Potential improvement options

The swale does not need any significant intervention however it could be better utilised as a stormwater quality treatment system.

Runoff from the western section of Trephina Street does not drain to the swale, but instead is collected by a kerb inlet pit and drains via a GPT to the pond. Road runoff from the western section of Trephina Street could potentially be diverted into the lower length of the swale to reduce the sediment and nutrient load flowing directly into the pond via the trunk drainage system.

In addition to the western section of Trephina Street not being treated, the runoff from houses is also directly connected to the trunk drainage system. Whilst lot runoff is likely to have a low suspended solids load it does contribute pollutants to the pond and it is generally worthwhile directing this runoff to vegetated treatment systems such as the vegetated swale.

Low flows generated by frequent rainfall events could be 'daylighted' to the swale surface for treatment. These frequent events generate a significant amount of stormwater pollution and treating these events in the swale would improve the quality of flows draining to the pond.

In future the detail for castellated kerb could be altered to ensure that the flows do not bypass the gaps. The gaps could either be made wider or have diagonal slots in the direction of flow rather than perpendicular slots to encourage the stormwater to pass through smoothly. Another improvement would be to have a greater cross-fall on the gutter.

Asset 18: Medhurst Crescent Swale

General information

Description

Swale between Chance Street and Medhurst Crescent at Crace (in line with Galore Street).

This swale only conveys high flows in excess of the drainage system capacity – it is an overland flowpath located in a low point.

The swale was designed and built by the land developer as part of the Crace estate, before being handed over to the ACT Government.

Asset type	Swale	**Asset context**	Recent greenfield development
Year built	2010	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Overland flows above drainage system capacity
Length	60 m	**Depth**	TBC
Width	25 m	**Grade**	TBC
Total area	1,500 m^2	**Construction cost**	TBC
Inlet/s	Overflow from Chance Street	**Outlet/s**	Inlet pit at grade
Expected performance	N/A – the Medhurst Crescent swale is not a water quality treatment system		

Information reviewed to date

Information	Requested	Received	Reviewed
DA report	✓		
Design drawings		✓	Partially reviewed

Site inspections

Site inspections have been undertaken on the following dates:

- 15 November 2014 – dry weather

- 30 November 2014 – wet weather

Design objectives

The Medhurst Crescent swale is an overland flowpath for high flows in excess of the drainage system capacity. It would only convey flows infrequently when the capacity of the drainage system is exceeded. This is expected to be approximately once each 5 years, as the design standard for the minor drainage system in residential areas is the 5 year ARI event.

Medhurst Crescent swale is therefore not a water quality treatment system.

Performance issues

No performance issues have been observed. During a typical storm event, this swale remains dry as the only source of inflows appears to be overflows from Chance Street.

We have not been able to witness this swale performing in its capacity as an overland flow conveyance system.

The swale appears to be stable and well vegetated.

Potential improvement options

There is no need for any action at Medhurst Crescent.

Asset 19: Plimsoll Drive Swale

General information

Description

Swale within wide median along Plimsoll Drive, Casey. Five sections from Critchley Street to the downstream Springbank Rise Pond.

The swale was designed and built by the land developer as part of the Springbank Rise estate, before being handed over to the ACT Government (yet to occur).

Asset type	Swale	**Asset context**	Recent greenfield development
Year built	2010-14	**Year of handover to TAMS**	Not yet handed over
Catchment area	TBC	**Catchment type**	Road runoff
Length	Approximately 1 km	**Depth**	TBC
Width	TBC	**Grade**	TBC
Total area	TBC	**Construction cost**	TBC
Inlet/s	Castellated gutters	**Outlet/s**	Swale discharges directly to Springbank Rise Pond
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
DA report	✓		
Design drawings		✓	Partially reviewed

Site inspections

Site inspections have been undertaken on the following dates:

- 12 July 2012 – dry weather
- 16 November 2012 – wet weather

- 17 November 2012 – with Joel Kelly, PACS ACT Government
- 24 November 2012 – semi-wet weather

Design objectives

The Plimsoll Drive swale has been constructed as part of a treatment train to meet the requirements of the WSUD Code (2009).

It is located in the upper part of the catchment and is the first step in the treatment train. Downstream is an estate-scale pond (Springbank Rise Pond at corner of Yeend Ave and Renouf St) and then a waterway drains from here into the regional Gungahlin Pond on Ginninderra Creek.

Performance issues

We note that the developer has been having significant difficulty establishing this swale and achieving a stable outcome. There appear to have been numerous design changes since it was first built, and these have substantially impacted on the swale's potential stormwater treatment performance.

The key performance limitation is brought about by the route which stormwater follows from the roadway to reach the invert of the swale. The flows from an approximately 15-20 m length of road are collected in a narrow kerbside rocky unvegetated drainage channel. The strip of dense planting behind the drainage channel is raised to form a bund, forcing all of the stormwater to flow alongside the back of the kerb until a gap in the vegetation directs concentrated flows to the invert of the central swale (refer Figure 1). At these points, most flows travel only a short distance along the swale before dropping into a drainage pit.

Figure 1: Location of stormwater flow from kerb edge to swale invert. Top: at commencement of rain event - 16 November 2014; Bottom left: scoured bark mulch following rain event - 17 November 2014; Bottom right: after reinstating mulch and installation of sediment fence to slow flows – 24 November

The key locations where there are ongoing stability issues are the locations where stormwater drops from the drainage channel just below road level down to the invert of the swale. On 16 November, these sections had been constructed in unconsolidated soil topped with loose mulch, which was grossly inadequate to cope with the flows from the drainage channel, which would have descended the steep slope with significant velocity.

Given the amount of scour that has occurred in these drop-down locations, many have since been reinforced with additional scour protection as shown in Figure 2 and Figure 3 and the swale base has also had additional rock added.

Now most stormwater flows through this system do not have any contact with vegetation and therefore receive minimal treatment.

A second issue is that most flows must pass across a footpath in order to reach the swale. This may have been acceptable if flows were well-distributed along the length of the swale, however the way it has been constructed, flows cross the footpath at a few key locations where there is significant flow across the path. This is visible in Figure 1.

Figure 2: A large amount of rock is required for scour protection on steep banks

(looking downstream) (looking upstream)

Figure 3: Swale earlier condition – 12 July 2014 (L) and after placement of additional scour protection – 24 November (R) at a number of different locations along the swale

The castellated gutter is generally functioning well, with enough fall provided within the gaps to ensure that stormwater passes through. A dropdown has also generally been provided at the back of the kerb such that a small amount of sediment will not block the gap. Whilst there is generally adequate fall across the castellated gutter to avoid sediment build up, in some sections of the swale minor blockage of the castellated gutter has been observed (Figure 4). This could potentially become an increasing issue over time, as stormwater will bypass the blocked gaps and pass through in one location where scour will be more likely.

Figure 4: Blocked castellated kerb

In some areas the castellated gutter backs onto a large turfed area (Figure 5). Where the flows can pass through the gutter easily the turf acts as an effective buffer treatment system. In many low intensity rainfall events much of the runoff would be absorbed by the turfed area without any flows reaching the swale invert.

Figure 5: Wide turf areas between the castellated gutter and swale invert

It appears that earlier sections of rock scour protection were completed using a smaller shale based rock (Figure 6). More recent rock works have been completed using a larger basalt based rock (Figure 7), presumably to ensure that the rock is not washed out by high velocity flows in the areas of steep grade. The larger rock size provides for a rougher channel that aids in keeping velocities low.

Figure 6: Earlier kerb with shale based scour protection

Figure 7: Recent kerb to swale transition with basalt based scour protection

In general the vegetation is performing well (refer Figure 8), but there are some locations at the upstream end of the swale where it has not established well (Figure 9).

Figure 8: Good vegetation cover in the upper section of Plimsoll Drive swale, also showing flow of stormwater from the roadway across the path (November 2014)

Stormwater from the eastern (southbound) roadway drains to a spoon drain and a number of tree pits have been constructed to treat stormwater from the spoon drain (Figure 10). However, the tree pit surface level has been finished too high preventing stormwater from flowing into the tree pit and instead forcing it to bypass to the downstream drainage system.

In addition to the erosion issues, TAMS has also reported that the swale has been impacted by significant sediment loads from construction in the catchment. Being a new development area obviously a significant amount of construction activity has taken place. This means that the treatment systems and downstream receiving waters are likely to be subject to a much higher load of sediment than during their normal operating conditions. A number of construction sites were observed with no sediment control systems in place (Figure 11).

A final issue at Plimsoll Drive is that the treatment capacity of the swale does not appear to be fully utilised, as the catchment area draining to the swale is relatively small for the size of the swale. The majority of the development area on the upslope (western) side of the swale drains directly to the downstream pond via a pit and pipe network, bypassing the swale.

Figure 9: Poorly established plants to the swale base in the upper length of swale

Figure 10: Ineffective tree rain gardens to eastern side of Plimsoll Drive – stormwater would bypass

Figure 11: Stockpile with no sediment controls contributing sediment to the swale

Key causal factors and constraints

The Plimsoll Drive swale only collects runoff from the western (northbound) roadway of Plimsoll Avenue. The eastern (southbound) roadway is intended to drain to a number of street tree rain gardens in some locations however these are not functional as noted above.

Given the small catchment area draining towards it, the swale seems to be of very significant dimensions. It is presumed that this is to act as a major overland flow path, directing all flows to the downstream pond, which may also act as a detention basin. We will be able to look at this in more detail after a thorough review of the DA and design drawings.

The depth of the swale means that there is a significant drop from the roadway to the swale invert. This significant drop and the resulting steep slope has been the key causal factor leading to erosion. Steep drops like this are subject to erosion if not properly designed with appropriate scour protection. If the swale is only to treat the roadway then it may not have been necessary to construct the swale so deep below the roadway, however the swale is also a major feature of the streetscape providing a green corridor. It may be that the swale was constructed to the depth for landscaping reasons.

It appears that the original design intent was for the swale to have a continuous drop from the roadway to the swale invert, which would have helped to distribute flows along the length of the swale, minimising scour and erosion. However the constructed levels are such that the high point is not the road edge – there is a high point approximately 2 m from the road edge within the swale. This has led to concentration of flows which have forged a path down into the swale at the lowest point in each section.

Therefore the problems appear to have arisen in part at the construction stage, however the design drawings also indicate that the design was not developed well enough to demonstrate how the swale would work, and there is an inadequate level of detail on the drawings to provide appropriate instruction to the contractor. Civil drawings show some very basic swale sections (typical example shown in Figure 12) with the only detail on swale levels being a maximum slope of 25%. Landscape drawings show surface finishes and planting, but no levels in the swale. With this gap in the documentation, it is not surprising that there have been issues at the construction and establishment stages.

The erosion of the natural soils may be accentuated by the underlying soils in the swale base being dispersive. It is not clear whether soils for the swale were specified anywhere in the design package.

