



SOUTHERN LINKS 1 RESIDENTIAL DEVELOPMENT

STORMWATER OPERATIONS & MAINTENANCE PLAN

PROJECT INFORMATION

PROJECT 298001

DOCUMENT CONTROL

DATE OF ISSUE 02/09/2026

REVISION A

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1. Statement of Experience

Author

I am Min Shon, a Senior Civil Engineer with Maven Waikato Ltd. I hold a Master of Civil Engineering from the University of Auckland and am a Chartered Professional Engineer (CPEng) registered with Engineering New Zealand. I have over six (6) years of professional experience in civil engineering, with particular experience in land development, including earthworks, roading, and three waters infrastructure design.

I confirm that I have read and understood the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2023, and agree to comply with its requirements.

I acknowledge that, as an expert, I have an overriding duty to assist the decision-maker impartially on matters within my area of expertise. In preparing this report, I have exercised my independent professional judgement, and the opinions expressed in this report are my own. I understand that my duty as an expert is not to advocate for the interests of the applicant or any other party.

I confirm that the matters addressed in this report are within my area of expertise, except where I expressly identify that I have relied upon information, assessments or opinions provided by others. I have made all reasonable enquiries and have not knowingly omitted any material facts known to me that might alter or detract from the opinions expressed in this report.

Reviewer

My name is Sean McDonald. I am a Senior Engineer and Team Leader at Maven Waikato Ltd ("Maven"), a firm of consulting engineers and surveyors based in Hamilton. I have been employed by Maven since 2025. I hold a Bachelor of Engineering Technology (Highways) which I graduated from in 2006, hold a New Zealand Certificate of Engineering "Civil" (NZCE) and I am a member of Engineering New Zealand.

I have over 29 years' of experience in the field of civil engineering including as a civil engineering technician, New Zealand army engineer, council engineer and consulting engineer, with over 20 years' of experience post degree. Since obtaining my degree I have worked on a variety of civil projects including State Highway works, 3 Waters Infrastructure works, Residential Land Development, Commercial and Industrial Land Development and major Infrastructure projects such as the upgrade of the Port Boteny (Sydney) Naphtha Storage Facilities, the Transpower upgrade and extension of the Whakamuru Substation, the Central Government Rotorua Youth Justice Facility and Contact Energy's new Tauhara Geothermal power station.

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2. Introduction

2.1. Objective of the Stormwater Operations and Maintenance Plan

The objective of this Stormwater Operation and Maintenance Plan is to set out the requirements to be followed to ensure the efficient ongoing operation of the stormwater quality management devices within the SL1 – Residential Development. The information provided herein outlines the methodology associated with the stormwater infrastructures onsite. This report is to be read in conjunction with the engineering drawings around stormwater management within the site.

Once stormwater assets are vested, it is the responsibility of the nominated maintenance contractor to carry out maintenance of the stormwater system devices. The maintenance will be in generally accordance with this document, WRC Stormwater Guidelines and Hamilton City Council's SW Guidelines.

2.2. Stormwater Assets

The Public Assets constructed which will require operation and maintenance are:

- Stormwater discharge from SL1 - Residential will be conveyed via public piped networks, primary conveyance systems and overland flow paths to the proposed wetland systems.
- Stormwater discharge from road impervious areas will be conveyed via the primary stormwater network to the proposed wetlands, forebays and high flow bypass systems.
- Artificial wetlands, forebays and high flow bypass systems constructed within the development form part of the overall treatment train. These devices provide water quality treatment, conveyance, extended detention, attenuation and flood storage.
- Primary stormwater networks, including public piped networks, culvert crossings, diversion channels and overland flow paths, will maintain hydraulic connectivity through the site and convey stormwater to the proposed wetlands and existing streams/drains.
- Public stormwater assets, including primary pipe networks and wetlands, will be vested to Council subject to compliance with the relevant approval process.
- Private stormwater infrastructure, such as on-lot retention tanks, will remain in private ownership, with ongoing operation and maintenance responsibilities resting with the respective property owner.

2.3. Contact Information

A summary of the contact information relating to the ownership, maintenance manager, and designer for the stormwater system is included below.

Asset ID:		Resource Consent Number:	
Location:	37A Saxbys Road, Hamilton	Development Name / Legal Description:	
Asset Owner Details:			
Name:	Hamilton City Council	Postal Address: Hamilton City Council, Private Bag 3010, Hamilton 3240 Physical Address: 260 Anglesea St, Council Building Garden Place, Hamilton, 3204	
Telephone Number:	07 838 6699		
Email:	Refer to Online Contact Form		
Maintenance Manager Emergency Contact Details			
Name:	HCC call centre	Address: 260 Anglesea St, Council Building Garden Place, Hamilton, 3204	
Telephone Number: (Daytime)	07 838 6699		
Telephone Number: (Out-Of-Hours)	07 838 6699		
Email:	Relevant operational area inbox		

Designer Details:		
Name:	Dean Morris	19 Kaimiro Street, Pukete, Hamilton 3200
Telephone Number:	[REDACTED]	
Email:	[REDACTED]	
Applicant Details		
Name:	Golden Valley Farm Ltd	Address: Level 1, 137 Alexandra Street, Central, Hamilton, 3210
Telephone Number		
Email:		
Landowner Details:		
Name:	Golden Valley Farm Ltd	Address: Level 1, 137 Alexandra Street, Central, Hamilton, 3210
Telephone Number		
Email:		
Notes / Restrictions / Access		

3. Stormwater System Description

3.1. Site Description

The SL1 Residential Development forms part of the residential component of the wider Southern Links 1 (SL1) Growth Cell, a circa 440ha contiguous land area that stretches the south-western edge of Hamilton that includes the Hamilton Southern Links (RoNS) designation. The Residential Development is a listed project, which includes both residential and industrial components and together comprises circa 106ha of the overall SL1 Growth Cell. The residential component comprises circa 46ha and is in single ownership and is currently used for rural farming activities. The landholding includes three land parcels legally described as Lot 2 DP 589463 (22.21 ha); Lot 1 DPS 51518 (7.58 ha); and Part Lot 2 DP 25668 (33.64 ha).

The residential component provides for the establishment of circa 938 units, together with a neighbourhood commercial node, open spaces, waterbodies, and infrastructure devices including wetlands and roading. The proposed residential development is underpinned by a series of design principles, with a focus on creating a well-connected, legible, and diverse community on Hamilton's urban fringe. This is supported via a coordinated neighbourhood structure with a connected roading and pedestrian/cycle network, integrated open space and stormwater outcomes as well as varying housing typologies and densities (including single detached, duplex, and terraced apartments) which have been proposed to meet the growing and changing needs of the housing market to ensure there are options for future residents and thoughtfully located based on opportunities and constraints, with density ranging from terraced, duplex and detached dwellings to ensure integration with the adjoining urban footprint.

