met.



## ■ Figure B. 2 MUSIC model layout





## **B.6 Lake maintenance**

Maintenance is an essential part of a healthy lake system that continues to provide an aesthetic environment as water quality treatment. A maintenance procedure for the Lake has been prepared to provide all essential tasks needed to undertake a good maintenance regime. Refer to **Appendix C**.

## **B.7 Conclusion**

The size of the proposed East Lake would provide adequate water quality treatment to the proposed urbanised area. To ensure optimum water quality treatment the Lake would require adequate ongoing maintenance.

## **B.8 References**

Penrith City Council (2005), *Draft Stormwater Quality Control Policy*, Penrith City Council, Sydney.

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Duncan H. (1999), *Urban Stormwater Quality: A Statistical Overview*, Cooperative Research Centre for Catchment Hydrology, Australia.

## Appendix C. Maintenance for the East Lake

### C.1 Purpose

Wetlands provide a very effective means of treating stormwater in urban areas. However, wetlands constructed in urban environments are subject to external factors and hence, will not behave like natural systems without regular maintenance. Therefore, this Maintenance section has been prepared to outline the maintenance and operational requirements associated with the proposed stormwater wetland at East Lake. The main purpose of the wetland is to facilitate water quality treatment and to improve the aesthetic qualities of the area.

### C.2 Wetland Management

#### C.2.1 Wetland function

Constructed wetland ecosystems are vitally important and regarded as valuable environmental management tools with key qualities being that wetlands:

- Decrease stormwater pollution
- Provide habitat for native flora and fauna
- Act as a buffer for the protection of natural aquatic ecosystems

Wetlands function through a variety of biological, chemical and physical processes which interact to increase nutrient removal and uptake by wetland flora, the breakdown of harmful chemicals in stormwater and the action of wetland physical processes which slow down the velocity of running stormwater. Wetlands are vitally important and when successfully implemented provide attractive public amenity.

#### C.2.2 The role of vegetation

Vegetation plays an important role in the effective functioning of a wetland. The reed beds and littoral areas in the macrophyte zone enhance the stormwater treatment process by filtering the sediment from the water, facilitating nutrient removal and providing a habitat for wildlife. The reed beds also provide a substrate for microbial biofilms and enhance the transfer of oxygen to the substrate. The open water area provides increased exposure to sunlight, thus increasing the level of water treatment.

The macrophytes to be planted in the wetland will be selected by the Landscape Architects at the detailed design stage. A preliminary list of macrophytes supplied by the Landscape Architects includes:

- *Eleocharis sphacelata*,
- *Eleocharis acuta*,
- *Bolboschoenus fluviatilis*
- *Bolboschoenus caldwellii*
- *Baumea rubiginosa*,
- *Baumea articulata*
- *Lepironia articulata*
- *Schoenoplectus validus*
- *Schoenoplectus mucronatus*
- *Triglochin procerum*
- *Ludwigia peploides*
- *Philydrum lanuginosum*

- *Juncus usitatus*
- *Carex appressa*
- *Cyperus exaltatus*
- *Gahnia sieberiana*
- *Lomandra longifolia*

### Pest plant species

A number of undesirable weed species could potentially grow in the wetland. Therefore, maintenance staff must be familiar with the species originally planted in the wetland to enable identification of any foreign plant species. If any introduced weeds are observed, they must be removed as soon as possible to prevent infestation.

Undesirable weed species could include

- *Isolepis prolifera*
- Cumbungi *Typha* spp
- *Salvinia* *Salvinia molesta*
- Water Hyacinth
- *Eichhornia crassipes*
- Cabomba *Cabomba caroliniana*
- *Elodea* *Elodea canadensis*
- Alligatorweed *Alternanthera philoxeroides*
- Primrose Willow *Ludwigia peruviana*
- Mexican Waterlily *Nymphaea mexicana*
- Dense Waterweed *Egeria densa*.

For a complete description of these weed species and their controls please refer to **Section 5** of this report.

### Algal growth

Algal blooms tend to develop in warm, nutrient enriched waters. The presence of algae may cause deterioration in water quality and restrict light penetration into the water column. Algae may grow in the form of filamentous algae, such as *Enteromorpha* sp., *Spirogyra* sp. and *Cladophora* sp., which forms dense floating mats or in the form of blue-green algae, such as *Microcystis* and *Anabaena*, which forms on the surface of the water and in the water column.

Regular monitoring and maintenance of the wetland will help to minimise the likelihood of algal growth. Aquatic plants need to be maintained to enhance nutrient uptake and sediments captured in the sedimentation pond should be regularly removed to prevent the mobilisation of nutrients.

