To	From
Auckland Council	*Woods* *Sam Kirk – Associate Engineer* *W-REF: P25-609* *4 August 2026* *Reviewer: Jamie Whyte*

Milldale Stages 14-17 – Stormwater Design Memorandum

Statement of Qualifications and Experience

Originator: Sam Kirk – Associate Engineer

I, Sam Kirk, am an Associate Engineer at Woods. Woods is a multi-disciplinary consultancy specialising in planning, urban design, engineering, water infrastructure, and surveying. I have been employed at Woods since July 2025, although also previously between January 2019 and September 2022.

I hold the qualifications of a Bachelor of Surveying, which I completed in 2018, and I also hold a Cadastral Surveying License. I am also a Voting Member of S+SNZ.

I have eight years of experience in the Engineering industry. My experience includes the design and construction observation of a range of land development projects, including project management and the procurement of earthworks, roading, services and other infrastructure. I have been involved with the surveying, design and management of previous Milldale projects, dating back to Stage 1A. I have also been involved in managing multiple land development projects in London and Melbourne.

I confirm that, in my capacity as the author of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practices Note 2023.

Reviewer: Tim Rickards - Principal

I, Tim Rickards, am a Principal at Woods. I have been employed at Woods since February 2013.

I hold the qualifications of Bachelor of Engineering (Technology), which I completed in 2008. I am a Chartered Professional Engineer of Engineering New Zealand.

I have 20 years of professional experience in the Engineering industry. My experience includes the design and construction observation of a range of land development projects, including project management and the procurement of earthworks, roading, services and other infrastructure. I have been involved in the design and construction of most of the previous stages of Milldale including the surrounding Milldale Stage 4 development and the development of the secondary superlot developments at Milldale.

I confirm that, in my capacity as reviewer of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Approval: Jamie Whyte – Principal

I, Jamie Whyte, am a Principal at Wood & Partners Consultants Ltd. Wood & Partners Consultants Ltd is a multi-disciplinary consultancy specialising in planning, urban design, civil engineering, water infrastructure and surveying. I have been employed at Wood & Partners Consultants Ltd since January 2004.

I hold the qualifications of a Bachelor of Surveying from the University of Otago (BSurv), which I completed in 2003. I hold a professional qualification as a Register Professional Surveyor (RPSurv). I am a Full (voting) Member of Survey and Spatial New Zealand.

I have 20 years of professional experience in Subdivision Engineering and the Land Development industry. I have extensive knowledge in the design, construction and delivery of large-scale land development projects. My experience includes major roles on some of New Zealand's largest subdivision projects including Stonefields, Long Bay, Millwater and Milldale.

I confirm that, in my capacity as reviewer and approver of this report, I have read and abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

1. Background

This memorandum has been prepared by Woods on behalf of Fulton Hogan Land Development Limited (FHLD) in support of the substantive application for the Milldale Stages 14–17 Project under the Fast-track Approvals Act 2024 (FTAA).

The memorandum presents the consent-level stormwater design for the approximately 231 ha Development Area, with a particular focus on the contributing catchments, primary network interfaces and proposed communal stormwater-management devices. It should be read alongside the Stormwater Assessment – Milldale Stages 14-17, the associated flood modelling results, and the supporting application drawings.

2. Stormwater Design Strategy and Requirements

2.1. Stormwater Management Framework

The Wainui East Stormwater Management Plan, Version 4, dated 2016 and prepared by Woods (the Wainui East SMP V4), was developed for the wider Wainui East Future Urban Zone. However, it has been adopted by Auckland Council Healthy Waters only for the live-zoned Wainui Precinct, comprising the existing Milldale development.

The Milldale Stages 14–17 Development Area remains predominantly zoned Future Urban. It is therefore outside the area for which the Wainui East SMP V4 has been adopted and is not presently covered by the existing regional Network Discharge Consent stormwater-discharge framework.

The Stormwater Assessment – Milldale Stages 14-17 has been prepared in support of the substantive application. That assessment applies the catchment-wide stormwater-management framework, modelling and design approach developed through the Milldale North and Wainui West Stormwater Management Plan, Version 7 to the proposed development. It also supports the project-specific stormwater diversion and discharge permit sought through the application.

This memorandum provides the supporting design detail for the stormwater catchments, communal devices and network interfaces serving Stages 14–17, consistent with the Stormwater Assessment and the technical framework established by the Milldale North and Wainui West SMP V7.

2.2. Design Rainfall and Storm Event Parameters

The rainfall depths adopted for the Milldale Stages 14–17 stormwater design are based on the TP108 rainfall depths for the site, adjusted in accordance with the current Auckland Council Stormwater Code of Practice Version 4 (SWCoP V4) for the 3.8°C increase climate change scenario.

The adopted rainfall depths are summarised below in Table 1.