Notably, the sections of the swale where there is a significant turf area between the roadway and the swale appear to be performing much better. In these sections, flows are generally well-distributed through the castellated gutter; the turf acts as an effective buffer and there is no evidence of significant scour or erosion. Turf is a reasonably stable ground cover on steep slopes and under high velocities. Some blockage of the castellated gutter has been found where these is a turfed area behind the kerb and where no dropdown was provided from the back of kerb to the surface of the turf. Areas where this has occurred are likely to become blocked by sediment after a short period of time, however it would be relatively easy to rectify this problem.

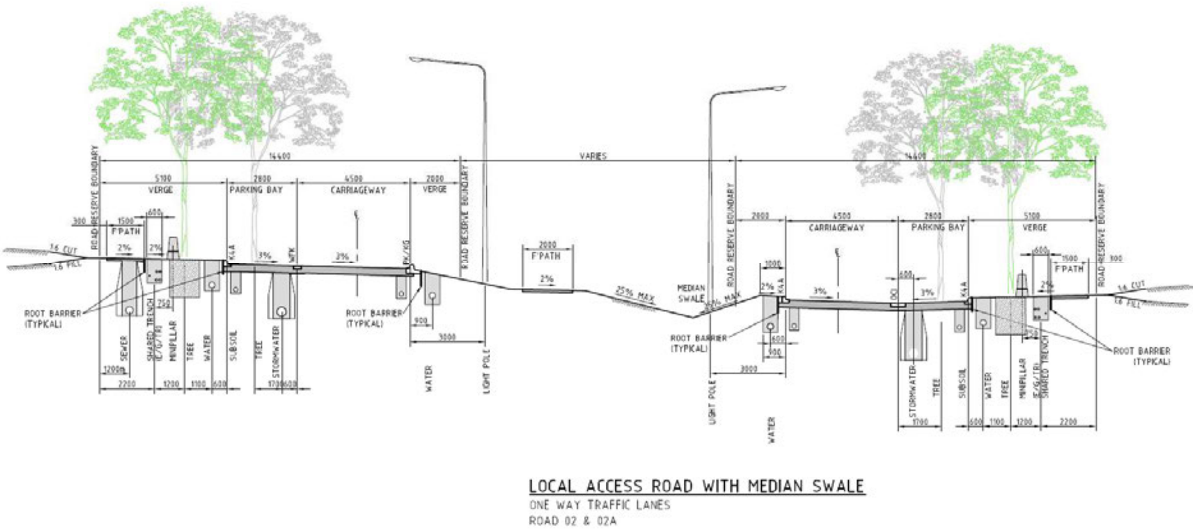

Figure 12: Typical swale section from the civil drawing set (4555-70-021)

Potential improvement options

This swale falls far short of its potential stormwater treatment role. After incremental attempts to repair scour and erosion, the swale that will eventually be handed over to the ACT Government may be stable, but will no longer be an effective stormwater treatment system. It will be a rock-lined drainage channel with landscaped surrounds.

Once stable, the swale could be left as it is, accepting that it will have a low stormwater treatment performance. Alternatively if there is a desire to improve its capacity to act as a stormwater treatment system, then a range of redesign options could be considered:

- The swale could be improved by allowing the flows form the kerbside drainage channel to pass through to the swale invert in a more dispersed manner, rather than concentrating flows in selected locations. This would require removal of some of the plants and the ‘bund’ that is preventing flows from passing directly down to the swale invert.

- Turf could be utilised in more parts of the swale. The upper banks of the swale could be re-profiled and revegetated with turf distribute flows better and provide a stable slope, as well as providing treatment of these flows before they reach the swale invert.

- Instead of trying to direct flows from the road to the swale invert overland, pipes could be retrofit to deliver low flows to the swale and take up the drop from the roadway to the swale. Pipe outlets should deliver flows well upstream of any stormwater outlet pits so that water has ample contact time with vegetation before it is discharged into the stormwater system.

- Where the swale invert itself is too steep and has been lined with rock, it could be regraded to include flatter vegetated sections and drop structures to take up the grade. This would provide significantly improved treatment performance over a fully rock-lined swale, and can be designed to be stable under a range of flows.

- A large-scale redesign could reduce the depths and grades in the swale, however this would require careful consideration of stormwater drainage and potential impacts on flooding.

- A combination of the above measures could also be used.

A few other minor changes could also improve the performance of the system:

- Where Cooley Crescent crosses Plimsoll Drive, water from this road currently drains by castellated gutter to a turf area, however some of this appears to bypass the swale and flow back onto the eastern roadway of Plimsoll Drive. Some minor regarding of this turf area could prevent this from occurring and direct flows into the swale for treatment.

- The tree pit raingardens on the eastern side of the road could be reset. This would require the removal of all vegetation. If done carefully the same vegetation may be able to be reused. After all vegetation is removed the filter media surface should be lowered to at least 200-250 mm below the invert of the spoon drain. The plants can then be replanted, leaving a strip adjacent to the spoon drain free of plants to prevent blockage of the inlet. The new lower filter media surface level will allow for inflow of stormwater as well as a volume of sediment storage before any flows will bypass the system.

Asset 20: Tsoulias Street Swale

General information

Description

Turf swale within the wide median of Tsoulias St, Gungahlin.

The swale was designed and built by the land developer as part of the Gungahlin estate, before being handed over to the ACT Government.

Asset type	Swale	**Asset context**	10 year old greenfield development
Year built	2003? TBC	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Adjacent roadways
Length	Approx. 250m	**Depth**	TBC
Width	35m	**Grade**	TBC
Total area	Approx 9,000 sqm	**Construction cost**	TBC
Inlet/s	Castellated kerb	**Outlet/s**	Pond
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
DA report	✓		
Design drawings		✓	

Site inspections

Site inspections have been undertaken on the following dates:

- 12 July 2014 – dry weather
- 24 November 2014 – semi-wet weather

Design objectives

The Tsoulias Street swale appears to function primarily as a conveyance system rather than a water quality treatment system.

The swale is located in the middle part of the catchment and is the first step in the treatment train for the roadway catchments of Tsoulias Street. The swale drains directly into to an estate-scale pond and then via a waterway into Yerrabi Pond.

The Tsoulias Street swale is designed to treat stormwater from the roadway catchment areas to the east and west of the swale and any runoff from the turfed areas adjacent to the swale. It also appears that high flows surcharge into the swale however this is a conveyance role rather than a treatment role.

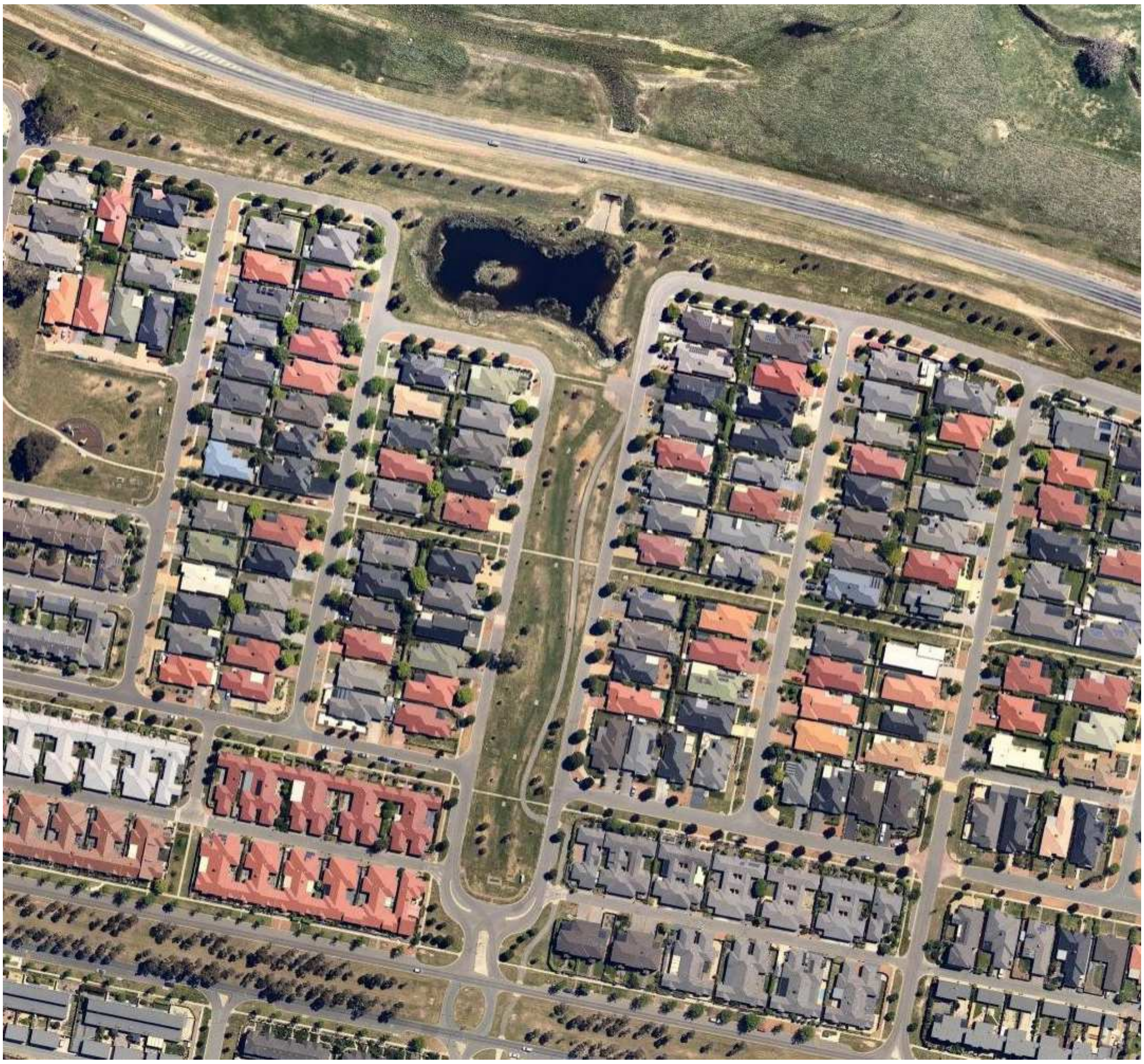

Figure 1: Swale aerial photo 29 October 2014 (NearMap)

Performance issues

In terms of its stormwater treatment role, the swale appears to generally be functioning as intended. To reach the swale invert, flows from the roadway pass through a castellated gutter and across a wide turf area before reaching the swale invert. Given the scale of the swale in relation to its catchment, most of the road runoff does not actually reach the swale base and is absorbed by the soils and vegetation in the zone approximately 15-20 m wide between the kerb and the swale. In this way treatment is provided adequately through passive watering of the turf area.