Located centrally within the SL1 Residential Development is a local neighbourhood commercial node that will provide a small-scale range of amenities, four to five small retail and food and beverage tenancies designed for convenience and support immediate local needs. This local node adjoins a neighbourhood reserve, adjacent to the north/south ecological corridor, providing neighbourhood park amenities to the SL1 Residential Development.

The proposal includes substantial enabling works to establish developable land, including bulk earthworks across the site. An integrated stormwater management system including artificial wetlands, detention/attenuation devices and treatment ponds are designed with the intent to discharge to ground water as relevant. Ecological restoration is integrated via riparian and corridor planting with appropriate design measures being adopted to enhance and protect key features including the upper tributaries of the Mangakōtukutuku Stream and associated drains.

Access and integration with the surrounding Hamilton area is provided through connected transport framework, including the establishment of intersections, roading, and walking and cycle networks, along with upgrades to existing transport infrastructure. The residential development is proposed to be serviced via a coordinated strategy, including the extension of public networks, upgrades, and installation of appropriate infrastructure.

3.2. Design Standards

The HCC Development Manual sets out design and construction standards for stormwater and requires all land development projects to be provided with a mean of stormwater disposal.

Stormwater systems have been designed in accordance with RITS and other relevant standards including the HCC Development Manual 2010 and caters for the primary pipe system up to the 10-year event as well as the secondary system and overland flow paths to manage excess runoff that cater for events exceeding the capacity of the primary piped system for events exceeding the 10-year event.

3.3. Stormwater Management Plan (SMP)

The planned development straddles the existing Network Discharge Consent ('NDC') boundary. As the development relates to undeveloped land stormwater discharge consents have been obtained.

The overarching stormwater strategy has been derived from the Maven Waikato SMP which sets out the high-level, best practice approach to stormwater management within the Residential Development site. The SMP outlines the overarching stormwater management principles which will form the basis of stormwater design to support future development on the proposed sites.

Furthermore, the stormwater management strategy, as detailed within the SMP, establishes a robust long term stormwater solution, which integrates desired urban form outcomes, with the mitigation of flooding (flood plains and OLFPs) and consideration of best-practice design outcomes as detailed within relevant Waikato guidance documents.

The key components of the Southern Links 1 stormwater management strategy are as follows:

- Retention of the required initial abstraction volume through distributed on-lot retention tanks provided for each residential lot.
- Stormwater conveyance for the 10-year event through the primary stormwater network to the proposed wetlands.
- Overland flow paths for the 100-year event to be accommodated within the site and conveyed through the roading network, roadside primary networks, retained drainage corridors, diversion channels and proposed wetlands.
- Treatment of runoff prior to discharge into the receiving environment in accordance with the Mangakōtukutuku ICMP, RITS and Waikato Regional Council guidelines.
- Use of an integrated treatment train approach incorporating on-lot retention tanks, conveyance systems, wetlands, forebays, high-flow bypass systems, diversion channels, culvert crossings and flood storage areas.
- Usage of soakage where possible and where practical to replenish groundwater and minimise runoff volume.

For further details please refer to the SMP prepared by Maven Waikato Ltd dated August 2026.

3.4. Capacity and Quality

Stormwater Strategy for Lot Areas

Roof runoff is managed using inert roofing materials, while driveway runoff is directed through a catch pit with a sump for pre-treatment before disposal underground stormwater tank. Overflow is located in the catchpit system for flows surpassing the designed event within the lot areas. Excess flows will be diverted into the downstream system via the road carriageway.

Stormwater Strategy for Road Carriageway

The Water Quality volume (WQV) will be provided through the proposed wetland system with the initial abstraction is to be provided within lot areas.

Stormwater Strategy for proposed SW Wetlands

The proposed wetlands forms critical part of the overall stormwater mitigation system. They have been sized to accommodate the 100-year event or excess flows from both the road carriageway and on lot flows exceeding the 10-year event. Additionally, these are also designed to provide treatment and attenuation of lower flow events.

Stormwater Strategy for Forebays

Forebays form part of the treatment train upstream of the wetlands. The forebays provide sediment capture and energy dissipation of incoming flows and assist in reducing maintenance requirements within the primary wetland treatment areas.

Rainfall events less than the 2-year event will be directed to the forebays. The forebays will provide energy dissipation of incoming flow and minimise erosion and scour within the wetlands.

Stormwater Strategy for High Flow Bypass

High-flow bypass systems are proposed for each sub-catchment to divert larger flows around the treatment train and convey flows to the downstream channel or stream.

High-flow bypass structures are incorporated into the wetland design to safely convey larger storm events while maintaining treatment performance for more frequent rainfall events. The high-flow bypass will operate with the proposed wetland systems and associated outlet structures to manage flows prior to discharge to the existing stream or downstream drainage network.

Stormwater Strategy for Hydraulic Connectivity

The proposed stormwater management system has been developed to maintain and improve hydraulic connectivity across the site. Existing external catchment flows will be maintained through the site via retained drainage corridors and diversion channels, while wetlands and associated storage areas provide attenuation and flood mitigation from the proposed site.

Existing drainage corridors are retained and supplemented by diversion channels, stream culvert crossings, wetlands, and associated storage areas. These elements work together to maintain conveyance of external flows, reduce flood risk within the development, and provide attenuation of post-development runoff prior to discharge.

3.5. Overland Flow

Additional branches of OLFPs will be created as roading corridors are formed. The following measures will be adopted to mitigate their effects of these overland flowpaths on the proposed development.

- Identify and maintain natural overland flow/watercourse locations to convey concentrated stormwater from the site. Utilise existing culverts (where possible) to maintain the same discharge locations, post development.
- Identify and retain any upstream OLFPs and/or watercourses to avoid any upstream flooding.
- Ensure OLFPs are to be designed where possible within the roading network and discharge into watercourses and 100-year detention devices.

The preliminary OLFP design is shown in Maven Associates drawings C460 contained within Appendix A. summary of results provided below Detailed design of the OLFPs will be provided at future detail design stage following the approval of the resource consent.

An assessment of the post development overland flow paths (OLFPs) has been carried out to evaluate the behaviour of surface runoff in the road carriageway under the proposed stormwater management system. The design scenario is based on the RCP8.5 climate change scenario, incorporating all proposed devices and the assessment is done through HEC-RAS 2D. The OLFPs represents the conveyance of surface runoff because of the proposed system during the 100-year storm event.