Milldale Design Rainfall Depth (mm)		
ARI	Rainfall	SWCoP V4 (3.8°C)
1-year	71.8	91.5
2-year	88	112.1
5-year	120	155.5
10-year	145	189.6
100-year	225	298.6

Table 1 – Milldale Design Rainfall Depths

The stormwater management devices are to be designed to the 95th percentile event. This event is defined as a 37mm, 24-hr rainfall event.

2.3. Stormwater Management

The proposed stormwater design applies an integrated, water-sensitive approach comprising:

- Water-quality treatment for runoff from all applicable impervious areas to the relevant GD01/TP10 treatment levels;
- Retention and detention at source, principally through dedicated storage within private roof-water tanks;
- Detention within communal stormwater-management devices where required by the applicable stormwater-management framework;
- Controlled stream recharge to support retained and realigned streams; and
- Safe conveyance of larger storm events through the primary and secondary stormwater networks.

Runoff from roads, JOALs and other public and private hardstand areas will be directed through the applicable communal stormwater-management devices. Roof runoff will be managed using inert roofing materials and private reuse tanks providing at least 5 mm of retention, together with detention storage. The detention component of the private tanks delays the discharge of roof runoff, such that these flows reach the downstream communal devices after the peak of the storm event.

Where detention applies, it will manage the difference between the applicable pre-development and post-development runoff volumes from the 95th-percentile rainfall event, with discharge occurring over a 24-hour drawdown period. Flows exceeding the applicable treatment and detention thresholds will be passed forward through the primary network, overland flow paths and receiving watercourses.

The primary network and communal devices have been sized at consent level for the ultimate development catchments. Final device details, private roof-water tanks and localised superlot reticulation will be confirmed through the applicable Engineering Approval and building-consent processes.

3. Proposed Stormwater Management Strategy

The proposed stormwater strategy builds on the systems implemented through earlier Milldale stages and the wider SMP framework. The Stormwater Assessment applies the updated Milldale North and Wainui West SMP V7 approach to Stages 14–17 and establishes the relevant water-quality, hydrology-mitigation and flood-management requirements.

The proposed treatment strategy comprises:

- Constructed wetlands serving the larger downstream catchments;
- Communal bioretention devices serving isolated or constrained catchments;
- Stream-recharge devices supporting selected retained or realigned streams;
- Private roof-water reuse tanks providing at-source retention and detention; and
- The primary stormwater network conveying flows from events up to the 10% AEP event; and
- The secondary stormwater network conveying excess runoff from larger events up to the 1% AEP event.

Constructed wetlands were the preferred communal device throughout the design-development process. However, their land and sizing requirements meant that communal bioretention devices provided a more practical solution for two isolated catchments while achieving the required stormwater-management outcomes.

The stream-recharge devices consolidate the management of road runoff within larger communal devices at the heads of selected streams. This is consistent with Auckland Transport's preference for integrated devices rather than numerous individual kerbside raingardens.

The detailed catchment allocation, device sizing and discharge arrangements are described in Sections 5 and 7.

4. Stormwater Management Options Assessment

4.1. Constructed Wetlands

Constructed wetlands were the preferred communal device throughout the design-development process and are proposed for the larger downstream catchments. They allow water-quality treatment and hydrology mitigation to be consolidated within devices integrated with the proposed drainage reserves and receiving watercourses.

GD01 Compliance: The wetlands will be designed in accordance with the applicable GD01 requirements for constructed wetland devices.

Treatment: The wetlands will provide water-quality treatment for runoff from roads, JOALs and other public and private hardstand areas. They will also provide detention in accordance with the applicable stormwater-management requirements. Roof runoff will first be managed through private roof-water tanks, with controlled discharges and overflows subsequently conveyed through the downstream stormwater network and wetlands. Larger storm events will bypass or pass through the devices using appropriately designed inlet, outlet and overflow arrangements.

Construction Costs: High – Constructed wetlands require a comparatively large land area, formation of permanent-water and live-storage areas, inlet and outlet structures, planting and maintenance access. Where wetlands can be accommodated within drainage reserves, the impact on developable land is reduced.

Maintenance Costs: Moderate – Routine maintenance will principally involve planting and weed management, removal of litter and sediment, and inspection and maintenance of the inlet and outlet structures. Longer-term sediment removal may require machinery access.

Safety in Design: The permanent water and live-storage areas introduce a potential drowning hazard. Detailed design will incorporate appropriate safety benching, batter slopes, planting, access controls and fencing where required. Safe access to the inlet, outlet and maintenance areas will also be provided.

Summary: Constructed wetlands provide an efficient catchment-scale solution for the larger catchments and offer water-quality, hydrology, landscape and ecological benefits. They are the preferred device where sufficient land and hydraulic head are available.

4.2. Communal Bioretention and Stream Re-Charge Devices

The communal bioretention and stream-recharge devices are consolidated bioretention systems serving combined catchments. This approach provides a practical means of treating and mitigating runoff while avoiding the servicing and maintenance implications associated with numerous individual treatment devices within the road corridor.