The main performance issue found in the Tsoulias St swale is the inability of stormwater to flow freely from the roadway into the swale due to minor blockage of the kerb gaps as shown in Figure 2. During a small rainfall event on 24 November we observed minor ponding on the roadway due to the inability of stormwater to drain away through the gaps. Sediment from the adjacent roadways is trapped immediately behind the castellated kerb and within the kerb gaps.

To keep the area behind the kerb free from blockages a strip of turf has been treated with herbicide. TAMS has also reported that when drainage becomes an issue, the strip behind the kerb is dug out to reduce levels (Joel Kelly, *pers. comm.*, 16 Nov 2014).

Figure 2: Image showing the castellated kerb on both sides of the swale and a close up of the accumulated sediment within one of the kerb gaps

Given the extremely wide swale compared to the catchment area it would be expected to intercept a very high percentage of the sediment load from the roadway.

The swale also conveys high flows in excess of the low flow drainage pipe that surcharge from the upstream surcharge pit shown in Figure 3. The surcharge pit has four incoming pipes (300 mm, 450 mm and two 900 mm diameters) and a single 600 mm diameter outlet pipe. The surcharge pit was not observed in operation and there was no evidence that water has surcharged from here recently.

There was no sign of any scour or erosion in the swale. The swale therefore appears to perform its conveyance function effectively though it may not perform in this capacity very frequently.

Figure 3: Surcharge pit at the upstream end of the swale

Key causal factors and constraints

The main causal factor of the blockage of the castellated gutter is the lack of fall across the kerb gaps and that no set-down has been provided from the back invert of the kerb gap to the top of the turf surface.

The minor ponding that occurs at the blocked kerb gaps is also caused by the relatively flat grade of the road, which prevents stormwater from moving along the gutter to the downstream gap.

Potential improvement options

The swale does not need any significant intervention however it could be better utilised as a stormwater quality treatment system.

Whilst all runoff from the small roadway catchment area always flows to the swale, stormwater generated by the adjacent residential developments flows into the pond via the trunk drainage system and GPT, without any treatment of flows to remove fine sediment or nutrients.

Most water quality treatment systems are configured such that all ‘low flows’ generated by frequent low intensity rainfall events are directed to the treatment system, whilst high flows from major events (e.g. greater than the 3 month ARI, and up to the 5-20 year ARI) bypass to the trunk drainage system. Events greater than the 5-20 year ARI generally flow overland and may inundate stormwater treatment systems with higher flows infrequently.

Based on our review of newer systems, it appears that since the Tsoulias Street swale was constructed, the design of castellated gutters elsewhere in the ACT has been improved to try to address the blockage of the gaps in the kerb. A greater cross-fall has been provided at newer sites, but another key factor which should be addressed is the provision of a set down at the back of the kerb such that accumulated sediment will not block the kerb gap. We also noticed that newer sites include smaller gaps in the kerb than at Tsoulias Street, and in this respect the Tsoulias Street system appears to work more effectively. Updated design standards and specifications should address these details.

It appears that the low flow pipe is too deep to daylight flows to the surface of the swale. However if additional catchments can be directed to the swale for treatment it would be beneficial for the downstream pond. Low flows generated by frequent events generate a significant amount of stormwater pollution and treating these events in the swale would improve the quality of flows draining to the pond.

If it is not utilised for open space activities it could potentially be revegetated with native grasses that would not require mowing, but would require periodic weeding. This would improve the treatment capacity of the swale, however at the moment it has excessive capacity for tis catchment, therefore if no additional flows are directed to the swale then revegetation would be for landscape and ecological reasons rather than for stormwater management reasons.

Asset 21: Franklin constructed waterway

General information

Description

Constructed waterway flowing through Harrison and Franklin. This review has focussed on the Franklin section, from Flemington Road to the online pond downstream of Hoskins Street.

The waterway is also known as Gungaderra Creek. It conveys flows from an undeveloped catchment upstream of Harrison, as well as runoff from the urban areas in Harrison and Franklin. Downstream of Franklin it flows through Canberra Grasslands Nature Reserve then into a concrete channel through Kaleen before meeting Ginninderra Creek at Giralang Pond.

Asset type	Constructed waterway	**Asset context**	Recent greenfield development
Year built	2008? TBC	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Mixed rural and urban
Length	1.4 km through Harrison + 1.4 km through Franklin	**Depth**	TBC
Width	Typically 15 m at the base (densely vegetated section) and 50 m total (between bike paths)	**Grade**	Typically <0.5%
Total area	TBC	**Construction cost**	TBC
Inlet/s	Upstream catchment via waterway itself (bridge under Flemington Road) Multiple inlets from urban area – mostly from ponds	**Outlet/s**	Directly into online pond downstream of Hoskins Street
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
DA report	✓		
Design drawings		✓	

Site inspections

Site inspections have been undertaken on the following dates:

- 12 July 2014– dry weather
- 16 November 2012 – wet weather
- 17 November 2012 – with Joel Kelly, PACS ACT Government

Design objectives

The waterway constructed through Franklin has a primary function of conveyance. It is not known whether it was designed with water quality treatment in mind, however the nature of its design (as a broad, gently-graded and well-vegetation system) means that it is likely to be operating effectively as a treatment system.

Most of the catchments draining into the waterway are either rural (upstream of Harrison), or have some form of pre-treatment. Within Harrison and Franklin, most of the stormwater runoff drains into a series of ponds before discharging into waterway. There are a few small outlets with no pre-treatment.

Downstream of Franklin, Gungaderra Creek flows through the Canberra Grasslands Nature Reserve. The waterway through the grasslands has significant ecological value which should be protected from the impacts of upstream development.

Performance issues

Generally the waterway at Franklin is performing well. Site observations have indicated that:

- It is stable, as are its various inflow points
- It is well-vegetated, with high vegetation density and few weeds within the waterway itself
- Water moves through relatively slowly, allowing sedimentation to occur. Contact time with the vegetation in the waterway may also allow it to operate like an ephemeral wetland and to take up significant nutrients
- There was very little visible litter anywhere in the system

Discussions with TAMS staff also indicated that:

- Maintenance at this site is straightforward, however the original designs included more formal landscaping, which they have let naturalise. Analysis of aerial photography from 2012 and 2014 suggests that the formal landscaping was along the dryland edges of the waterway corridor and around the ponds rather than within the waterway itself, which has always had a natural form.
- Generally maintenance activities are limited to mowing of the grassed batters – staff do not actively maintain the vegetation within the waterway itself

Some minor issues noted at the waterway in Franklin:

- Bike path under Flemington Road underpass flooded in a relatively small event (Figure 1). This is not necessarily an issue requiring rectification, but this area may be prone to damage in larger events.

- The waterway crossing between Henry Kendall Street and Clare Burton Crescent has only one small slot for water to escape after inundation. Water ponds and significant sediment settles on the bike path (Figure 2).

- Some of the trees on the banks are inundated in relatively small events and this may contribute to establishment issues (e.g. mulch has been washed away and water sits around the tree for extended periods after runoff has drained away – refer to Figure 3)

- After the rain on 16 November, there was water ponded on Hoskins Street immediately south of the waterway, unable to escape through stormwater pits. Blockage suspected (Figure 4).

Figure 1: Inundation of the underpass beneath Flemington Road

Figure 3: Ponded water around a tree on the edge of the waterway

Figure 2: Sedimentation on the bike path crossing between Henry Kendall Street and Clare Burton Crescent

Figure 4: Ponded water on Hoskins Street

There is no known monitoring of water quality in the Franklin waterway. The waterway's theoretical and actual treatment performance cannot be quantified in MUSIC until we have more details of its catchment area and dimensions from design drawings.

Key causal factors and constraints

Our assessment is that they key factors leading to success of the Franklin waterway have been:

- The site's natural topography allowed gentle grades and low velocities
- The design of the waterway itself is simple and robust with low maintenance requirements
- There was good vegetation establishment within the waterway prior to handover (including appropriate species selection)
- There is significant pre-treatment of inflows upstream of the waterway

Potential improvement options

Minor works could be undertaken to manage nuisance flooding and sedimentation issues on waterway crossings. Monitor trees for establishment issues associated with inundation; improve drainage if required.

It would be worthwhile monitoring the waterway for scour and erosion after major events, particularly key points where velocities may be higher like at waterway crossings.

Asset 22: Pond at Ian Potter Crescent and Tesselaar Street, Gungahlin

General information

Description

Online pond treating a small residential catchment.

The pond was built as part of greenfield development in the early 2000s. It pre-dates the ACT's WSUD code (2009) but was built at a time when stormwater treatment was beginning to diversify to include a range of smaller treatment systems located closer to the source.

Asset type	Pond	**Asset context**	Greenfield
Year built	2003	**Year of handover to TAMS**	TBC
Catchment area	17.6 ha	**Catchment type**	Residential
Normal water level (NWL)	620.9 m AHD	**Top of extended detention**	621.2 m AHD (0.3 m above NWL)
Surface area at NWL	2,379 m^2	**Open water approx. %**	50%
Volume at NWL	1,180 m^3	**Volume at top of extended detention**	2,183 m^3
Average depth at NWL	0.48 m	**Maximum depth at NWL**	1.65 m
Construction cost	TBC	**Cost per sqm**	TBC
Inlet/s	Inflows from small local catchment, via GPT; castellated gutters also allow some road runoff to drain directly into pond	**Outlet/s**	Slot weir and spillway to stormwater channel
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
Design reports	✓		
Design drawings		✓	preliminary review

Site inspections

Site inspections have been undertaken on the following dates:

- 12 July 2013 – dry weather
- 16 November 2014 – wet weather
- 17 November 2014 – with Joel Kelly, PACS ACT Government

Design objectives

As noted above, this pond pre-dates the ACT's WSUD Code (2009), and it is unknown whether it was designed to meet any particular pollutant removal targets.