Flow depths and velocities were assessed at key locations throughout the development covering all the various road/Accessway typologies ensuring and confirming conveyance of the OLFP is viable through proposed carriageway. See below table showing results at the key locations.

Most OLFP sections comply with standard design thresholds. However, three sections recorded maximum water depths above the 150mm guideline. Note these depths are likely to be reduced at further refined modelling at later stage.

- Catchment A: Max Depth = 220mm
- Catchment B: Max Depth = 280mm
- Catchment E: Max Depth = 320mm

Despite minor exceedances in depth, depth x velocity (m^2/s) values remain well below critical safety thresholds defined in Austroads 2012 Part 5, which specify;

- $< 0.4\text{m}^2/\text{s}$ for pedestrian Safety
- $< 0.6\text{m}^2/\text{s}$ for vehicle safety

The highest recorded value was $0.14\text{m}^2/\text{s}$ confirming safe flow conveyance for both pedestrians and vehicles under design conditions. Flow is primarily routed along proposed roads conveyed into roadside primary networks for the 10-year conveyance to the proposed wetlands.

It is noted that a separate flood sensitivity analysis has been completed using HEC-RAS 2D modelling assuming all stormwater devices are fully blocked.

4. Stormwater System Devices

4.1. Artificial Wetland

Artificial wetlands have been designed to provide stormwater treatment, extended detention, attenuation and flood storage prior to discharge to the existing stream or downstream stormwater network.

The Residential Development includes the construction of six (6) stormwater wetlands. The wetlands will form part of the overall treatment train system, including forebays, high flow bypass systems and primary conveyance systems.

Runoff from roads and developed areas will be conveyed through the primary stormwater network and directed to the proposed wetland systems. The forebays will provide sediment capture and energy dissipation prior to stormwater entering the wetlands. The wetlands will provide water quality treatment, extended detention and attenuation prior to discharge to the existing stream or downstream stormwater network.

Any rainfall event larger than the water quality volume extended detention storage will be directed via a high-flow bypass to the existing stream. The wetland outlet structures will include low-flow orifices, weirs, spillways and backflow prevention devices where required.

Sheet Piling

Continuous sheet pile walls may be installed around the perimeter of the proposed wetlands as a permanent groundwater cut-off system. The sheet piles would be embedded into the underlying Walton Subgroup to hydraulically isolate the wetland excavation from the surrounding confined aquifer, allowing local penetration of the confining silt layer while maintaining control of artesian groundwater pressures and reducing the risk of seepage, uplift, piping, and base heave.

Either steel or vinyl sheet piles may be adopted, subject to detailed design and constructability assessment, with the required embedment depth to be confirmed based on groundwater conditions, seepage control requirements, and geotechnical design considerations.

Inspection requirements

- Embankment & Emergency Spillway
 - Level of spillway
 - Vegetation and ground cover
 - Freeboard
 - No evidence of embankment erosion
 - Removal of debris on emergency spillway
- Riser & Service Spillway
 - No low flow orifice obstructed
 - No excessive sediment accumulation inside the riser
 - Function of outfall channels
 - Slope protection
 - No rip-rap failures
- Wetland
 - No undesirable vegetation growth
 - Removal of floating debris
 - No visible pollution
 - No evidence of edge erosion
 - No algal bloom or fish kill observed
- High Flow Bypass
 - No blockage within high flow bypass channel
 - No evidence of erosion or scour
 - Vegetation and ground cover maintained
 - Flow path remains clear of debris and obstruction
- Sediment Forebays
 - Sediment is not accumulated more than 50%
 - Provision of access of maintenance
 - No blockage at inlet or outlet
 - No evidence of scour or erosion around inlet structure

Maintenance procedures

Timing	Component	Action
Following storms / Monthly	Inlet	Inspect and remove rubbish and debris from inlets.
	Trash racks and debris screens	Inspect and clear all litter, including leaves, rubbish, branches, and any other materials.
	Sediment forebay	Check the forebay for accumulated sediment. Test sediments for contaminants prior to dredging and dispose of sediment to landfill or similar, suitable for contaminant levels.
	Risers, control structures, grates, outlet pipes, skimmers, weirs, and orifices	Inspect control structures, weirs, orifices, outfall pipes for leaks and blockages. Clear and remove all blockages to avoid local flooding. Inspect outflow pipes for leaky joints or soil piping erosion.

		Check if anti-seep collars need repair or replacement. Check outfall and water discharge areas for erosion and restore and stabilise erosion.
	Emergency overflow or spillway	Check emergency overflow path remains clear of debris and blockages and remove any blockages. Check flow paths for erosion and repair as necessary.
	Erosion and bank stability	Inspect banks for settlement, erosion, scouring, cracking, sloughing, seepage and rilling.
	Water body	Remove rubbish and other floating debris from wetland pond.
	Wildlife	Remove dead animals to prevent disease spread.
	Soil	Inspect for loss of soil on wetland banks from erosion.
Annually	Valves and pumps	Check pumps and valves. Check moving parts for corrosion and lubricate.
2+ years	Wetland liners	Inspect liner for leaks and fix as per manufacturers or design specifications.
	Sediment forebay	Check the forebay for accumulated sediment. Test sediment for contaminants prior to dredging and dispose of sediment to landfill or similar suitable for contaminant levels.

Troubleshooting

Symptom	Possible problems	Solutions
Wetland water levels remain high	The outlet riser openings may be too narrow to allow fast draining after a storm	Unless water levels remain high for more than two days or flooding is a threat, action may not be necessary,
	Outlets structures are clogged	Check outlet structures and openings for blockage by debris or sediment, and clean as necessary.
Wetland is dry	Invasive plants	Remove plants by hand. (no herbicide)
	A maintenance valve is open	Check drain valves and shut if open
	Water leaking from cracks in outlet structure	Inspect for cracks and repair as necessary. Inspect for leaky joints at outlet pipes and repair.
	Wetland in area of changing groundwater levels	Pond will remain dry as long as groundwater levels are low. Design for pond should have taken this into account, so this may be normal for this wetland.
Stormwater discharging from the wetland looks dirty, muddy, or dark	High concentration of sediments washing into wetland, especially silts and clays, due to erosion or construction in the catchment area	Check catchment for erosion areas, including construction works. Check erosion controls are in place.