The stream-recharge devices are sized for road-reserve catchments and are proposed as Auckland Transport assets. The communal bioretention devices serve isolated catchments where the land and sizing requirements associated with a constructed wetland make a wetland less practical.

GD01 Compliance: The devices will be designed in accordance with GD01 and, where applicable, the Auckland Transport Bioretention Design Guide.

Treatment: The devices will provide water-quality treatment and applicable hydrology mitigation through filtration, temporary storage and evapotranspiration. The stream-recharge devices will also provide controlled discharge to the upper reaches of retained or realigned streams. The design will not rely on infiltration unless suitable ground conditions are confirmed through detailed design.

Construction Costs: Moderate – The construction requirements are generally similar to those for conventional raingardens, including excavation, drainage, filter media, planting and inlet and outlet structures. Consolidating several road catchments into larger communal devices reduces the number of individual devices and associated service conflicts.

Maintenance Costs: Moderate – Maintenance will include litter and sediment removal, weed and planting management, inspection of inlet and outlet structures and periodic replacement of filter media. Although the devices require more maintenance than a detention-only basin, consolidating them into a smaller number of communal assets reduces the servicing, traffic-management and maintenance implications associated with numerous kerbside raingardens.

Safety in Design: The devices are relatively shallow compared with wetlands and conventional drainage structures. Routine inspections and surface maintenance can generally be undertaken without entering confined spaces. Detailed design will address safe maintenance access, batter slopes, maximum ponding depths and temporary traffic-management requirements.

Summary: Communal bioretention and stream-recharge devices provide the treatment performance of raingardens while allowing stormwater management to be delivered across larger, consolidated catchments. They are appropriate for the road-only stream-recharge catchments and for isolated catchments where constructed wetlands are not practical.

4.3. Private Roof-Water Reuse Tanks

Private roof-water reuse tanks are proposed for each residential DUE, including future dwellings within the residential superlots. They provide at-source management of roof runoff and support the integrated treatment approach established by the Milldale North and Wainui West SMP V7 and Stormwater Assessment.

GD01 Compliance: Rainwater reuse systems are consistent with the water-sensitive design principles of GD01, although the detailed design and maintenance requirements for individual tanks are not specifically addressed by GD01.

Treatment: Each tank will provide dedicated reuse storage equivalent to at least 5 mm of runoff from the contributing roof area. The retained water will be available for non-potable uses such as toilet flushing and gardening. Roofs will be constructed using inert materials that do not generate contaminants of concern.

Construction Costs: Moderate – The tanks and associated private reticulation will be installed as part of the building development. The cost is distributed across the individual dwellings rather than requiring a separate communal land area.

Maintenance Costs: Low – Routine maintenance will generally involve inspection and cleaning of the tank, screens, filters, pumps and associated pipework.

Safety in Design: Routine inspection and maintenance should be capable of being undertaken from the surface. The tank design should avoid the need for entry wherever practicable, as any entry would involve confined-space hazards.

Summary: Private roof-water tanks provide the required at-source retention and non-potable reuse without requiring additional communal land. Final tank sizing and design will be confirmed through the relevant building-consent process.

4.4. Other Treatment Devices

A range of stormwater-management devices has been considered against the applicable GD01 requirements and the strategy established through the Milldale North and Wainui West SMP V7 and the Stormwater Assessment – Milldale Stages 14-17. This assessment is summarised below in Table 3.

Treatment Device	Achieve GD01/ SMP Requirements	Shortlisted	Comments
Constructed wetlands	✓	✓	Preferred communal device for the larger downstream catchments. Wetlands provide water-quality treatment and detention where required and are proposed where sufficient land and hydraulic head are available.
Communal bioretention devices	✓	✓	Consolidated bioretention systems serving combined catchments. These are proposed for isolated catchments where the land area or sizing requirements associated with a wetland make a wetland less practical.
Stream-recharge devices	✓	✓	Consolidated bioretention systems serving combined road-reserve catchments. These devices provide treatment, applicable hydrology mitigation and controlled discharge to retained or realigned stream heads. They are proposed as Auckland Transport assets.
Private roof-water reuse tanks	✓	✓	Proposed for residential roof catchments as part of the integrated treatment approach. The tanks provide at-source retention and non-potable reuse, with final design confirmed via the building-consent process.
Individual kerbside raingardens	✓	✗	Capable of providing the required treatment and hydrology mitigation. However, numerous individual devices would create servicing, maintenance and road-corridor constraints. Larger communal devices are preferred, consistent with Auckland Transport's preference for integrated devices.
Individual Offline raingardens	✓	✗	Capable of providing treatment and detention but generally require a similar land area to communal bioretention devices or wetlands. They have not been selected as a separate device type because these func-tions are provided by the proposed communal devices.
Dry basins	✗	✗	Provide detention but not the water-quality treatment required for runoff from all applicable impervious areas. Additional upstream treatment would be required, making them less suitable than the proposed wetlands and bioretention devices.
Underground detention tanks	✗	✗	Can provide detention where land is constrained but do not provide water-quality, ecological or landscape benefits. They also introduce confined-space inspection and maintenance requirements.
Wet ponds	✗	✗	Not preferred due to water-temperature, permanent-water and safety considerations. Constructed wetlands provide a more appropriate treatment solution for the proposed catchments.
Swales	✗	✗	Swales can provide conveyance and some pre-treatment but do not provide the complete treatment and detention functions required without bespoke designs. They may be used as supplementary network elements where appropriate.