The pond is part of a treatment train:

- Some flows receive pre-treatment in grass swale upstream (although note that most flows bypass the swale in a pit and pipe system)
- There is a GPT on the main stormwater line immediately upstream of the pond
- Downstream of the pond, there is further treatment in a vegetated creek system alongside Horse Park Drive, a second small pond at the downstream end of Forde and then in Yerrabi Pond and Gungahlin Pond

Performance issues

There has been no known water quality monitoring at this pond. Our visual assessment indicates that the pond is generally functioning adequately, however the following issues would limit the treatment effectiveness of the system:

- As the pond has no high flow bypass, it receives high flows in larger rain events
- The low-level outlet is relatively large, so we expect that there would be a relatively short detention time in the system
- This pond has a higher coverage of macrophytes that others in ACT, but the macrophytes are dominated by *Typha* which senesces in winter, reducing treatment performance and visual amenity at this time of year (refer to Figure 1). *Typha* is common in urban systems and can grow in deeper water than many other species
- Analysis of aerial photography indicates that the pond is sometimes covered in floating weeds, as shown in Figure 2. This is a common issue in urban ponds and is fuelled by similar conditions as algal blooms

- The pond has a reasonable length to width ratio, however there are some areas which are somewhat cut off from the main flowpath, which could be better activated – the bathymetry could be modified to improve flow distribution throughout the system

Figure 1: Vegetation condition in winter (July 2014)

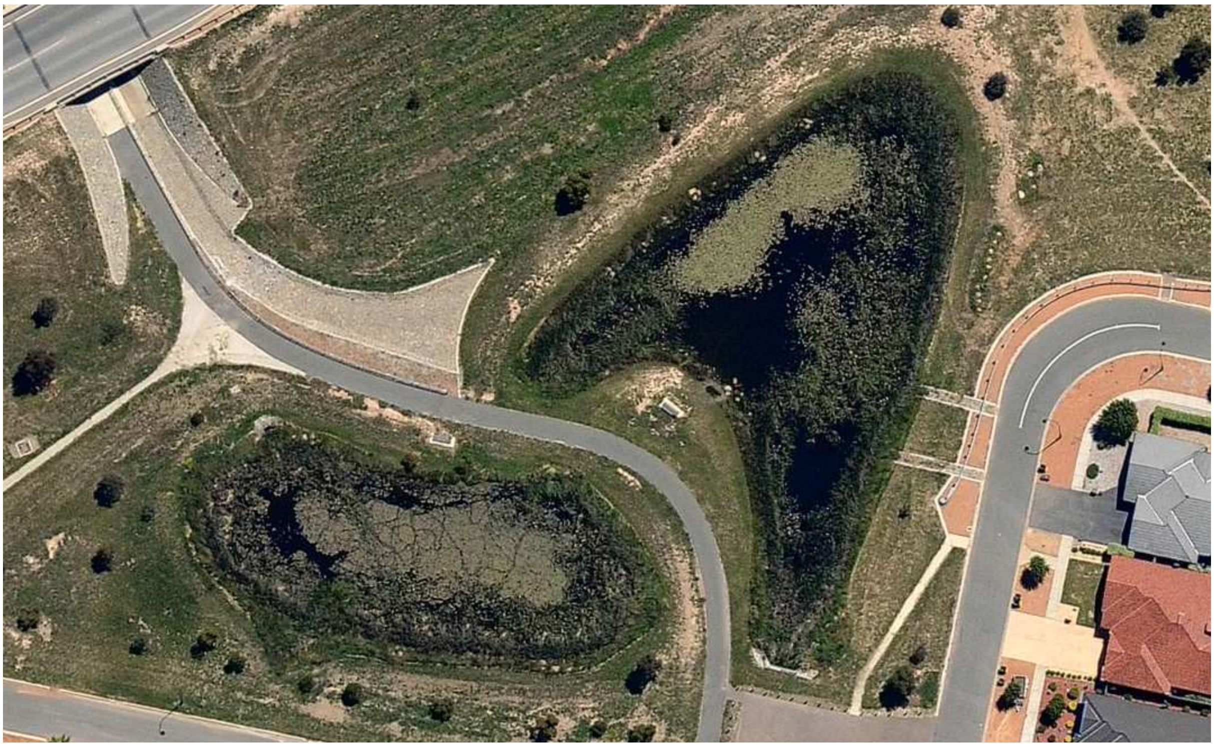

Figure 2: Floating weed cover in November 2010 (NearMap)

TAMS report that this pond is low maintenance, only requiring mowing around the edges and maintenance of the GPT at the inlet. However if the pond ever needs de-silting, this has not been planned for and there does not appear to be any maintenance drain. There would be reasonable (informal) access for desilting equipment around the northern half of the pond's perimeter.

Key causal factors and constraints

The pond is probably functioning as it was designed, however a key question remains over whether the pond was intended to be an open water system or a macrophyte wetland. It is unclear whether macrophytes were planted or whether *Typha* has colonised the system after construction. Aerial photography from 2009 and 2012 (ACTmapi) and 2010 to 2014 (NearMap) suggests that the macrophyte cover has fluctuated over time, but has generally been increasing over these years. It is possible that macrophyte coverage has increased as sediment has accumulated in the pond. As sediment has accumulated and water depths have reduced, this would have allowed macrophytes to colonise a greater area of the pond, beyond its edges.

If this system is modified to improve its performance, the following key constraints will need to be accommodated:

- Levels of major structures
- Existing vegetation including established trees around the pond

Potential improvement options

There are no major issues which need urgent attention at this site, however if the opportunity arises for renewal of this asset, then some changes would be recommended in line with current best practice in stormwater treatment wetland design:

- A high flow bypass would protect the system from high flows and improve the treatment performance overall
- Shallower water depths would allow a greater diversity of macrophytes to be planted and established
- A modified bathymetry should encourage better flow distribution throughout the system
- The outlet should be redesigned for a notional detention time of approximately 72 hours, and a greater depth of extended detention would allow more stormwater runoff to be retained for longer in the system
- Consider potential options to improve future sediment management – e.g. a dedicated sediment pond upstream of the macrophyte zone

A logical opportunity for asset renewal may arise when sediment accumulates to a point where desilting is required.

Asset 23: Giralang Pond

General information

Description

Giralang Pond is an online pond on Ginninderra Creek. Giralang Pond is downstream of Gungahlin Pond and upstream of Lake Ginninderra. Giralang Pond is fed by a large upstream catchment.

The pond has two main inlets, including flows from Ginninderra Creek entering the north of the pond and a second inlet enters from the east from Gungaderra Creek which drains a large area to the east of the pond. The pond contains a small island and is surrounded by soft landscaped edges.

Asset type	Pond	**Asset context**	Recent greenfield development
Year built	1970s (TBC)	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Mixed Urban and rural
Normal water level (NWL)	Pond: TBC	**Top of extended detention**	Pond: TBC
Surface area at NWL	1.3 ha	**Open water approx. %**	99%
Volume at NWL	TBC	**Volume at top of extended detention**	TBC
Average depth at NWL	TBC	**Maximum depth at NWL**	TBC
Construction cost	TBC	**Cost per sqm**	TBC
Inlet/s	Natural channel of Ginninderra Creek and the concrete channel of Gungaderra Creek. There is a trash rack on the Gungaderra Creek inlet to the pond.	**Outlet/s:**	A series of approximately 14 shallow box culverts and a 14m long overflow weir which is also a pedestrian and cycle bridge crossing
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
Design reports	✓		
Design drawings	✓		

Site inspections

Site inspections have been undertaken on the following dates:

- 12 July 2014 – dry weather
- 24 November 2014 – wet weather

Design objectives

It is thought that Giralang Pond was constructed as part of the residential development in the 1970s. It is not known what the key objectives were for the construction of the pond but it is likely to have been built as a multi-purpose system for

- Improving the water quality of runoff from Ginninderra and Gungaderra Creeks and their catchments
- Providing a key landscape element in a park within Giralang, also accessible to the surrounding areas
- Habitat value (however it is not clear whether this was a key objective which influenced the design)

Performance issues

A major issue at Giralang Pond is related to the accumulation of sediment and organic matter in the pond. The pond exhibits two main flow paths from the creek inlets as shown by the blue dashed lines in Figure 1. The sediment plume flowing through Giralang Pond in the image clearly shows the flows paths through the pond. The areas where the water is clearer (shown in red) show the 'dead zones' in the pond where incoming water is effectively bypassing and water in these zones is not flushed in the typical small to medium rain events.

These zones can also be seen to have shallower water both as observed in the field and in aerial photos of the pond (refer Figure 2). With the sediment large amounts of organics are also accumulating in the pond. This material has a high oxygen demand as it breaks down. During periods of dry weather when oxygen is not replenished in the pond from the upstream creeks, the dissolved oxygen level in the pond are substantially reduced. This can cause fish kills in the pond as the low oxygen places stress on aquatic fauna in the pond. The lowered oxygen levels can also create issues as the decaying organic matter in an anaerobic environment produces gases such as hydrogen sulphide (rotten egg gas) which has an unpleasant odour.

A news article earlier this year ("Giralang Pond's black water and dying fish spur call for planning rethink" *Canberra Times* 5 February 2014) indicated that this has been an issue in Giralang Pond. Waterwatch monitoring has also been undertaken for more than a decade at the Gungaderra Creek inlet to Giralang Pond. Comments in the field notes indicate frequent occurrence of surface scums and unpleasant odours. The data itself indicates that turbidity and nutrient concentrations are sometimes very high and dissolved oxygen is sometimes very low.