	Forebay full of sediment	Forebay usually needs more frequent clearing of sediment than wetland pond.
	Local works disturbing soils, with rain washing these into wetland	Check erosion and sediment controls in place on local construction sites.
Pond banks are eroding	Water flowing down pond banks is eroding soils	Minor erosion can be repaired by replacing soil and stabilising with planting or other methods.
	Stormwater outlet pipes direct flow at banks	Cause of erosion from direct discharge may need to be identified, for example, by extending pipes down into pond. Extensive erosion due to continuing discharge may require erosion protection.
Water is leaking from the wetland and through the banks along pipes	Leak collars around pipes have failed or have not been fitted correctly.	Qualified contractors should make immediate repairs. It usually requires pond to be drained, banks excavated, leak collars repaired, and pond banks reinstated.
High flow bypass is eroding	Concentrated flow or insufficient ground protection	Check flow path, reinstate erosion protection and repair damaged areas as necessary.
Backflow into wetland occurs	Backflow prevention device is blocked, damaged or not operating	Inspect backflow prevention device and repair or replace as necessary.

4.2. Lot Retention Tanks

Lot Retention Tanks for the Residential Development will be constructed to capture surface water from roof areas and retain water on-lot for non-potable reuse.

As per Hamilton City Council's Plan Change 12 (Three Waters Rules), standard 5m³ retention tank is proposed for each residential lot. The lot retention tanks form part of the overall stormwater management system and provide retention of the required initial abstraction volume at source. The lot retention tanks will remain in private ownership. Ongoing operation and maintenance responsibilities will be with the property owners or occupiers.

Overflow from the lot retention tanks will discharge to the downstream stormwater network once the available storage volume has been exceeded.

The lot retention tanks shall be inspected in line with the Waikato Stormwater Management Guideline 2020 and Hamilton City Council HCC:02 Rainwater reuse tank practice note. This will include manual/mechanical removal of debris, sediment, leaves and vegetation from the gutters, downpipes, pre-screening devices, filters, overflow pipes and other components associated with the lot retention tanks.

Inspection requirements

- Debris cleanout
 - Removal of debris
 - No dumping of wastes into tanks
 - Litter has been removed
- Gutter and Downpipe
 - No blockage within gutters and downpipes

- No evidence of damage or leakage
- No disconnection from the lot retention tank
- Only roof water is directed to the lot retention tank
- Pre-screening devices and filters
 - Screens and filters are clean
 - No excessive sediment or organic matter accumulation
 - No damaged or missing screens
 - First flush diverter, if provided, is operating as intended
- Overflow
 - No blockage within overflow pipe
 - Overflow pipe is operating as intended
 - No evidence of erosion or scour at the overflow discharge point
 - No stormwater surcharge back into the tank from the downstream stormwater system
- Pump and non-portable water supply
 - Pump is operating as intended
 - No evidence of damage to pipework or electrical components
 - Non-potable water taps are clearly marked
 - Backflow prevention device is maintained and tested where required
- Tank
 - No evidence of cracks or damage
 - No evidence of leakage
 - No excessive sludge or sediment build up
 - Access lid is secure
 - Access to the tank, pump, screens and filters is maintained

Maintenance procedures

Timing	Component	Action
Following storms	Gutters and downpipes	Check for leaves, litter, sediment and debris and remove as necessary
	Pre-screening devices and filters	Check for blockage and clean as necessary.
	Overflow pipe	Check overflow pipe is clear and operating as intended.
	Overflow discharge point	Check for erosion or scour and repair as necessary.
3 Monthly	Pre-screening devices and filters	Inspect and clean pre-screening devices, leaf guards, first flush diverters and filters.
	Gutters and downpipes	Remove leaves, litter, sediment and other debris.
6 Monthly	Gutters	Inspect and clean gutters.
	Downpipes	Check for blockage, damage or leakage and repair as necessary.
	Overflow pipe	Check overflow pipe is clear and remove any blockage.
	Tank inlet and outlet	Check for blockage, damage or leakage and repair as necessary.
Yearly	Tank	Check for sludge and sediment build up. Remove sludge and sediment if required.

	Surrounding vegetation	Clear surrounding vegetation and overhanging trees from roof areas.
	Access lid	Check access lid is secure and safe.
	Backflow prevention device	Inspect and test by certified inspector where required.
5 Yearly	Tank structure	Inspect tank structural integrity by qualified professional.
	Pipework	Inspect pipework by qualified professional.
	Pump and electrical components	Inspect pump and electrical components by qualified professional.

Troubleshooting

Symptom	Possible problems	Solutions
Tank not filling	Gutters or downpipes are blocked	Remove leaves, litter, sediment and debris from gutters and downpipes.
	Pre-screening devices or filters are blocked	Clean pre-screening devices and filters.
	Downpipe is disconnected from tank	Reconnect downpipe to the tank.
Non-potable water supply not operating	Tank is empty	Check tank water level.
	Pump is not operating	Check power supply and pump operation.
	Electrical or pump fault	Arrange inspection by qualified professional.
Poor water quality	Sediment or sludge accumulated in tank	Inspect tank and remove sediment or sludge if required.
	Leaves or organic matter entering tank	Clean gutters, screens, filters and first flush diverter.
	Stagnant water or odour from tank	Clean tank and remove organic matter.
Overflow not operating	Overflow pipe is blocked	Remove blockage from overflow pipe.
	Overflow discharge point is blocked	Remove debris and sediment build up.
	Stormwater is surcharging back into tank	Check downstream stormwater connection and repair as necessary.
Water leaking from tank	Tank wall or fittings damaged	Inspect tank and repair as necessary.
	Pipe connection is leaking	Repair or replace damaged pipe connection.
Mosquitoes or pests	Damaged or missing insect screens	Repair or replace insect screens.
	Access lid not secure	Secure access lid
	Organic matter accumulated in tank	Clean tank, gutters and filters

5. Reporting and Scheduling

Recording and Reporting of Operation and Maintenance activities to the WRC

Recording of information and device tracking are important components of the maintenance of stormwater system devices. It is important that site operator and/or owners track maintenance by use of database. This helps inspectors to understand what devices need to be inspected, when they need to be inspected, and when was the last maintenance. Contractors nominated by HCC will record operation and maintenance activities and report to Waikato Regional Council by use of a database. Established checklists will be used during the inspection and maintenance activities, and the activities will never rely on the memory of any one individual.

Appendix A – Auckland Council’s Wetlands Operation and Maintenance Guide



WETLANDS

Operation & Maintenance Guide

STORMWATER DEVICE INFORMATION SERIES

**Auckland
Council**
Te Kaunihera o Tāmaki Makaurau



What are constructed wetlands?

Constructed wetlands are large shallow planted ponds that filter stormwater runoff, slow flows and help control flooding downstream. Similar to natural wetlands, they look attractive and provide home and shelter to wildlife. Constructed wetlands help remove sediments, nutrients and contaminants from incoming stormwater before discharging to downstream stormwater system or waterways.

This guide offers a general description of constructed wetlands. Each constructed wetland is specifically designed to suit a particular site, so construction details will be on design and site construction plans. Correct construction levels are crucial for supplying suitable drainage for wetland plants.