Algal blooms can be prevented using strategies such as:

- Changing conditions in the water body so that algae are less likely to bloom (e.g. oxygenation, treating the sediments)
- Harvesting macroalgae in shallow water or on beaches to keep the shoreline clean
- Increasing flushing so that more nutrients are lost from the water body

Algal blooms can be actively managed using the following management techniques (DNR 2010):



- Artificial destratification – altering the thermal layers within a waterbody which may be beneficial for algal blooms.
- Biomanipulation.
- Water treatment - Algae can be removed from wetlands using a number of strategies including coagulation using aluminium and ferric iron salts or organic polymers, filtration of the water body, and the use of algicides to remove any algal blooms present.

### C.3 Wildlife management

#### C.3.1 Wildlife habitat

Constructed wetlands provide a sanctuary for birds and other animals. Feeding, nesting and breeding activities are enhanced within the wetland area and the abundance and diversity of wildlife can improve the aesthetic characteristics of the wetland basin.

#### C.3.2 Pest animal species

Animal species which could potentially pose a threat to the wetland environment are mosquitoes, mosquito fish, European Carp and introduced waterbirds.

##### Mosquitos

Mosquitoes pose the greatest risk to human health as they may transmit disease. A variety of design and management strategies can be employed to minimise the likelihood of large mosquito populations. These include:

- Creating a water disturbance such as a jet or cascade operated by a submersible pump to disturb the mosquito breeding cycle and kill off populations
- Vary water levels during the breeding cycle to kill populations of mosquitoes
- Implementing a deep wetland design which allows wind wave disturbance and incorporates a steep bank slope to reduce habitat sites.

If present in an artificial wetland mosquito populations can be managed using aerial larvicide application. This application can be conducted by a suitably qualified operator using a hand based applicator or in large scale cases a small helicopter. The application process should be preceded by a pre-treatment survey to determine mosquito abundance and distribution and by a post-treatment survey to determine the success of the larvicide application.

The application of larvicide is heavily dependent upon local weather conditions and environmental characteristics and should only be conducted by a certified operator.

### C.4 Wetland maintenance operations

#### C.4.1 Routine maintenance tasks

A routine inspection of the wetland is required to be undertaken monthly and after storm events or any other events such as floods, fire and chemical spills that may affect the wetland's function. It is recommended that most items be inspected monthly, however, some items only require attention three-monthly, bi-annually or annually. **Table C. 1** outlines the frequency at which each item should be inspected and the appropriate maintenance activities associated with that item.

■ Table C. 1 Description of routine inspection tasks

Item	Inspection frequency	Maintenance required
<b>Physical</b>		
Debris and litter removal, including at the inlet, outlet and overflow structures	Monthly and immediately after storm events	Hand removal and appropriate disposal of material.
Signage	As required	Inspect signs for vandalism. Replace and/or repair signs as necessary.
Sedimentation	As required	Remove sediment from the basin when 0.3m deep using an excavator.
Erosion	Monthly or after storm events	Check the verges and record the location and extent of any erosion. Stabilise erosion sites as necessary.
Water Level	Monthly	Record any changes in water level.
<b>Biological</b>		
Weeds	Monthly or after storm events	Hand removal of any introduced species before the infestation becomes difficult to control.
Mosquitoes	Three-monthly	Check for presence of mosquitoes at dawn and dusk. Check for larvae in pooled water and in shallow sections of the wetland. Check for the presence of invertebrates and small fish, which help to control mosquitoes.
Birds and other animals	Three-monthly	Record the presence of animals, including evidence of their existence such as droppings or tracks.
Blue-green algae	Monthly	Check for presence of green surface film, scum, discolouration or new odours.
Water quality	Bi-annually	Take water samples every 6 months or as necessary, depending on water quality testing results.
Change in waterplants	Annually	Record diagrammatically the location and abundance of waterplants and compare with original records. Note any discolouration, disease or death.
Replanting	As required	Replace plants as necessary, according to location and abundance of species.

#### C.4.2 Maintenance checklist

A maintenance checklist has been developed which will enable all aspects of the maintenance program, both physical and biological, to be completed and verified. A copy of the maintenance checklist is attached in **Appendix C1**.

Data collected at the wetland should be recorded in a database to assist in the long-term monitoring of the site. Any information recorded in field notes taken during routine inspections and associated maintenance work, as



well as results of laboratory testing should be stored in this database. Detailed descriptions of any changes to the wetland will assist management in identifying future needs and maintenance priorities.