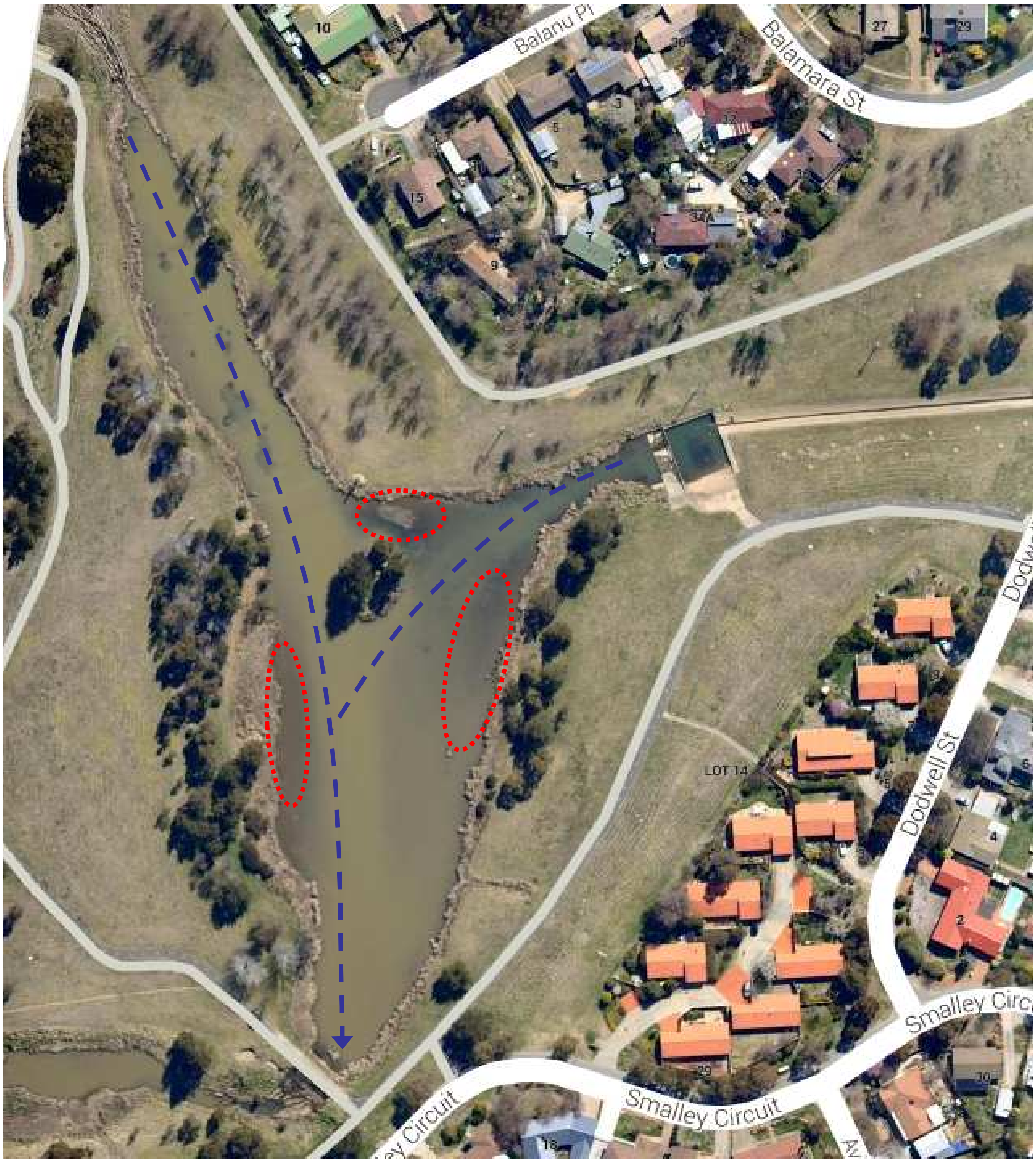

Figure 1: Flow paths (blue line) and sediment build up (red areas) in Giralang Pond (base image from Sep 2012, Nearmap)

Figure 2: Sediment accumulation in dead zones

A second major performance issues at present is the failure of the main outlet from Giralang Pond. The outlet consists of approximately 14 low box culverts. These culverts are easily blocked by organic debris such as large leaf litter, branches, etc. Figure 3 shows the culverts after a relatively small rain event. The culverts are almost completely blocked and water is therefore flowing over the spillway which is also a pedestrian and cycle path.

The outlet downstream of the spillway/bridge is also eroding and requires structural repairs. At the end of the concrete apron from the spillway there is a reno mattress which has substantially failed. This is shown in Figure 4. Also at the outlet there is a scour hole which has become approximately 1 m deep. Based on analysis from Nearmap imagery, this scour hole appears to have substantially worsened since 2010. The scour hole is likely to have been formed by water flowing over the spillway and in large events outflanking the spillway and flowing down the grass embankment and back into the creekline. Due to the concentrated flows over a relatively steep grade it has eroded in this location.

Also the downstream section of Ginninderra Creek is suffering from minor erosion of its banks immediately downstream of the outlet of Giralang Pond. The creek in this location has a 90 degree bend to the right. The outside bank at this bend is undercut and eroding as shown in Figure 1. This is highly likely to continue eroding into the future without stabilisation works.

Figure 3: Outlet structure showing blocked culverts and debris trapped by railing on the bridge indicating that in water is flowing over the bridge in relatively minor rain events

Figure 4: Outlet structure downstream showing failed reno mattress. Rocks from the mattress are visible on the stream bed.

Figure 5: Eroded creek bank at outlet of Giralang Pond

Giralang Pond itself is generally stable with most of the edges in reasonable condition and with a combination of a thin strip of macrophyte vegetation and a wider strip of terrestrial vegetation.

Some of the minor issues with the pond are:

- Some of the edges are likely to be suffering from undercutting and erosion in a number of places and are likely to continue to erode at a slow rate into the future. This is visible for example around the edges of the island. Carp in the pond could be potentially contributing to the erosion.

- A small portion of the gabion wall on the southern side of the inlet from Gungaderra Creek has failed

- Weed growth around the terrestrial edges

- Patchy vegetation establishment on the banks in a number of locations

Key causal factors and constraints

The sediment deposition is occurring in Giralang Pond in dead zones where the water slows, velocities are low and sediment has a chance to settle out. In the main section of the channel where the velocities are higher there is less chance for the sediment to settle and any sediment that does settle in these zones has a higher likelihood of being washed out again. The island is contributing significantly to one dead zones as it creates a preferential flow path in the system.

A key causal factor in the sediment accumulation is also the relatively small size of the pond in relation to a very large upstream catchment (with significant sediment loads associated with residential development upstream over recent years). There is no high flow bypass so large amounts of sediment enter the pond. Even if only a small proportion of the total sediment load is captured in the pond, this can mean rapid build up of sediment in the pond.

Low oxygen levels and fish kills have been caused by decomposing organic matter in the pond – a common issue wherever significant sediment loads have accumulated.

The blockage of the culverts is caused by the use of the multiple shallow small culverts which are easily blocked by relatively small debris. This blockage of the small culverts is contributing to the erosion scour hole at the outlet.

The erosion downstream of the pond outlet at the apron is caused by the high velocities of water flowing over the concrete apron without any energy dissipation. The energy of the flows is dissipating on the reno mattress and this has failed over time. Water is now cascading off the end of the concrete apron into the creek bed and is causing scour of the bed of the creek. This is issue is unrelated to the blocked culverts – even if the culverts always flowed freely, the failure of the reno mattress would not be rectified.

Potential improvement options

Giralang Pond requires a broader re-think of its role in the context of its catchment. As it is a small online pond receiving flows from two large catchments it is difficult to achieve significant water quality improvement outcomes with Giralang Pond or to easily address some of the more fundamental issues with the pond such as excessive sediment accumulation and the ability to remove this sediment from the pond. One fundamental option recommended for consideration is therefore the removal of Giralang Pond and replacement with an extension of the natural creekline. This option would have significant landscape impacts which would need to be considered, however the impact could be offset with other improvements.

In terms of more routine improvement options a key recommendation is to upgrade the existing outlet which is causing erosion and a safety hazard. This would require reconfiguring the outlet to a structure which is less likely to block and which reduces the risk to safety of pedestrians and cyclists. This could take the form of a simple overflow weir.

At the same time that rectification works are undertaken to the outlet, consideration could be given to retrofitting the outlet with a riser to provide extended detention, to improve treatment performance. Any works to the outlet would need to ensure no impacts on flooding upstream. Hence this would likely require a lowering of the pond normal water level which would then rise to the existing normal water level during a rain event and then slowly draw down over the following 1 to 3 days. This would allow a small portion of water to be treated to a higher quality. However the overall volume of water treated would be relatively low in relation to the catchment area.

The short circuiting of the pond is difficult to rectify at this stage without earthworks in the pond itself. One option for in pond works could be to improve the flow paths by creating vegetated benches in the pond which help to distribute water more evenly over the system and also filter the water as they pass through the bench. The benches would need to be relatively robust and able to withstand the flows in the creek.

No water level control was observed in the pond during the site visits making it difficult to clean and de-silt the pond. An option is to include water level control in the pond to allow for maintenance - desilting the pond and general maintenance procedures such as vegetation establishment or control of algal blooms. Due to the level of the pond in relation to the downstream water level, it is unlikely that that the entire pond would be able to be drained.

With regards to the low oxygen environment conditions that form in dry periods this could potentially be rectified by:

- Removing sediment from the pond and removing material such as the organics and nutrient rich material that has accumulated in the pond

- Pumping water from the pond, from multiple offtake points, back into the upstream section of Ginninderra Creek where a healthy macrophyte bed has formed upstream of the pond. Trickling the water through the vegetation would help to improve the water quality as well as re-aerating water in the pond.

Asset 24: Point Hut Pond

General information

Description	
Large pond located online on a tributary of the Murrumbidgee, south of Lake Tuggeranong and. Lower Stranger Pond. The catchment includes the suburbs of Conder, Banks and Gordon. The main inlets are pre-treated in GPTs. The pond was built when Tuggeranong was developed in the 1980s.	

Asset type	Regional pond	**Asset context**	Old urban
Year built	1980s	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Urban
Normal water level (NWL)	TBC	**Top of extended detention**	TBC (~50 mm above NWL)
Surface area at NWL	15.5 ha	**Open water approx. %**	99%
Volume at NWL	TBC	**Volume at top of extended detention**	TBC
Average depth at NWL	TBC	**Maximum depth at NWL**	TBC (approx. 10 m)
Construction cost	TBC	**Cost per sqm**	TBC
Inlet/s	Multiple channel and pipe inlets. Largest is Knoke Ave waterway	**Outlet/s**	Concrete weir with low-flow notch
Expected performance	TBC	**Source**	

Information reviewed to date

Information	Requested	Received	Reviewed
Design reports	✓		
Design drawings	✓	selected drawings	
ACT water monitoring data	✓		

Site inspections

Site inspections have been undertaken on the following dates:

- 16 October 2014 – dry weather
- 16 November 2014 – wet weather

Design objectives

Point Hut Pond was designed and built before there were any specific design objectives for water quality treatment in urban ponds, or guidelines with specific advice on sizing and design.

It is understood that the broad design objectives at the time included:

- Flood detention
- Stormwater treatment upstream of the Murrumbidgee River
- Amenity
- Recreational objectives

Canberra's Urban Lakes and Ponds Plan of Management (Canberra Urban Parks and Places/Urban Services, 2001) identifies the prime management purposes of Point Hut Pond as "water quality management" and "informal recreation". It identifies the following values of Point Hut Pond:

- Recreation (high)
- Visual/landscape amenity (moderate)
- Flood management (moderate)
- Ecological/environmental (low)
- Fish (low)
- Sporting (low)

Point Hut Pond has extensive community facilities consistent with a major regional park, including parking, paths, facilities for people with disabilities, landscaping, toilets, barbeques, picnic tables, play and adventure play equipment. Permitted activities include fishing, model and recreational boating, windsurfing and sailing. Motorised craft, special events and commercial activities are subject to permit.

The Carers of Point Hut Pond (2014) note that popular activities at the pond are picnics, playgrounds, walking, running, cycling and fishing.

Upstream of the pond there is limited pre-treatment of stormwater flows, which are delivered to the pond via concrete channels and pipes. While most of the tributaries draining into Point Hut Pond are partially grassed, they have concrete low flow channels, which means that the majority of flows are conveyed within the concrete channel (refer to Asset 42 – Knoke Avenue waterway). There is basic pre-treatment in GPTs at the main pond inlets.

Downstream of Point Hut Pond, flows drain into a small creek and then into the Murrumbidgee. There are two small online ponds on the creekline (refer to Asset 41).