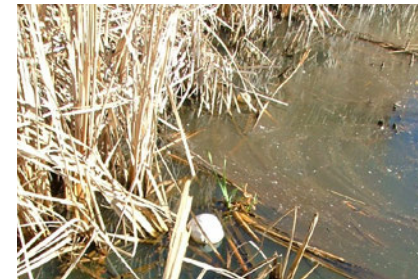
How and when should maintenance be carried out?

Constructed wetlands need to be maintained in two main ways. Firstly, so they continue to work as designed (filtering stormwater, slowing flows and controlling downstream flooding) and secondly, to look attractive. A full inspection of constructed wetlands should take place a year after construction is completed.

This may be carried out by the construction contractor to coincide with the end of the defects liability period. The tables below give only typical timelines and actions for maintaining constructed wetlands. This is a general guide - each wetland should have its own detailed maintenance plan to suit the particular catchment size, pollutant loads and inflows.

WARNING - CONTAMINATED SOIL

Constructed wetlands treat stormwater run-off, so will collect contaminants in the sediments of the pond and forebay. All material removed from these sites should be tested for contaminants before being disposed of at a suitable secure landfill.



Eight key components of a constructed wetland

5. Plants

Usually native plants, in the pond and on littoral shelf.
Species chosen to suit various water level zones in wetland.
(For suitable species and planting guidelines, refer to ARC Technical Report TR2009/083 Landscape and Ecology Values within Stormwater Management)

1. Inlet

Inlet pipe, receiving runoff.
Erosion controls at inlet (rip rap, energy dissipaters) slow flows. Debris screens or trash racks capture rubbish.

2. Sedimentation forebay (if included)

Forebay helps slow runoff and sediment drops to the bottom. Separated from main pond by a bund or low dam.

3. Main wetland

Shallow wide pond of variable depth to 1m, planted with aquatic species. Fine sediments settle to bottom and contaminants such as oil and grease break down.

4. Shallow wetland area (Littoral shelf)

Shoreline of the pond, planted with swamp species submerged at times. Plants take up nutrients (nitrogen and phosphorous) as well as slow flows and trap sediment.

6. Risers/outlets

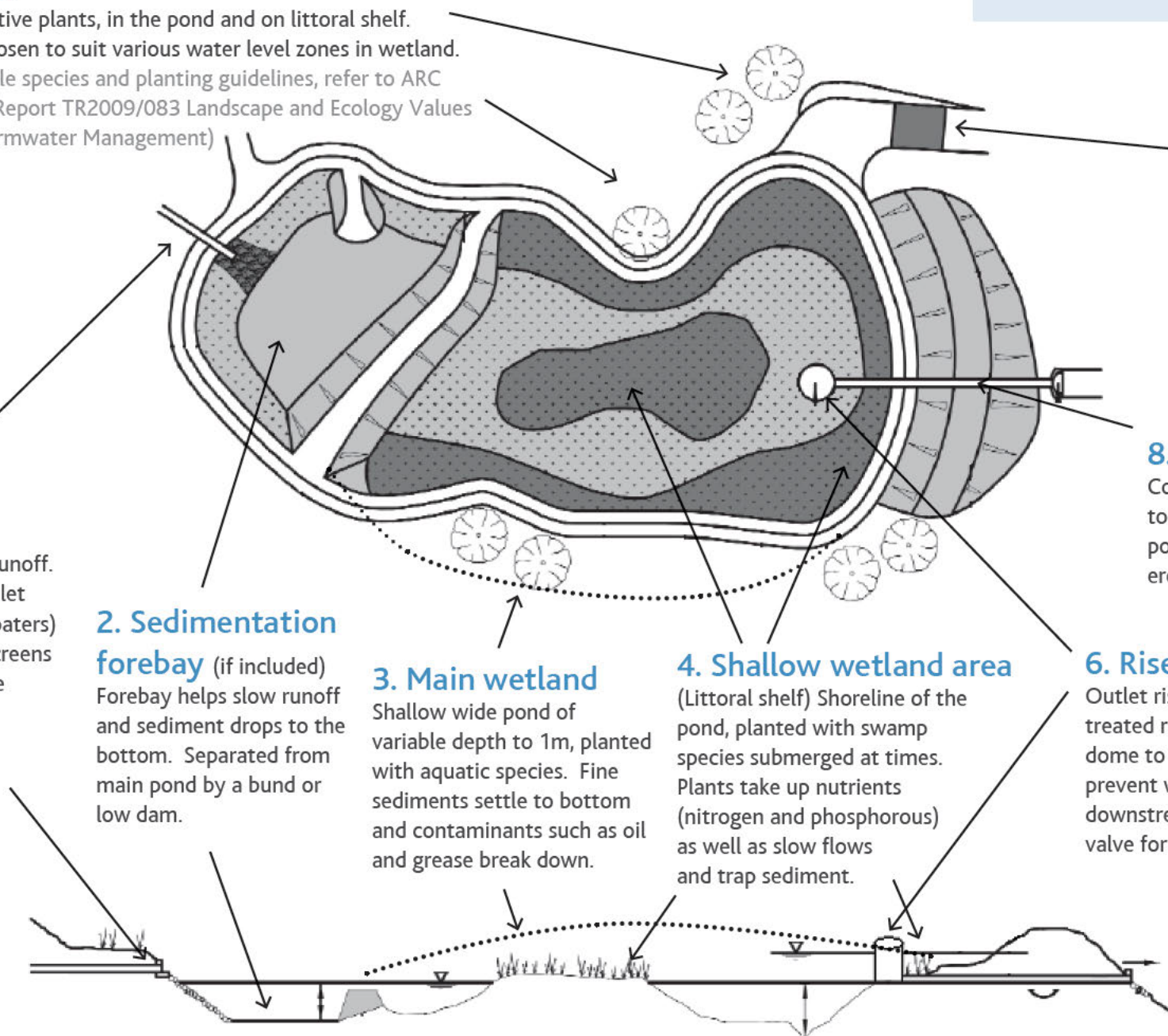
Outlet riser pipe or weir for discharge of treated runoff. Risers may have scruffy dome to trap debris, or baffles/skimmer to prevent water life and debris from flowing downstream. Some risers have drain-down valve for maintenance.

7. Emergency overflow

Structure to allow extreme heavy rain flows to bypass wetland and drain downstream, to prevent overtopping of wetland banks. May be in outlet riser or separate.

8. Anti-seep collars

Collars are fitted to all pipework to prevent pond leakage and potential bank collapse from erosion.