Table 3 – Summary of Treatment Devices Considered

5. Stormwater Design Discussion

5.1. Natural Watercourses

Stages 14 to 17 discharges to several watercourses:

Stage 14:

- Stream 4 via piped stormwater reticulation network and stormwater recharge devices.
- Stream 7 via piped stormwater reticulation network and stormwater recharge devices.
- Stream 8 via piped stormwater reticulation network and stormwater recharge devices.
- Orewa Awa via piped stormwater reticulation network and wetlands.

Stage 15:

- Stream 4 via piped stormwater reticulation network and stormwater recharge devices.
- Stream 7 via piped stormwater reticulation network and stormwater recharge devices.
- Orewa Awa via piped stormwater reticulation network and wetlands.

Stage 16:

- Stream 10 via piped stormwater reticulation network and stormwater recharge devices.
- Waterloo Creek via piped stormwater reticulation network, wetlands and communal bioretention devices.

Stage 17:

- Waterloo Creek via piped stormwater reticulation network and communal bioretention devices.
- Watercourse P3 via piped stormwater reticulation network and communal bioretention devices.

5.2. Private Lots

5.2.1. Residential lots

Roof runoff from the residential lots and future residential superlot dwellings will be managed through private roof-water tanks. Each tank will provide dedicated reuse storage equivalent to at least 5 mm of runoff from the contributing roof area and, where required, separate detention storage with controlled discharge over a 24-hour period. Controlled discharges and overflows will connect to the downstream public stormwater network and may pass through the applicable communal stormwater-management device. Final tank sizing and private reticulation will be confirmed through the relevant building-consent process.

Runoff from private hardstand areas and JOALs will be conveyed through the public network to the applicable constructed wetland or communal bioretention device for treatment and hydrology mitigation.

The primary network and communal devices have been sized at consent level to accommodate the anticipated ultimate development of the residential superlots.

5.2.2. Te Korowai o Maraeriki

Te Korowai o Maraeriki is the land north of the Orewa Awa and is predominantly proposed to remain as a permeable catchment with replanting of the portions of pasture proposed or currently already being undertaken. There is also wetland and stream rehabilitation proposed in this portion of the site. No further stormwater devices are required to mitigate these works.

Within the Te Korowai o Maraeriki lot it is proposed to construct the potable water and wastewater treatment plants. The combined area of these plants is approximately 2.4 ha of which approximately 50% will be impermeable surface, with the balance being permeable landscaping.

A private bioretention device is proposed to provide water quality treatment and stormwater detention to the flows from this impervious area prior to release to the Orewa Awa. Allowance for this device has been made on the treatment plant site layout plans. The sizing and details of the device will be confirmed as part of the detailed design phase of the treatment plants.

5.3. Road Reserve, Lot Hardstand and JOAL Detention

Apart from roof runoff which will be treated at source, treatment devices are required to provide detention for the Road Reserve, lot hardstand and JOAL runoff.

Detention requirements will be sized as agreed with Healthy Waters and in line with Section 2.3 above.

5.4. Stormwater Catchments

The stormwater drainage network in Stages 14 to 17 splits the stages into 11 stormwater catchments. Refer to drawings P24-128-00-3010-DR to 3013-DR which is included as part of Appendix A.

5.5. Wetlands

Six constructed wetlands are proposed to provide water-quality treatment and detention for the applicable Stages 14–17 catchments.

The wetlands have been designed as broad, planted devices with a permanent-water depth of up to 1.5 m, a live-storage depth of up to 0.8 m and a minimum freeboard allowance of 400 mm.

Runoff from the upstream piped networks will pass through a gross pollutant trap, forebay or similar inlet treatment feature before entering the principal wetland area. The final inlet arrangement will be confirmed through the Engineering Approval process.

The wetlands will receive runoff from their contributing road, JOAL and private hardstand catchments. Roof runoff will be managed at source through private roof-water tanks, with controlled discharges subsequently conveyed through the public stormwater network and applicable wetland. The detention provided within the tanks delays the arrival of these flows, such that they pass through the wetlands after the peak of the storm event. The wetland treatment and live-storage volumes have been sized for their contributing hardstand catchments, including any offset storage confirmed by the calculations in Appendix B.

As the wetlands are integrated with the stormwater drainage network, the 10% AEP primary-network flows will be safely conveyed through or around each device. Where practicable, a high-flow bypass will be provided to limit the volume and velocity of larger storm flows passing through the principal wetland area. Established planting will also assist in reducing velocities and protecting the wetland surfaces from erosion.