Performance issues

The ACT Government undertakes water quality monitoring at Point Hut Pond. The 2011-12 report (ACT Government 2012) states that:

> *"Water quality in Point Hut Pond (Site 270) has been historically poor compared with the standards set for its designated uses in the Territory Plan and by comparison with other lake sites in the ACT. The watershed is almost entirely urban, and the floor of the pond is silt-like."*

Despite this, water quality in 2011-12 was reasonably good. Historically, the key water quality issues have been:

- High turbidity and suspended solids associated with construction in the catchment (up until the mid-2000s)
- Ongoing high suspended solids and turbidity associated with re-suspension from the silty floor of the pond
- Elevated phosphorus associated with stormwater inflows
- Sometimes high cholorophyll-a and cyanobacteria - there are sometimes algal blooms (e.g. Jan-Feb 2010 and early 2014)
- Occasionally low dissolved oxygen – typically in periods of low inflow and warm summer conditions

TAMS has noted that Point Hut Pond has reduced capacity due to accumulated sediment, and that this is one of the causes of poor water quality. They also note "frequent" algal blooms.

Waterwatch monitoring has been undertaken at Point Hut Pond over 2012-2014. Most of the observations are from the northern inlet (near Evan Place). Results are consistent with the ACT monitoring data in showing high turbidity and phosphorus concentrations. Dissolved oxygen levels are typically reasonably high. The comments note an algal bloom and bad smell in early 2014 (January and May). The comments also often note significant rubbish in the pond after rain events.

We reviewed past aerial images and saw evidence of the algal bloom in late 2013/early 2014. An image from December 2013 (Figure 1) shows algae at the southern inlet and in a few places along the shoreline where there is limited water movement. A similar picture can be seen in May 2014 (the next available Nearmap image).

The Point Hut Pond Carer's Group (Carers of Point Hut Pond 2014) notes the following issues in Point Hut Pond:

- Poor quality of stormwater inflows. Key concerns associated with this include rubbish, sediment accumulation and blue-green algal blooms.
- Human activity around the pond. Key concerns associated with this include illegal vehicle access (particularly at north-west corner – off Lawton Place), illegal off-road motorbike use (on the paths around the pond), rubbish dumping and vandalism.

During our site inspections we did not observe large quantities of litter in the pond or at its edges, but noted that it has accumulated in significant quantities at certain locations. An example is shown in Figure 2. We noted bank erosion at the north-west corner, in the same location where the Carers have noted that illegal vehicle access occurs. This is shown in Figure 3. We also noted that there is a large population of water birds feeding the birds appears to be a common practice.

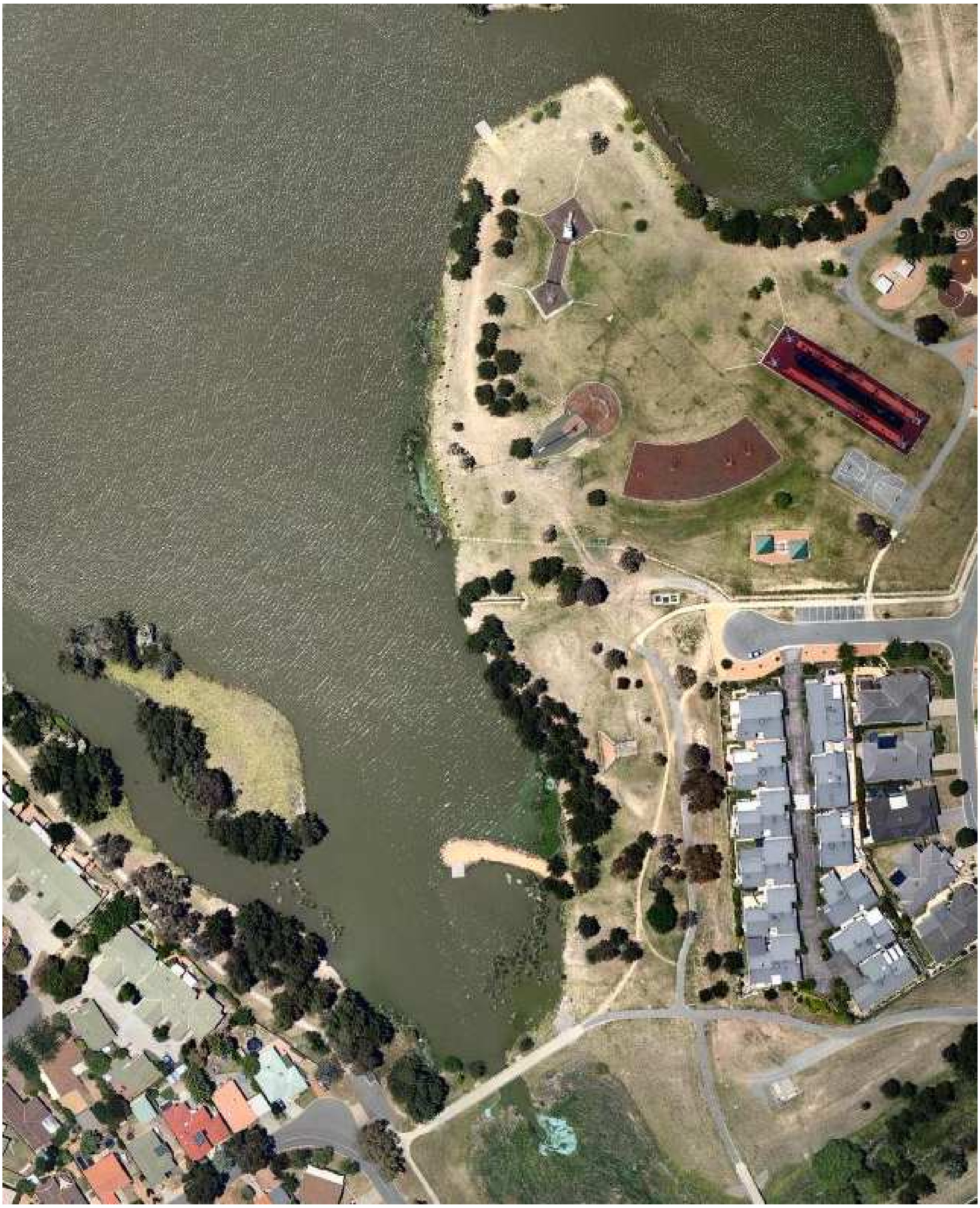

Figure 1: Algal bloom around the edges of Point Hut Pond, 12 December 2013 (Nearmap)

Figure 2: Accumulated litter on the edge of Point Hut Pond

Figure 3: Erosion of the north-western bank of Point Hut Pond – near Lawton Place

In terms of the pond's performance as a water quality treatment system, this has never been measured, however our observations are that:

- The pond is probably functioning as per its hydraulic design intent and therefore meeting flood detention objectives
- It is typical of many 1980s stormwater ponds in that it is online and lacks any high flow bypass, meaningful extended detention or macrophyte zone
- Although intended to act as a water quality treatment system, it is not easy to remove accumulated sediments from the pond. This means that accumulated sediments could be contributing to in-pond water quality issues by re-releasing pollutants into the water body
- The pond becomes very deep by its downstream end (approximately 10 m) therefore stratification is likely to be an issue, which would exacerbate re-release of pollutants and in-pond water quality issues

Key causal factors and constraints

Point Hut Pond is typical of its era, however stormwater treatment practices have evolved significantly since the 1980s.

This system could be modified to improve its performance, however the following key constraints will need to be accommodated:

- Location and levels of major structures
- Existing vegetation including established trees
- Value of the existing landscape

Potential improvement options

A range of options could be considered to improve the water quality treatment performance of Point Hut Pond. These range from minor interventions to major re-design options. Each would require significant additional investigation in order to define the options, costs and benefits:

- Accumulated sediments could be removed from the pond (we would recommend a study first to identify the quantity and quality of accumulated sediments)
- The upstream catchment could be retrofit with stormwater treatment to improve water quality reaching the pond
- The normal water level could be lowered and a new riser outlet could be installed so that extended detention could be incorporated into the pond
- In conjunction with the above, additional macrophyte planting could be established in the edge zone, including the ephemeral zone which would be created

Given the role of the pond as a recreational facility, it is probably not appropriate to undertake a complete redesign of the pond, as deep open water is important to support its recreational objectives.

References

ACT Government Environment and Sustainable Development Directorate 2012 "ACT Water Report 2011-12"

Carers of Point Hut Pond 2014 "Carers of Point Hut Pond Plan"

Asset 25: Coombs Pond A

General information

Description

Coombs Pond A is located at Terry Connolly Street in Coombs. It is a large online pond treating a large mixed-use residential catchment.

This pond is "regional" infrastructure built downstream of the estate to polish stormwater and meet the regional targets in the ACT's WSUD Code.

Asset type	Regional pond	**Asset context**	Greenfield
Year built	2011	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Mixed use
Normal water level (NWL)	549.0 m AHD	**Top of extended detention**	550.6 m AHD (1.6 m above NWL)
Surface area at NWL	17,985 m^2	**Open water approx. %**	98%
Volume at NWL	40,400 m^3	**Volume at top of extended detention**	TBC
Average depth at NWL	2.2 m	**Maximum depth at NWL**	7.0 m
Construction cost	TBC	**Cost per sqm**	TBC
Inlet/s	At main inlet two open channels join immediately upstream of pond and enter via GPT; also other smaller inlets around pond	**Outlet/s**	Primary outlet: concrete overflow structure within pond; Secondary spillway: over embankment
Expected performance	Pollutant load reductions to meet regional targets in WSUD Code: TSS: 85% TP: 70% TN: 60%	**Source**	Patrick Paynter, pers. comm. Oct 2014

Information reviewed to date

Information	Requested	Received	Reviewed
Design reports	✓		
Design drawings		✓	✓

Site inspections

Site inspections have been undertaken on the following dates:

- 17 February 2013 – dry weather
- 30 November 2014 – wet weather

Design objectives

As noted above, this pond has been designed to meet the "regional" or catchment-wide targets in the ACT WSUD Code (2009). This means that the expectation is that upstream estate development will meet the targets for development or redevelopment sites, and the regional ponds will meet the difference between the development/redevelopment targets and the regional targets. Both sets of targets are shown in Table 1.

Table 1: Development/redevelopment and regional targets in the ACT WSUD Code (2009)

Context	Development/redevelopment	Regional
Reduction in average annual suspended solids (SS) export load	60%	85%
Reduction in average annual total phosphorus (TP) export load	45%	70%
Reduction in average annual total nitrogen (TN) export load	40%	60%

While the regional targets are only a small amount higher than the development/redevelopment targets, they are equivalent to 63% reduction in TSS, 45% reduction in TP and 33% reduction in TN within the regional infrastructure itself. These load reductions also need to be achieved on pre-treated flows, which contain lower concentrations of pollutants and are therefore harder to meet.

Coombs Pond A can therefore be considered as the final step in a treatment train:

- The upstream development is being designed to meet the development/redevelopment pollutant load reduction targets shown in Table 1
- The pond is designed to polish flows to meet the regional targets in Table 1

In addition to pollutant load removal, it is clear that Coombs Pond A has been designed to meet other objectives, including flood detention and landscape objectives. The civil design drawings show that the 100 year ARI flood would detained within the extended detention area and the landscape design includes landscaped edges, paths and viewing areas.