MAINTENANCE SCHEDULE

Following storms

Timing	Component	Action
	Inlet	• Inspect and remove rubbish and debris from inlets. • Check area around inlet, especially energy dissipation (rip rap) structures for erosion and cracking, and if present, repair.
	Trash racks and debris screens (if fitted)	• Inspect and clear all litter, including leaves, rubbish, branches and any other material that would block flows. Check racks for corrosion and replace if necessary.
	Sediment forebay	• Check the forebay for accumulated sediment. In general the forebay should be dredged if sediment fills over 50% of design volume. • Test sediments for contaminants (eg heavy metals, PAHs) prior to dredging and dispose of sediment to landfill or similar suitable for contaminant levels.
	Bund	• Check for erosion or instability and repair if required.
	Risers, control structures, grates, outlet pipes, skimmers, weirs and orifices	• Inspect control structures, weirs, orifices, outfall pipes for leaks and blockages. Blockage could be sediment build up, floating debris, rubbish. • Control structures could be overgrown with vegetation. • Clear and remove all blockages to avoid local flooding. Areas around control structure need to be clear of vegetation and rubbish to maintain stormwater flow. A boat may be required to access the outlet. • Inspect outflow pipes for leaky joints or soil piping erosion. • Check if anti-seep collars need repair or replacement. • Check outfall and water discharge areas for erosion and restore and stabilise erosion. • Check energy dissipaters are adequate.
	Emergency overflow or spillway	• Check emergency overflow path remains clear of debris and blockages, and remove any blockages. Check flow path for erosion and repair as necessary. Structural repairs must be repaired immediately to avoid catastrophic failure.

MAINTENANCE SCHEDULE cont...

TIMING	COMPONENT	ACTION
Following storms	Erosion and bank stability	• Inspect banks for settlement, erosion, scouring, cracking, sloughing, seepage and rilling. • Remove woody vegetation growth (unless species specifically included in pond planting plans) to avoid future root damage to banks. Removal will require bank material replacement and repair, compacted to design specification of maximum 90% dry soil density. • Inspect for pedestrian and cycle traffic or pathways on banks. • Either restrict traffic by closing paths off, or provide suitable resistant ground cover to avoid erosion from traffic.
	Water body	• Remove rubbish and other floating debris from wetland pond. • Inspect for algal blooms (usually dense water discolouration or surface scum) or fish kills – these could indicate water has extremely low levels of oxygen (eutrophication), or high nutrient loads or pollutants. • Test water quality if these problems suspected.
	Wildlife	• Control pest species so they do not threaten birds and aquatic life of the wetland. • Remove dead animals, especially water birds, to prevent disease spread. Wet areas where mosquito (mosquito larvae) could breed need careful maintenance.
	Soil	• Inspect for loss of soil on wetland banks from erosion. If plants are struggling to grow soil fertilizer may be required, but extra care must be taken to prevent fertilizer from entering wetland and local waterways.
Monthly	Inlet	• Inspect and remove rubbish and debris from inlets.
	Trash racks and debris screens (if fitted)	• Inspect and clear all litter, including leaves, rubbish, branches and any other material that would block flows. • Check racks for corrosion and replace if necessary.

MAINTENANCE SCHEDULE cont...

TIMING	COMPONENT	ACTION
Monthly	Risers, control structures, grates, outlet pipes, skimmers, weirs and orifices	- Inspect control structures, weirs, orifices, outfall pipes for leaks and blockages. Blockage could be sediment build up, floating debris, rubbish. Control structures could be overgrown with vegetation. - Clear and remove all blockages to avoid local flooding. Areas around control structure need to be clear of vegetation and rubbish to maintain stormwater flow. - Boat may be required to access outlet.
	Emergency overflow or spillway	- Check emergency overflow path remains clear of debris and blockages, and remove any blockages. - Check flow path for erosion and repair as necessary. Structural repairs must be repaired immediately to avoid catastrophic failure.
	Erosion and bank stability	- Inspect banks for settlement, erosion, scouring, cracking, sloughing, seepage and rilling. - Remove woody vegetation growth (unless species specifically included in pond planting plans) to avoid future root damage to banks. Removal will require bank material replacement and repair, compacted to design specification (of maximum 90% dry soil density). - Inspect for pedestrian and cycle traffic or pathways on banks. - Either restrict traffic by closing paths off, or provide suitable resistant ground cover to avoid erosion from traffic.
	Landscaping	Clear wetland plants of weeds and prune and replace three-monthly. Mow split grass around pond monthly. Schedules may vary depending on seasonal growth.
	Water body	Remove rubbish and other floating debris from wetland pond. Inspect for algal blooms (usually dense water discolouration or surface scum) or fish kills – these could indicate water has extremely low levels of oxygen (eutrophication), or high nutrient loads or pollutants. Test water quality if these problems suspected.

MAINTENANCE SCHEDULE cont...

TIMING	COMPONENT	ACTION
6 Monthly	Wildlife	- Control pest species so they do not threaten birds and aquatic life of the wetland. Remove dead animals, especially water birds, to prevent disease spread. - Wet areas where mosquito (mosquito larvae) could breed need careful maintenance.
	Soil	Inspect for loss of soil on wetland banks from erosion. If plants are struggling to grow soil fertilizer may be required, but extra care must be taken to prevent fertilizer from entering wetland and local waterways.
	Inlet	Check area around inlet, especially energy dissipation (rip rap) structures for erosion and cracking, and if present, repair.
	Bund	Check for erosion or instability and repair if required.
	Risers, control structures, grates, outlet pipes, skimmers, weirs and orifices	- Inspect outflow pipes for leaky joints or soil piping erosion. - Check if anti-seep collars need repair or replacement. - Check outfall and water discharge areas for erosion and restore and stabilise erosion. Check energy dissipaters are adequate.
Anually	Littoral zones	- Inspect wetland plants for exotic or invasive/nuisance water species and remove. - Control may be done manually, or with appropriate herbicide by properly licensed and registered professional. Follow up inspections may be needed during growing season.
	Valves and pumps	- Check pumps and valves, if present, are functioning properly. - Check moving parts for corrosion and lubricate if required.
	Wetland liner	Inspect liner for leaks and fix as per manufacturer's or design specifications.
2+ Years	Sediment forebay	- Check the forebay for accumulated sediment. In general the forebay should be dredged if sediment fills over 50% of design volume. - Test sediments for contaminants (eg heavy metals, PAHs) prior to dredging and dispose of sediment to landfill or similar suitable for contaminant levels.