### **Aquatic vegetation**

Over time, there may be some changes in the distribution and abundance of aquatic species found in the wetland. Undesirable plants should be removed by hand as soon as possible to minimise further spreading and to avoid the use of pesticides.

A thorough annual inspection is recommended to document the precise location and abundance of aquatic vegetation, however, any significant changes to the wetland vegetation should be recorded when observed. The results of the inspection should be illustrated diagrammatically and compared with the initial planting guide. The condition of the plants, particularly any signs of disease, pests or stunted growth should also be noted.

### **Water quality**

Water quality changes can be accessed through physical and chemical testing. Measurements of suspended solids; nutrients including total phosphorus, total nitrogen and ammonia; heavy metals; hydrocarbons including oils and grease; organics; pathogens including faecal coliforms; oxygen demand; pH and temperature should be recorded bi-annually, after the initial establishment of plants.

### **Basin shape and size**

The capacity of the wetland to hold and treat stormwater is dependent upon the shape and size of the basin. Changes to embankment slope and depth may affect the volume of runoff which can be contained in the wetland. Embankments should be inspected monthly to assess any changes which may have occurred as a result of erosion, scouring or changes to vegetation cover. Any changes in water level and basin depth due to changed flow conditions, evaporation or sedimentation should also be recorded. Weed management

## **C.5 Weed management**

There are many definitions to describe what a weed is. A suitable description of a weed is an unwanted plant growing in a given area which, to reduce its effect on the economy, the environments, human health and amenity requires some form of action control or management action. Weeds are also known as invasive plants. (DEWHA 2010a, NSW DPI 2010). Weeds are among the most serious threats to Australia's natural environment and primary production industries. They displace native species, cause significant land degradation, and reduce farm and forest productivity, and generally interfere with the natural balance of ecological communities (DEWHA 2010b).

### **C.5.1 Weed control methods**

As weeds have such a great economical and environmental impact, appropriate control and management measures are required to minimise any possible weed impacts. The most effective means of weed control is through early detection and eradication where necessary.

#### **Herbicide use and safety**

As described above weed infestations can be controlled using herbicide suppletion. When spraying weed infestations with weeds caution should be used at all times as any 'over-spray' may have negative impacts upon non-targeted vegetation and the local environment. The following parameters must be employed when using herbicide to control weed infestation:

- Only licensed operators may undertake herbicide spraying.
- Only use herbicides according to the product label instructions.
- Use only non-residual herbicide (e.g. Biactive Roundup).

- Ensure all personal protective equipment (PPE) is worn; including, overalls, covered shoes, gloves, glasses and mask.
- Monitor local weather conditions and do not spray on days which are windy, days of rain, or when rain is expected in the proceeding days.

Employees working in the wetland are advised to minimise skin contact with water in the wetland basin. Either waterproof boots, thigh boots or gum boots should be worn at all times. Other protective clothing, sunscreen and insect repellent should be provided by Council for all staff working in and around the wetland area. The Occupational Health and Safety Act 2000 was established to protect the health, safety and welfare of people at work.

#### C.5.2 Common aquatic weeds

Common aquatic weeds which may be present include:

- Isolepis prolifera,
- Cumbungi (*Typha* spp.)
- Salvinia (*Salvinia molesta*)
- Water Hyacinth (*Eichhornia crassipes*)
- Cabomba (*Cabomba caroliniana*)
- Elodea (*Elodea canadensis*)
- Alligatorweed (*Alternanthera philoxeroides*)
- Primrose Willow (*Ludwigia peruviana*)
- Mexican Waterlily (*Nymphaea mexicana*) and
- Dense Waterweed (*Egeria densa*)

#### C.5.3 Noxious weeds

The outlet from the East Lake discharges into South Creek which is a tributary of the Hawkesbury River. A list of declared noxious weeds in the control area of Hawkesbury River County Council is included in **Appendix C1**.

## C.6 References

NSW Department of the Environment, Water, Heritage and the Arts (2010a), *Weeds in Australia - What is a weed?*, NSW Government, <http://www.weeds.gov.au/weeds/what.html>, Accessed July 2010.

NSW Department of the Environment, Water, Heritage and the Arts 2010b; “*Weeds in Australia – Why are weeds a problem?*” Available online: <http://www.weeds.gov.au/weeds/what.html> Accessed July 2010.

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Sainty, G. and Dalby-Ball, M. (2000), *Maintenance Manual for Water Bodies on the Glen Alpine Golf Course*, Unpublished report to Lend Lease Residential prepared by Sainty and Associates Pty Ltd.