An outlet structure will be constructed within each wetland and will generally comprise a controlled low-flow outlet and an overflow structure. The current consent-level design provides for an orifice outlet and scruffy-dome overflow. Final outlet sizing, overflow arrangements and associated erosion protection will be confirmed through Engineering Approval.

Water stored above the permanent-water level will drain through the controlled outlet. Water velocities are expected to reduce as the wetland drains, while established planting will assist in limiting the movement of debris and sediment towards the outlet structure.

The wetlands are anticipated to be unlined, subject to confirmation through geotechnical assessment and detailed design. They will be heavily planted to support treatment performance and discourage uncontrolled public access. Plant species will be selected to tolerate the anticipated permanent and intermittent wet conditions. The current design allows for a nominal 300 mm depth of suitable topsoil to support the wetland planting, subject to confirmation through detailed landscape and wetland design.

The wetlands will generally be located within or adjacent to drainage reserves and receiving watercourses. The wetland embankments and surrounding ground levels will be designed to prevent external 10% AEP and 1% AEP flood flows from entering the permanent-water and live-storage areas.

Safety measures, including benching, batter slopes, perimeter planting and fencing where required, are addressed in Appendix C.

5.6. Communal Bioretention and Stream Re-Charge Devices

The proposed design includes:

- Three stream-recharge devices serving the Streams 4 and 7 (combined device), Stream 8 and Stream 10 catchments; and
- Two communal bioretention devices, identified as Devices F and G.

These devices are consolidated bioretention systems operating on the same general principles as large raingardens. They provide a practical means of treating and mitigating runoff from larger combined catchments while avoiding the servicing and maintenance implications associated with numerous individual roadside raingardens.

The stream-recharge devices will receive runoff from their contributing road-reserve catchments and are proposed as Auckland Transport assets. They will provide water-quality treatment, applicable hydrology mitigation and controlled discharge to the upper reaches of the relevant retained or realigned streams.

Communal Bioretention Devices F and G will serve the applicable road, JOAL and private hardstand catchments before discharging to Waterloo Creek. These devices are proposed in isolated catchments where the land area and sizing requirements associated with a constructed wetland made a wetland less practical.

Each device will generally comprise an inlet arrangement, temporary surface storage, bioretention filter media, underdrainage, a controlled outlet and provision for larger flows to bypass or overflow the treatment area. The devices will provide the required water-quality treatment and detention volumes identified in Section 5.4 and Appendix B.

The consent-level design does not rely on infiltration into the underlying ground. Any contribution from infiltration will only be relied upon where suitable ground conditions are confirmed through geotechnical assessment and detailed design.

Final device dimensions, media specifications, inlet and outlet arrangements, flow controls, bypass provisions, planting, maintenance access, erosion protection and asset-ownership requirements will be confirmed through the Engineering Approval process. The detailed design will also address safe access and temporary ponding within and around the devices.

6. Operations & Maintenance Requirements

The maintenance of the proposed stormwater systems will need to be considered as a key aspect of the design, ensuring that the design considers the full design life of the system. The below section discusses the expected required maintenance of the key aspects of the stormwater system.

6.1. Pipe Network

The proposed stormwater network will have a 100-year design life in accordance the Auckland Council Stormwater Code of Practice. Very little maintenance is expected to be required to the pipe network during this time.

The stormwater network will utilise sumps on the proposed catchpits and these will require regular cleaning to remove sediment build-up. It is anticipated that this be done twice per year, but may vary.

6.2. Wetlands

Maintenance of the constructed wetlands will include:

- Inspection of inlet, outlet and overflow structures;
- Removal of litter and accumulated sediment from inlet pre-treatment components, including any GPT (gross pollutant trap) and the wetland forebay;
- Management of weeds and wetland planting;
- Inspection of embankments, batters and access arrangements; and
- Repair of erosion, planting or structural defects where required.

Routine planting maintenance and surface inspections will generally be undertaken on foot. However, maintenance access will also allow for machinery where longer-term sediment removal or repair of inlet and outlet structures is required.

Final inspection frequencies, sediment-removal triggers and vegetation-management requirements will be established through the operation and maintenance documentation. Wetland batters will generally be no steeper than 1V:3H where pedestrian maintenance access is required.

6.3. Bioretention Devices

The communal bioretention and stream-recharge devices will require regular maintenance to maintain their hydraulic performance, treatment function and landscape quality.

Maintenance will generally include:

- Removal of litter, debris and accumulated sediment;
- Management of weeds and planting;
- Inspection of inlet, outlet, overflow and underdrain components;
- Inspection and cleaning of any GPTs or other upstream inlet pre-treatment components;
- Monitoring of surface ponding and drawdown performance; and
- Partial or full replacement of filter media where declining hydraulic or treatment performance is identified.

During earthworks and construction, sediment-laden runoff must be prevented from entering the devices. Filter socks or equivalent protection should remain over device inlets until construction within the contributing catchment is complete and the catchment has been stabilised.