TROUBLESHOOTING

SYMPTOM	POSSIBLE PROBLEMS	SOLUTION
Wetland water levels remain high	The outlet riser openings may be too narrow to allow fast draining after a storm	Unless water levels remain high for more than two days or flooding is a threat, action may not be necessary. Refer decision to supervisor if necessary.
	Outlet structures are clogged	Check outlet structures and openings for blockage by debris or sediment, and clean as necessary.
	Invasive plants (such as raupo) clogging pond area	Remove plants by hand – do not use herbicides.
	A maintenance valve is open.	Check drain valves and shut if open.
Wetland is dry	Water leaking from cracks in outlet structure.	- Inspect for cracks and repair as necessary. - Inspect for leaky joints at outlet pipes and repair.
	Wetland in area of changing groundwater levels.	- Pond will remain dry as long as groundwater levels are low. - Design for pond should have taken this into account, so this may be normal for this wetland.
	Ground water levels have dropped due to drought conditions	Drought conditions cannot be solved, until wet season restores wetland pond levels. Use drought opportunity to clean sediments from forebay and repair stormwater infrastructure.
Stormwater discharging from the wetland looks dirty, muddy or dark	High concentration of sediments washing into wetland, especially silts and clays, due to erosion or construction in the catchment area.	- Check catchment for erosion areas, including construction works. - Check erosion controls are in place. Add or repair erosion control as required.
	Forebay full of sediment.	Forebay usually needs more frequent clearing of sediment than wetland pond. Dredging required when forebay water storage is around 50% of total volume.
	Local works disturbing soils, with rain washing these into wetland.	- Check erosion and sediment controls in place on local construction sites. - Repair if necessary and stabilise areas of exposed soil where erosion occurring.
	Wetland outlet constructed too close to inlet, preventing treatment of water before discharge.	Should have been designed to suit. Well placed baffles or islands in wetland may redirect and slow flows to increase treatment between inlet and outlet points.

TROUBLESHOOTING cont...

SYMPTOM	POSSIBLE PROBLEMS	SOLUTION
Wetland plants are growing over the edges and across surface of the pond	Wetland plants are growing in shallow edges of pond.	Constructed wetlands are designed to have plants growing large fringes across pond. No action required unless plants are affecting pond function, for instance, clogging outlet structure.
Pond banks are eroding	Water flowing down pond banks is eroding soils. Stormwater outlet pipes direct flow at banks.	- Minor erosion can be repaired by replacing soil and stabilising with planting or other methods. - Cause of erosion from direct discharge may be repaired, for instance, by extending pipes down into pond. - Extensive erosion due to continuing discharge may require erosion protection such as rip-rap, geotextile.
Water is leaking from the wetland and through the banks along pipes	Leak collars around pipes have failed or have not been fitted correctly (or at all). This can lead to failure of banks.	Failure of pond banks can cause major damage at pond and downstream, so qualified construction contractors should make immediate repairs. This usually requires pond to be drained, banks excavated, leak collars repaired, and pond banks reconstructed to original design specifications.
Dead or dying birds	Botulism is a common killer of pond birds. Birds ingest toxins produced by the bacteria <i>Clostridium botulinum</i>, either from the water or by eating maggots or other infected food sources. Botulism can occur when water levels are low, often mid to late summer when pond water stagnates. It can also appear after algal blooms, when water oxygen levels are low.	- Remove all dead birds and animals from the area to reduce the spread of Botulism. Avoid algal blooms (see below). - Maintain flows through the ponds to avoid stagnant water. Improve shading over the water.

TROUBLESHOOTING cont...

SYMPTOM	POSSIBLE PROBLEMS	SOLUTION
Algal blooms (Yellow, green, red or blue-green coloured scum on the surface of the water.)	Algae is naturally present in waterways. Algal blooms occur in good growing conditions, including stagnant or slow moving water, high levels of nutrients, and warm and sunny weather.	• Avoid blooms by reducing nutrients entering the wetland, (for instance, controlling fertilizers from the surrounding area) and by maintaining water flows. • Although there are a number of suggested ways to deal with blooms, few are proven to work. The use of barley straw bales in the pond may work in some cases.
Animal pests present	Dense plant cover and abundant food supply in wetlands supports many animals, including pest species.	• Thin out vegetation where possible. • Set traps and poison in the area, using recommended procedures such as careful poison placement and providing warning signs.
Plants on edge of pond dying	Plants are suffering extreme wet and dry conditions.	• Choose plant varieties suitable to local conditions. • New plants need watering until established. • Replace unsuitable varieties.

Quick maintenance checks

- ✓ Check for leaks and erosion on and around banks, especially at leak collars.
- ✓ Regularly clear rubbish and dead vegetation around outlet structures, trash racks and forebay.
- ✓ Remove dead birds in case of botulism, especially in hot, humid conditions
- ✓ Keep new plants watered and control weed species.

Avoid

- ✗ Do not let erosion go unchecked. Repair, and replace erosion controls if necessary.
- ✗ Do not let forebay volume reach over half-full of sediment. Dredge and dispose of to suitable landfill.
- ✗ Prevent fertilizers, pesticides and herbicides entering the pond to avoid algal blooms and polluting downstream waterways.
- ✗ Do not ignore algal blooms and unusually dirty or dark pond water. These can affect the health of the wetland and downstream waterways.

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Appendix B – Recommended Maintenance Event and Frequency Checklists

Appendix C – Troubleshooting Guide

Symptom	Possible problems	Solution
		Establishing plants need watering in dry weather.
	Plants stressed due to attack by plant pests or diseases. Pests may include insects or animals.	- Check for leaf damage or pests and consult gardening manuals or a garden centre for the best treatment. - Stressed plants need replacing with healthy variety or pest-resistance species.
	Rain garden soil mix compacted	Loosen the top 500mm of soil by tilling or forking. Do not allow vehicle, pedestrian and bicycle access to the rain garden.

18.2.1.4 Infiltration devices

Infiltration devices are very sensitive to impaired performance if excessive amounts of sediments or oils and greases are introduced into them. The greatest problem is clogging of soils in the sides and bottom or in the case of permeable paving surface clogging. This can occur fairly rapidly if inflow sediment loads are not reduced by pre-treatment devices.

Other contaminants, which are attached to sediments, are not considered a clogging concern.

Another problem is poor drainage as a result of high water table, groundwater mounding or a confining soil layer. Prolonged wetness encourages micro-organism growths that tend to clog soils.

18.2.1.5 Ponds and wetlands

One of the greatest benefits of stormwater management ponds and wetlands is their resilient performance even when excessive contaminant loads enter them. However, performance will suffer if sediment is introduced in large amounts over a lengthy time frame. Sediments reduce the volume of storage and reduce extended detention times, which ultimately reduce the pond or wetland's contaminant reduction potential.

This impaired function is not something that tends to occur dramatically in a short time period but rather occurs cumulatively over a longer time period if the incoming sediment load is consistently elevated.