## Appendix C1 – Noxious Weeds

Weed	Class	Legal requirements
African boxthorn [ <i>Lycium ferocissimum</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
African feathergrass [ <i>Pennisetum macrourum</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
African olive [ <i>Olea europaea subspecies cuspidata</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
African turnipweed [ <i>Sisymbrium runcinatum</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
African turnipweed [ <i>Sisymbrium thellungii</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Alligator weed [ <i>Alternanthera philoxeroides</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Anchored water hyacinth [ <i>Eichhornia azurea</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Annual ragweed [ <i>Ambrosia artemisiifolia</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Arrowhead [ <i>Sagittaria montevidensis</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Artichoke thistle [ <i>Cynara cardunculus</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Athel pine [ <i>Tamarix aphylla</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Bathurst/Noogoora/Hunter/South American/Californian/cockle burr [ <i>Xanthium</i> species]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority

Bear-skin fescue [ <i>Festuca gautieri</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Black knapweed [ <i>Centaurea nigra</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Blackberry [ <i>Rubus fruticosus</i> aggregate species] except cultivars Black satin, Chehalem, Chester Thornless, Dirksen Thornless, Loch Ness, Murrindindi, Silvan, Smoothstem, Thornfree	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed This is an All of NSW declaration
Bridal creeper [ <i>Asparagus asparagoides</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Broomrapes [ <i>Orobanche</i> species] Includes all <i>Orobanche</i> species except the native <i>O. cernua</i> variety <i>australiana</i> and <i>O. minor</i>	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Burr ragweed [ <i>Ambrosia confertiflora</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Cabomba [ <i>Cabomba caroliniana</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Cayenne snakeweed [ <i>Stachytarpheta cayennensis</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Chilean needle grass [ <i>Nassella neesiana</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
Chinese violet [ <i>Asystasia gangetica</i> subspecies <i>micrantha</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Clockweed [ <i>Gaura parviflora</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Columbus grass [ <i>Sorghum x alnum</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Corn sowthistle [ <i>Sonchus arvensis</i> ]	5	The requirements in the Noxious Weeds Act

		1993 for a notifiable weed must be complied with This is an All of NSW declaration
Crofton weed [ <i>Ageratina adenophora</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Dodder [ <i>Cuscuta</i> species] Includes All <i>Cuscuta</i> species except the native species <i>C. australis</i> , <i>C. tasmanica</i> and <i>C. victoriana</i>	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
East Indian hygrophylla [ <i>Hygrophila polysperma</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Espartillo [ <i>Achnatherum brachychaetum</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Eurasian water milfoil [ <i>Myriophyllum spicatum</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Fine-bristled burr grass [ <i>Cenchrus brownii</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Fountain grass [ <i>Pennisetum setaceum</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Gallon's curse [ <i>Cenchrus biflorus</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Giant Parramatta grass [ <i>Sporobolus fertilis</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Glaucous starthistle [ <i>Carthamus glaucus</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Golden dodder [ <i>Cuscuta campestris</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Golden thistle [ <i>Scolymus hispanicus</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Green cestrum [ <i>Cestrum parqui</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Harrisia cactus [ <i>Harrisia</i> species]	4	The growth and spread of the plant must be



		controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed This is an All of NSW declaration
Hawkweed [ <i>Hieracium</i> species]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Horsetail [ <i>Equisetum</i> species]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Hygrophila [ <i>Hygrophila costata</i> ]	2	The plant must be eradicated from the land and the land must be kept free of the plant
Hymenachne [ <i>Hymenachne amplexicaulis</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Italian bugloss [ <i>Echium</i> species]		See Paterson's curse, Vipers bugloss, Italian bugloss
Johnson grass [ <i>Sorghum halepense</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Karoo thorn [ <i>Acacia karroo</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Kochia [ <i>Bassia scoparia</i> ] except <i>Bassia scoparia</i> subspecies <i>trichophylla</i>	1	except <i>B. scoparia</i> subspecies <i>trichophylla</i> The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Lagarosiphon [ <i>Lagarosiphon major</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Lantana [ <i>Lantana</i> species]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Leafy elodea [ <i>Egeria densa</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Lippia [ <i>Phyla canescens</i> ]	4	The plant must not be sold, propagated or knowingly distributed by any person other than a person involved in hay or lucerne production. The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control