The maintenance and asset-ownership arrangements for the stream-recharge devices will be coordinated with Auckland Transport through the Engineering Approval and vesting processes. The operation and maintenance requirements for the communal bioretention devices will similarly be confirmed through Engineering Approval.

6.4. Private Roof-Water Reuse Tanks

The private roof-water reuse tanks will remain privately owned and maintained.

- Routine maintenance will generally include:
- Inspection and cleaning of inlet screens and filters;

- Inspection of pumps and reuse pipework;
- Checking overflow arrangements and connections to the public network; and
- Removal of accumulated sediment where required.

Final operation and maintenance requirements will be established through the relevant building-consent documentation. Tank arrangements should avoid the need for confined-space entry wherever practicable.

7. Proposed Treatment Devices

This section summarises the proposed stormwater-management device for each principal catchment. The contributing areas and required and provided treatment and detention capacities are based on the consent-level design and are supported by the calculations in Appendix B.

Where surplus detention storage within one communal device is relied upon to offset a shortfall in another catchment, this is identified in the relevant device subsection. Final device dimensions, contributing flow splits, outlet controls and storage volumes will be confirmed through the Engineering Approval process.

7.1. Wetland A

Wetland A Catchment

- Catchment Area – Road and Lots: 84,900 m^2
- Required water quality treatment volume: 457 m^3
- Required detention volume: 869 m^3

Wetland A is proposed north of Wainui Road, northeast of its intersection with Gervin Road, and will discharge to the Orewa Awa. The current design provides approximately 538 m^3 of water-quality treatment volume and 1,117 m^3 of detention storage.

The sizing of this device results surplus detention storage which may be used at detailed design through catchment adjustment to optimise the developments stormwater device designs.