Another problem that ponds and wetlands have that other devices do not have to such an extent is maintenance problems associated with debris clogging inlets and outlet areas. While other devices can have visual issues related to debris, pond outlets can become blocked, especially the extended detention orifices. Clogging of these outfall orifices can cause significant adverse effects by elevating water in the pond or wetland and potentially killing the vegetation, increasing safety concerns and increasing the zone of saturation in the pond or wetland embankment.

Sediment forebay clogged with sediment and needing to be cleaned out



A recommended maintenance schedule for wetlands is provided below:

Timing	Component	Action
	Bund	Check for erosion or instability and repair if required.
	Risers, control structures, grates, outlet pipes, skimmers, weirs and orifices	- Inspect outflow pipes for leaky joints or soil piping erosion. - Check if anti-seep collars need repair or replacement. - Check outfall and water discharge areas for erosion and restore and stabilise erosion. Check energy dissipaters are adequate.
	Littoral zones	- Inspect wetland plants for exotic or invasive/nuisance water species and remove. - Control may be done manually, or with appropriate herbicide by properly licensed and registered professionals. Follow up inspections may be needed during growing season.
Annually	Valves and pumps	- Check pumps and valves, if present, are functioning properly. - Check moving parts for corrosion and lubricate if required.
2+ years	Wetland liners	Inspect liner for leaks and fix as per manufacturer's or design specifications.
	Sediment forebay	- Check the forebay for accumulated sediment. In general the forebay should be dredged if sediment fills over 50% of design volume. - Test sediment for contaminants (eg. heavy metals, PAHs) prior to dredging and dispose of sediment to landfill or similar suitable for contaminant levels.

Table 18-7: Trouble shooting for wetland¹⁷⁷

Symptom	Possible problems	Solution
Wetland water levels remain high	The outlet riser openings may be too narrow to allow fast draining after a storm	Unless water levels remain high for more than two days or flooding is a threat, action may not be necessary. Refer decision to supervisor if necessary.
	Outlet structures are clogged	Check outlet structures and openings for blockage by debris or sediment, and clean as necessary.
Wetland is dry	Invasive plants (such as raupo) clogging pond area	Remove plants by hand, do not use herbicide.
	A maintenance valve is open	Check drain valves and shut if open
	Water leaking from cracks in outlet structure	- Inspect for cracks and repair as necessary - Inspect for leaky joints at outlet pipes and repair

¹⁷⁷ Auckland Council Wetlands Operation and Maintenance Guide

Symptom	Possible problems	Solution
	Wetland in area of changing groundwater levels	- Pond will remain dry as long as groundwater levels are low. - Design for pond should have taken this into account, so this may be normal for this wetland.
	Groundwater levels have dropped due to drought conditions	Drought conditions cannot be solved, until wet season restores wetland pond levels. Use drought opportunity to clean sediments from forebay and repair stormwater infrastructure.
Stormwater discharging from the wetland looks dirty, muddy or dark	High concentration of sediments washing into wetland, especially silts and clays, due to erosion or construction in the catchment area	- Check catchment for erosion areas, including construction works. - Check erosion controls are in place. Add or repair erosion control as required
	Forebay full of sediment	Forebay usually needs more frequent clearing of sediment than wetland pond. Dredging required when forebay water storage is around 50% of total volume.
	Local works disturbing soils, with rain washing these into wetland	- Check erosion and sediment controls in place on local construction sites - Repair if necessary and stabilise areas of exposed soil where erosion occurring
	Wetland outlet constructed too close to inlet, preventing treatment of water before discharge	Should have been designed to suit. Well placed baffles or islands in wetland may redirect and slow flows to increase treatment between inlet and outlet points.
Wetland plants are growing over the edges and across surface of the pond	Wetland plants are growing in shallow edges of pond	Constructed wetlands are designed to have plants growing large fringes across pond. No action required unless plants are affecting pond function, for instance, clogging outlet structure.
Pond banks are eroding	Water flowing down pond banks is eroding soils	Minor erosion can be repaired by replacing soil and stabilising with planting or other methods
	Stormwater outlet pipes direct flow at banks	- Cause of erosion from direct discharge may be repaired, for instance, by extending pipes down into pond. - Extensive erosion due to continuing discharge may require erosion protection such as rip-rap, geotextile.
Water is leaking from the wetland and through the banks along pipes	Leak collars around pipes have failed or have not been fitted correctly (or at all). This can lead to failure of banks.	Failure of pond banks can cause major damage at pond and downstream, so qualified construction contractors should make immediate repairs. This usually requires pond to be drained, banks excavated, leak collars repaired, and pond banks

Symptom	Possible problems	Solution
		reconstructed to original design specifications.
Dead or dying birds	Botulism is a common killer of pond birds. Birds ingest toxins produced by the bacteria <i>Clostridium botulinum</i> , either from the water or by eating maggots or other infected food sources. Botulism can occur when water levels are low, often mid to late summer when pond water stagnates. It can also appear after algal blooms, when water oxygen levels are low.	- Remove all dead birds and animals from the area to reduce the spread of Botulism. Avoid algal blooms (see below). - Maintain flows through the ponds to avoid stagnant water. Improve shading over the water.
Algal blooms (yellow, green, red or blue-green coloured scum on the surface of the water)	Algae is naturally present in waterways. Algal blooms occur in good growing conditions, including stagnant or slow moving water, high levels of nutrients, and warm and sunny weather	- Avoid blooms by reducing nutrients entering the wetland, (for instance, controlling fertilizers from the surrounding area) and by maintaining water flows. - Although there are a number of suggested ways to deal with blooms, few are proven to work. The use of barley straw bales in the pond may work in some cases.
Animal pests present	Dense plant cover and abundant food supply in wetlands supports many animals, including pest species	- Thin out vegetation where possible. - Set traps and poison in the area, using recommended procedures such as careful poison placement and providing warning signs.
Plants on edge of pond dying	Plants are suffering extreme wet and dry conditions.	- Choose plant varieties suitable to local conditions. - New plants need watering until established. - Replace unsuitable varieties.

18.2.1.6 Green roofs

Principal reasons why this device performance can deteriorate are the following:

- Impermeable membrane failure due to leakage, puncture or UV deterioration
- Excessive weed growth outcompeting planted growth
- Ponding of water on flat roofs
- Concentration of flows across the green roof causing scour and discharge at locations not designed for
- Clogging of substrate, and
- Plugged outlets.

18.2.1.7 Water tanks

Water tank function can be compromised mainly due to two reasons:

1. Inadequate water supply where demand exceeds supply, and
2. The tank outlets or downspouts become clogged due to excessive vegetative entry into the tank from roof spouting.