Performance issues

Currently Coombs Pond A is effectively acting as a sediment basin while significant construction is underway in its catchment. At this stage, most of the estate infrastructure is complete upstream of Coombs Pond A and construction is underway on private lots. This presents significant issues, some of which are likely to continue well into the asset's lifetime, for example:

- Accumulated sediment may trigger the need for expensive desilting early in the pond's life
- The sediment-laden runoff appears to have led to difficulty establishing vegetation in and around the pond
- Accumulated sediment reduces the visual appeal and amenity of the pond
- Landscape features such as paths and walls will need cleaning and renewing when construction is complete

Figure 1 shows the sediment accumulating at the main inlet into Pond A.

Figure 1: Sediment accumulation in front of the main inlet to Pond A

It is too early to assess the pond's long-term water quality performance, however our review indicates that, sediment issues aside, there are some inherent design limitations which would limit the treatment effectiveness of the system:

- As the pond has no high flow bypass, it receives high flows in larger rain events
- There is no riser outlet, so there would be a relatively short detention time in the system

- There is very limited macrophyte coverage (although we note that the design drawings included a more significant extent of macrophyte planting, which has not been established – refer to Figure 2)

- The pond is deep and therefore at risk of thermal stratification, which tends to exacerbate water quality issues associated with anaerobic decomposition and re-release of pollutants from accumulated settled sediments

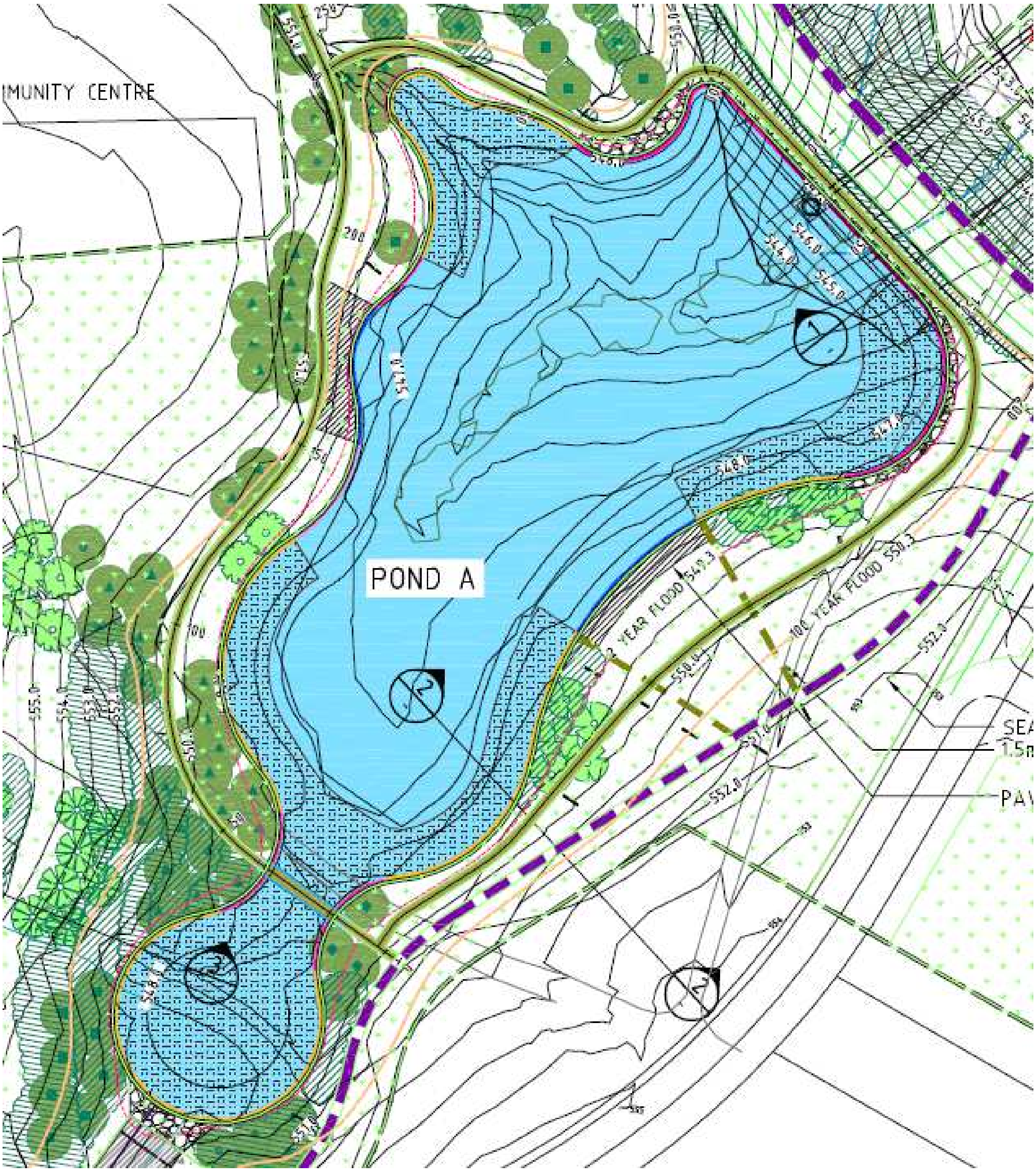

Figure 2: Snapshot from the landscape master plan for Pond A, showing proposed macrophyte area (hatched)

Maintenance issues are also likely to limit the pond's long-term performance. The key issue will be the difficulty removing accumulated settled sediments from the pond. While the new urban development upstream of the pond will include WSUD and this will reduce pollutant loads entering the pond, there will still be a significant residual load which enters the pond. This will be complex and expensive to remove, as:

- There is no separate sediment basin upstream of the pond

- The pond is large and deep, and not designed to be drained regularly

- While there is provision to drain the pond via a dam valve, access to this is not straightforward, with TAMS noting that access requires the grate on the outlet pit to be lifted via a crane

- TAMS' comments also suggest that the dam valve needs to be operated from the base of the outlet pit (a confined space and hazardous location during water release), however the design drawings (which are very limited in their detail) appear to show that the valve can be operated via a handle at the top of the outlet pit. It is unclear whether this is a design, construction or communication issue.

The lack of water level control is a second related issue. Macrophyte establishment (or re-establishment) requires careful water level control to allow planting and establishment in ideal conditions. If seedlings are inundated in deep water too early in their life, they will fail to establish. This could have been a factor in the failure of macrophyte establishment at this site. Currently, the dam valve is the only way to control the water level in the pond.

TAMS have also noted that he hand rails on top of the GPT are of a solid construction, so if a large item comes down the stormwater channel then these will have to be replaced. Figure 3 shows material accumulating against the hand rails of the GPT.

Figure 3: Material accumulating against the hand rails of the GPT at Coombs Pond A

Key causal factors and constraints

Both Coombs Pond A and B were built prior to new urban development upstream, and handed over before upstream stormwater drainage systems and other infrastructure were installed. We understand that design work for the ponds also preceded much of the design work for the upstream estates, therefore the designers had to base their work on significant assumptions about future development, not all of which proved to be correct once the estate design was complete.

TAMS provided background information about particularly severe erosion and sediment control problems upstream of Pond A during the estate development process. They observed that the developer had inadequate erosion and sediment controls and sediment was accumulating in the pond. They made an effort to raise the issue with the EPA and have it addressed by the developer, however there was minimal improvement in erosion and sediment control practices at the site, and sediment continued to build up in the pond. It appears that this occurred mainly over late 2013-early 2014 when the developer was undertaking bulk earthworks, stormwater and road construction works.

When we visited the site in late 2014 there were fewer major erosion and sediment control issues, however some of the issues raised by TAMS remained, and house building was underway so that stormwater runoff was still sediment-laden from uncontrolled building sites. Figure 4 shows the main stormwater channel upstream of Pond A, which has exposed soils on steep batters with no erosion controls in place. It is also possible to see significant sediment accumulation within the channel itself, which is gradually being washed down into the pond in each rain event. Our observations in wet weather were that where significant sediment had accumulated in the system (e.g. in the channel shown in Figure 4 and in the GPT immediately upstream of the pond), this was resuspended during the rain event.

Figure 4: Uncontrolled erosion on a steep batter slope and accumulated sediment in the channel bed upstream of Coombs Pond A

Observations of large sedges growing in the sediment within the GPT suggest that this sediment has been present for some time.

The ACT Government recognises that staging was a significant issue at Coombs, and better approaches are discussed in the main part of this report. The issues are mentioned here as they are important to understanding the context of the asset and potential options for its improvement.

Our review has also identified a number of design issues which will limit long-term performance of the pond. These will be difficult to rectify post-construction, however could be revisited at some stage in the future when major works are required to renew this asset. If this system is modified to improve its performance, the following key constraints will need to be accommodated:

- This is an online system and it would be prohibitively expensive to retrofit a high-flow bypass
- Existing topography and layout of the pond
- Location and levels of major structures
- Existing landscape features and vegetation around the system

Potential improvement options

If the opportunity arises for renewal of this asset, then some changes could be investigated to improve the long-term performance of this asset:

- Assess the feasibility of re-designing the inlet area to be a stand-alone sediment basin upstream of the pond
- A riser outlet and extended detention would allow more stormwater runoff to be retained for longer in the system
- A modified outlet could also allow better water level control in the upper zone, which would assist with macrophyte re-establishment
- More macrophytes would improve the pond’s water quality performance

Asset 26: Coombs Pond B

General information

Description

Coombs Pond B is located at Edgeworth Parade in Coombs. It is a large online pond treating a large mixed-use residential catchment.

This pond is "regional" infrastructure built downstream of the estate to polish stormwater and meet the regional targets in the ACT's WSUD Code.

Asset type	Regional pond	**Asset context**	Greenfield
Year built	2012	**Year of handover to TAMS**	TBC
Catchment area	TBC	**Catchment type**	Mixed use
Normal water level (NWL)	550.5 m AHD	**Top of extended detention**	552.5 m AHD (2.0 m above NWL)
Surface area at NWL	45,050 m^2	**Open water approx. %**	50%
Volume at NWL	158,000 m^3	**Volume at top of extended detention**	TBC
Average depth at NWL	3.5 m	**Maximum depth at NWL**	10.5 m
Construction cost	TBC	**Cost per sqm**	TBC
Inlet/s	At main inlet several pipes discharge into open channel and enter via GPT; also other smaller inlets around pond	**Outlet/s**	Primary outlet: concrete overflow structure within pond; Secondary spillway: over embankment
Expected performance	Pollutant load reductions to meet regional targets in WSUD Code: TSS: 85% TP: 70% TN: 60%	**Source**	Patrick Paynter, pers. comm. Oct 2014

Information reviewed to date

Information	Requested	Received	Reviewed
Design reports	✓		
Design drawings		✓	✓

Site inspections

Site inspections have been undertaken on the following dates:

- 17 February 2013 – dry weather
- 30 November 2014 – wet weather

Design objectives

As noted above, this pond has been designed to meet the “regional” or catchment-wide targets in the ACT WSUD Code (2009). This means that the expectation is that upstream estate development will meet the targets for development or redevelopment sites, and the regional ponds will meet the difference between the development/redevelopment targets and the regional targets. Both sets of targets are shown in Table 1.