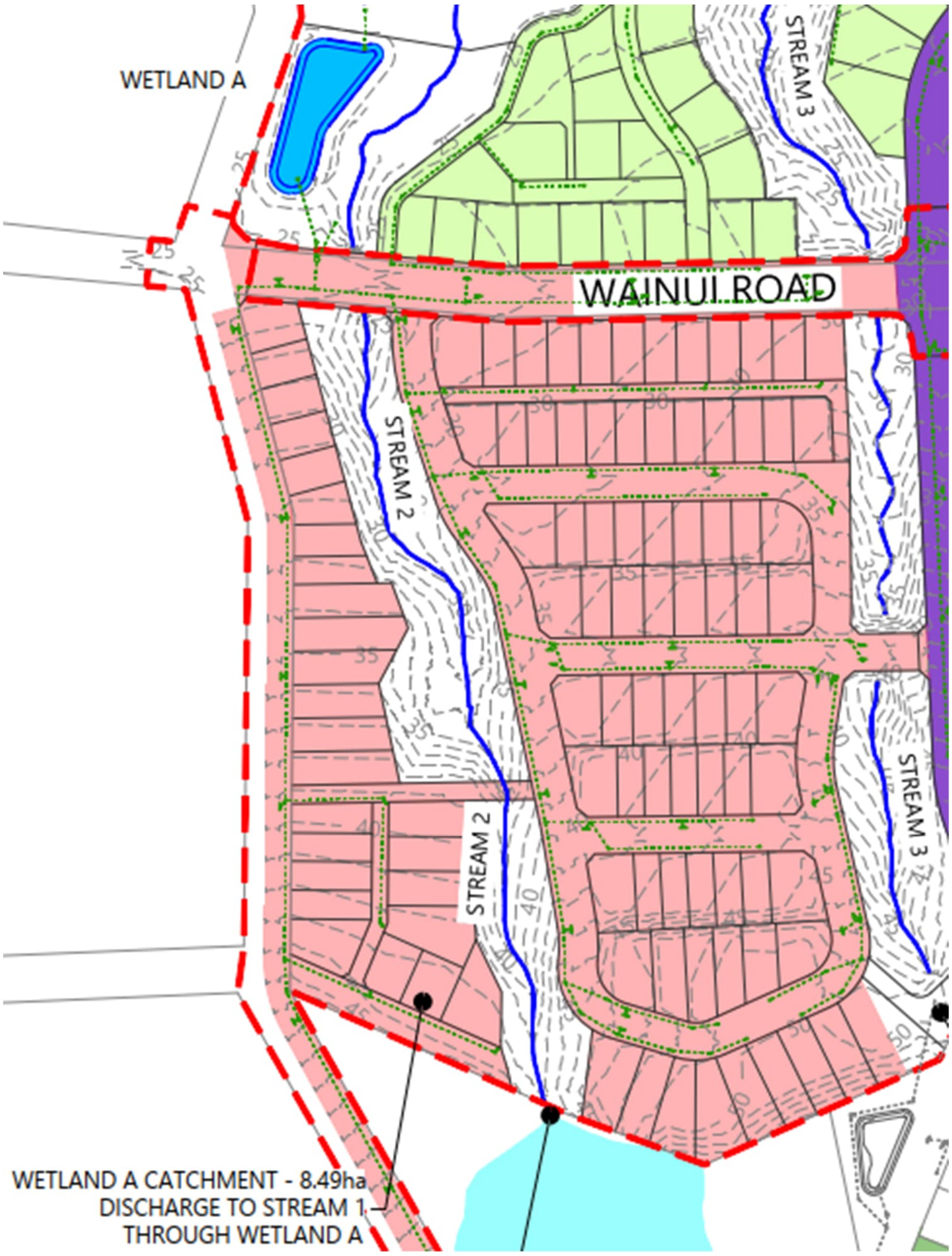

Image 1: Wetland A Catchment - Red

7.2. Wetland B

Wetland B Catchment

- Catchment Area – Road and Lots: 152,200 m^2
- Required water quality treatment volume: 688 m^3
- Required detention volume: 1257 m^3

Wetland B is proposed beside the northern Stream Edge Road, adjacent to the Orewa Awa. The current design provides approximately 700 m^3 of water-quality treatment volume and 1,277 m^3 of detention storage.

The sizing of this device results surplus detention storage which may be used at detailed design through catchment adjustment to optimise the developments stormwater device designs.

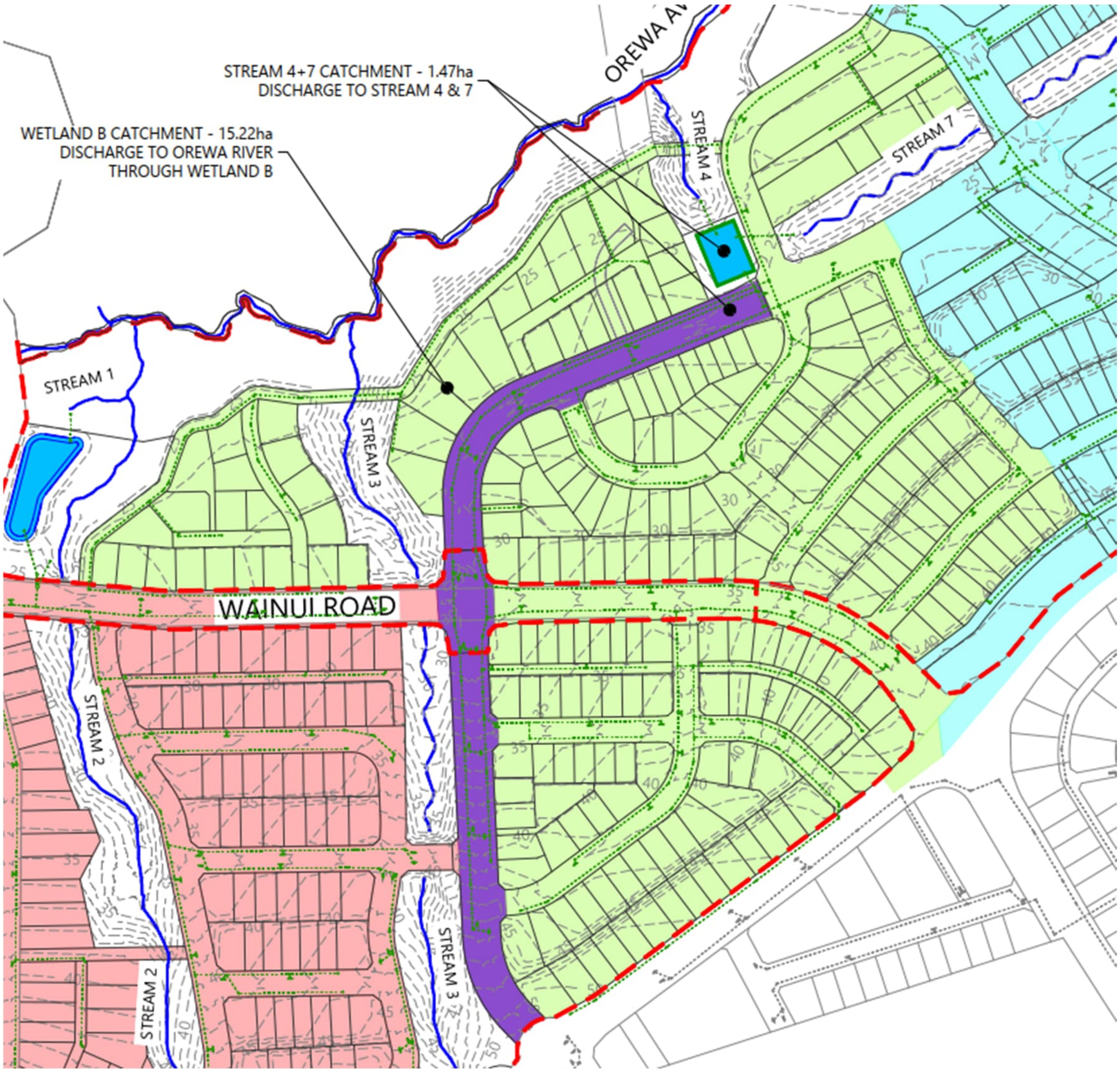

Image 2: Wetland B Catchment - Green

7.3. Streams 4 and 7 recharge bioretention device

Streams 4+7 Catchments (through Stormwater Recharge Device)

- Catchment Area – Roads: 14,700 m^2
- Required detention volume: 282 m^3

A stream-recharge device is proposed beside the Stream Edge Collector Road at the head of Stream 4. The device will provide the required water-quality treatment capacity and approximately 283 m³ of detention storage before discharging to both Streams 4 and 7.