		authority. This is an All of NSW declaration
Long-leaf willow primrose [ <i>Ludwigia longifolia</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Long-leaf willow primrose [ <i>Ludwigia longifolia</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Ludwigia [ <i>Ludwigia peruviana</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Mexican feather grass [ <i>Nassella tenuissima</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Mexican poppy [ <i>Argemone mexicana</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Miconia [ <i>Miconia</i> species]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Mimosa [ <i>Mimosa pigra</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Mossman River grass [ <i>Cenchrus echinatus</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Mother-of-millions [ <i>Bryophyllum</i> species and hybrids]	3	The plant must be fully and continuously suppressed and destroyed and the plant may not be sold, propagated or knowingly distributed
Noogoora burr [ <i>Xanthium</i> species]		See Bathurst/Noogoora/Hunter/South American/Californian/cockle burr
Onion grass [ <i>Romulea</i> species] Includes all <i>Romulea</i> species and varieties except <i>R. rosea</i> var. <i>australis</i>	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Oxalis [ <i>Oxalis</i> species and varieties] Includes all <i>Oxalis</i> species and varieties except the native species <i>O. chnoodes</i> , <i>O. exilis</i> , <i>O. perennans</i> , <i>O. radicata</i> , <i>O. rubens</i> , and <i>O. thompsoniae</i>	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Pampas grass [ <i>Cortaderia</i> species]	3	The plant must be fully and continuously suppressed and destroyed
Parthenium weed [ <i>Parthenium hysterophorus</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration

Paterson's curse, Vipers bugloss, Italian bugloss [ <i>Echium</i> species]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Pellitory [ <i>Parietaria judaica</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Pond apple [ <i>Annona glabra</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Prickly acacia [ <i>Acacia nilotica</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Prickly pear [ <i>Cylindropuntia</i> species]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed This is an All of NSW declaration
Prickly pear [ <i>Opuntia</i> species except <i>O. ficus-indica</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed This is an All of NSW declaration
Privet (Broad-leaf) [ <i>Ligustrum lucidum</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
Privet (Narrow-leaf/Chinese) [ <i>Ligustrum sinense</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
Red rice [ <i>Oryza rufipogon</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Rhus tree [ <i>Toxicodendron succedaneum</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority This is an All of NSW declaration
Rubbervine [ <i>Cryptostegia grandiflora</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration



Sagittaria [ <i>Sagittaria platyphylla</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Salvinia [ <i>Salvinia molesta</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Sand oat [ <i>Avena strigosa</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Senegal tea plant [ <i>Gymnocoronis spilanthoides</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Serrated tussock [ <i>Nassella trichotoma</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
Siam weed [ <i>Chromolaena odorata</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Smooth-stemmed turnip [ <i>Brassica barrelieri</i> subspecies <i>oxyrrhina</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Soldier thistle [ <i>Picnomon acarna</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Spiny burrgrass [ <i>Cenchrus incertus</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
Spiny burrgrass [ <i>Cenchrus longispinus</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated or knowingly distributed
Spotted knapweed [ <i>Centaurea maculosa</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
St. John's wort [ <i>Hypericum perforatum</i> ]	4	The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority
Texas blueweed [ <i>Helianthus ciliaris</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration

Water caltrop [ <i>Trapa</i> species]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Water hyacinth [ <i>Eichhornia crassipes</i> ]	3	The plant must be fully and continuously suppressed and destroyed
Water lettuce [ <i>Pistia stratiotes</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Water soldier [ <i>Stratiotes aloides</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Willows [ <i>Salix</i> species] Includes all <i>Salix</i> species except <i>S. babylonica</i> , <i>S. x reichardtii</i> , <i>S. x calodendron</i>	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Witchweed [ <i>Striga</i> species] Includes all <i>Striga</i> species except native species and <i>Striga parviflora</i>	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Yellow burrhead [ <i>Limnocharis flava</i> ]	1	The plant must be eradicated from the land and the land must be kept free of the plant This is an All of NSW declaration
Yellow nutgrass [ <i>Cyperus esculentus</i> ]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration

## **Appendix C2 – Maintenance Checklist**



# Inspection Checklist

Name .....

Signature .....

Date .....

Item	Action Required			Comments <sup>4</sup>	Action Taken <sup>5</sup>
	None <sup>1</sup>	Soon <sup>2</sup>	Urgent <sup>3</sup>		
Physical					
Debris and litter					
Signage					
Sedimentation					
Erosion					
Water Level					
Biological					
Weeds					
Mosquitoes					
Birds / Other Animals					
Blue-green Algae					
Water Quality					
Change in Waterplants					
Replanting					

<sup>1</sup> The item is in good condition and no additional maintenance is required<sup>2</sup> The item is in reasonable condition; however, further maintenance is required prior to the next inspection.<sup>3</sup> The item is in poor condition and requires immediate action<sup>4</sup> Describe any additional work required<sup>5</sup> Describe the date and action taken to rectify the issue