Table 1: Development/redevelopment and regional targets in the ACT WSUD Code (2009)

Context	Development/redevelopment	Regional
Reduction in average annual suspended solids (SS) export load	60%	85%
Reduction in average annual total phosphorus (TP) export load	45%	70%
Reduction in average annual total nitrogen (TN) export load	40%	60%

While the regional targets are only a small amount higher than the development/redevelopment targets, they are equivalent to 63% reduction in TSS, 45% reduction in TP and 33% reduction in TN within the regional infrastructure itself. These load reductions also need to be achieved on pre-treated flows, which contain lower concentrations of pollutants and are therefore harder to meet.

Coombs Pond A can therefore be considered as the final step in a treatment train:

- The upstream development is being designed to meet the development/redevelopment pollutant load reduction targets shown in Table 1
- The pond is designed to polish flows to meet the regional targets in Table 1

In addition to pollutant load removal, it is clear that Coombs Pond B has been designed to meet other objectives, including flood detention and landscape objectives. The civil design drawings show that the 100 year ARI flood would detained within the extended detention area and the landscape design includes landscaped edges, paths and viewing areas.

Performance issues

Currently Coombs Pond B is effectively acting as a sediment basin while significant construction is underway in its catchment. At this stage, there is estate development underway on the northern side of the pond, while house-building is underway on the southern side. This presents significant issues, some of which are likely to continue well into the asset's lifetime, for example:

- Accumulated sediment may trigger the need for expensive desilting early in the pond's life
- The sediment-laden runoff appears to have led to difficulty establishing vegetation in and around the pond
- Accumulated sediment reduces the visual appeal and amenity of the pond
- Landscape features such as paths and walls will need cleaning and renewing when construction is complete

Figure 1 shows the sediment accumulating at an inlet on the southern side of Pond B.

Figure 1: Sediment accumulation in front of an inlet on the southern side of Pond B

It is too early to assess the pond's long-term water quality performance, however our review indicates that, sediment issues aside, there are some inherent design limitations which would limit the treatment effectiveness of the system:

- As the pond has no high flow bypass, it receives high flows in larger rain events
- There is no riser outlet, so there would be a relatively short detention time in the system

- There is very limited macrophyte coverage (although we note that the design drawings included a more significant extent of macrophyte planting, which has not been established – refer to Figure 2. Analysis of Nearmap aerial photography shows that macrophytes were planted in the pond but failed to establish – it appears that water levels were raised too quickly over small establishing seedlings – refer to Figure 3, Figure 4 and Figure 5)

- The pond is deep and therefore at risk of thermal stratification, which tends to exacerbate water quality issues associated with anaerobic decomposition and re-release of pollutants from accumulated settled sediments

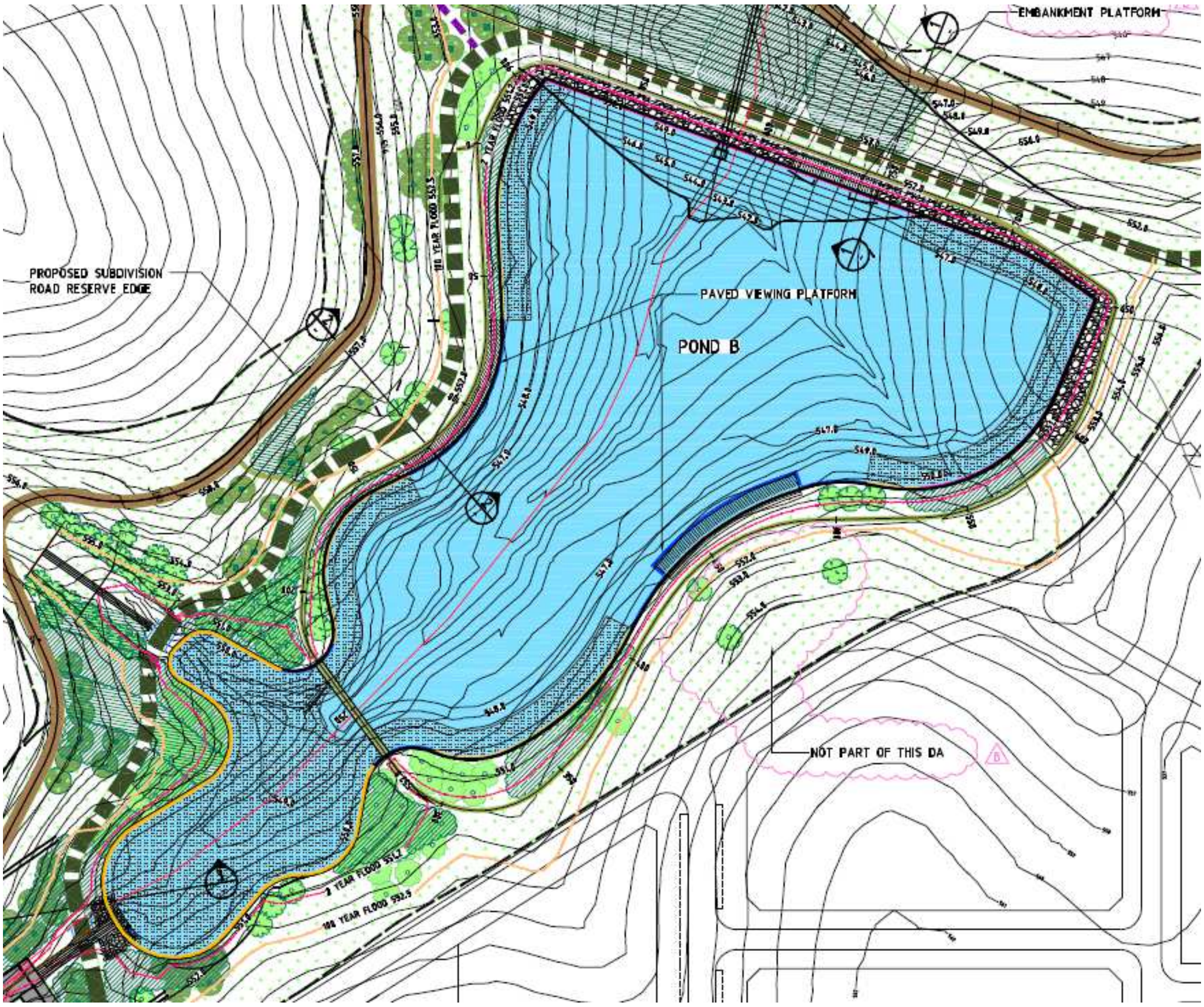

Figure 2: Snapshot from the landscape master plan for Pond B, showing proposed macrophyte area (hatched)

Figure 3: Snapshot of macrophyte planting at one location at Coombs Pond B (Nearmap 13 March 2013)

Figure 4: Snapshot of the same location four months later, showing macrophtyes completely inundated before many of them have grown large enough for the water depth (Nearmap 24 July 2013)

Figure 5: Snapshot of the same location one year on, showing that only a few macrophytes have survived, in the shallowest water near the edge of the pond (Nearmap 31 August 2014)

Maintenance issues are also likely to limit the pond's long-term performance. The key issue will be the difficulty removing accumulated settled sediments from the pond. While the new urban development upstream of the pond will include WSUD and this will reduce pollutant loads entering the pond, there will still be a significant residual load which enters the pond. This will be complex and expensive to remove, as:

- There is no separate sediment basin upstream of the pond
- The pond is large and deep, and not designed to be drained regularly
- While there is provision to drain the pond via a dam valve, access to this is not straightforward, with TAMS noting that access requires the grate on the outlet pit to be lifted via a crane
- TAMS' comments also suggest that the dam valve needs to be operated from the base of the outlet pit (a confined space and hazardous location during water release), however the design drawings (which are very limited in their detail) appear to show that the valve can be operated via a handle at the top of the outlet pit. It is unclear whether this is a design, construction or communication issue.

The lack of water level control is a second related issue. Macrophyte establishment (or re-establishment) requires careful water level control to allow planting and establishment in ideal conditions. If seedlings are inundated in deep water too early in their life, they will fail to establish. This could have been a factor in the failure of macrophyte establishment at this site. Currently, the dam valve is the only way to control the water level in the pond.

TAMS have also noted the following issues associated with the GPT upstream of Coombs Pond B:

- The drying pad outside the GPT, which is where the material is meant to be dried after removal from the GPT, was approved as a gravel pad. This has washed away, as shown in Figure 6, and needs to be replaced with concrete or bitumen to prevent ongoing washout.
- The hand rails on top of the GPT are of a solid construction so if a large item comes down the stormwater channel then these will have to be replaced

Figure 6: Damaged drying pad at Coombs Pond B

Key causal factors and constraints

Both Coombs Pond A and B were built prior to new urban development upstream, and handed over before upstream stormwater drainage systems and other infrastructure were installed. This has resulted in significant sediment loading on the ponds while construction work is underway in the upstream catchment. We understand that design work for the ponds also preceded much of the design work for the upstream estates, therefore the designers had to base their work on significant assumptions about future development, not all of which proved to be correct once the estate design was complete.

The ACT Government recognises that staging was a significant issue at Coombs, and better approaches are discussed in the main part of this report. The issues are mentioned here as they are important to understanding the context of the asset and potential options for its improvement.

Our review has also identified a number of design issues which will limit long-term performance of the pond. These will be difficult to rectify post-construction, however could be revisited at some stage in the future when major works are required to renew this asset. If this system is modified to improve its performance, the following key constraints will need to be accommodated:

- This is an online system and it would be prohibitively expensive to retrofit a high-flow bypass
- Existing topography and layout of the pond
- Location and levels of major structures
- Existing landscape features and vegetation around the system

Potential improvement options

If the opportunity arises for renewal of this asset, then some changes could be investigated to improve the long-term performance of this asset:

- Assess the feasibility of re-designing the inlet area to be a stand-alone sediment basin upstream of the pond
- A riser outlet and extended detention would allow more stormwater runoff to be retained for longer in the system
- A modified outlet could also allow better water level control in the upper zone, which would assist with macrophyte re-establishment
- More macrophytes would improve the pond's water quality performance

An immediate action at Coombs Pond B is to replace the gravel pad at the GPT with a concrete/bitumen pad.