The final distribution of controlled discharge between Streams 4 and 7 will be confirmed through the Engineering Approval process

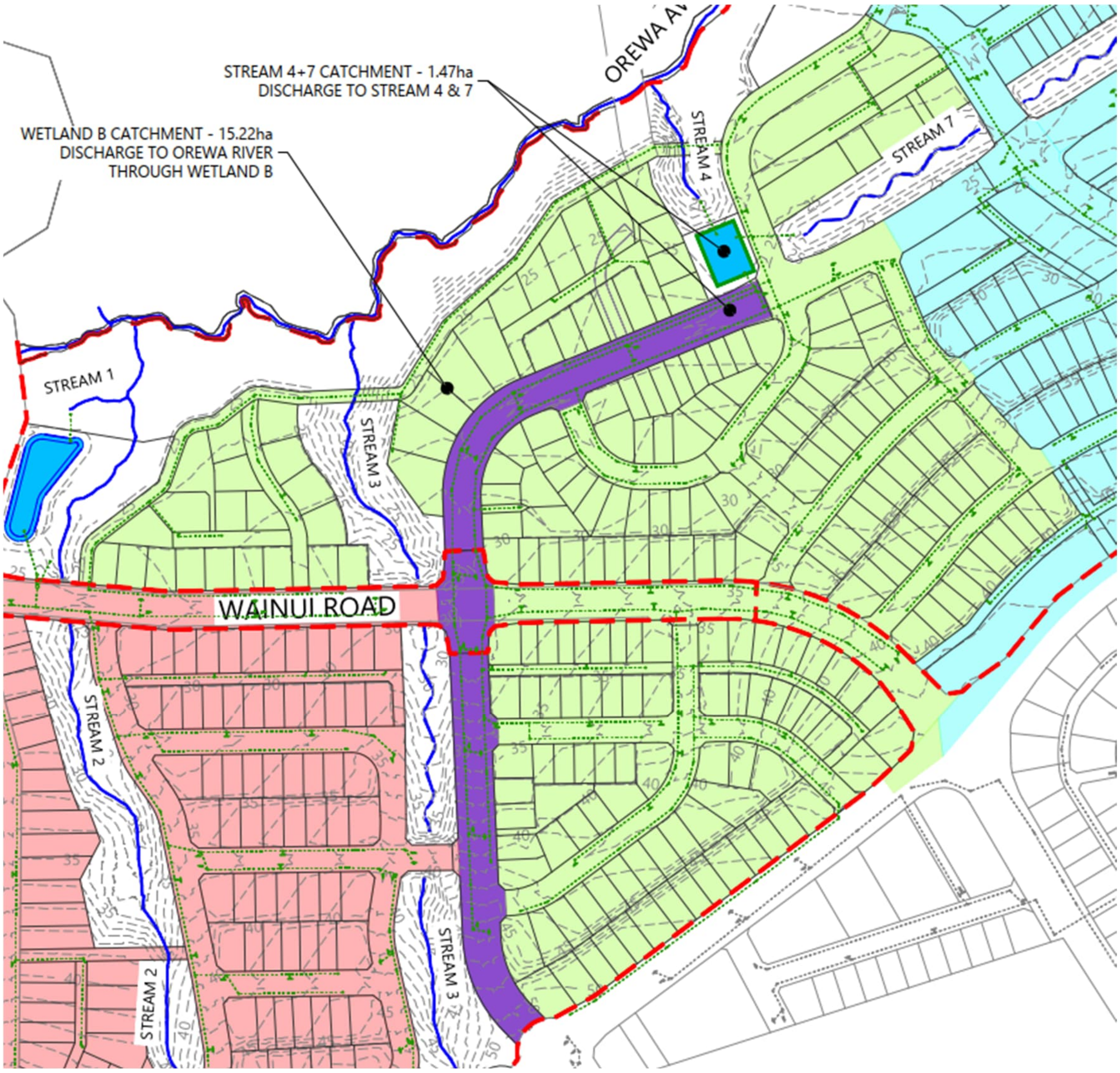

Image 3: Streams 4 & 7 Catchment – Dark Purple

7.4. Wetland C

Wetland C Catchment

- o Catchment Area – Road and Lots: 325,300 m^2
- o Required water quality treatment volume: 1,745 m^3
- o Required detention volume: 3,315 m^3

Wetland C is proposed beside the northern Stream Edge Road, adjacent to the Orewa Awa. The current design provides approximately 1,787 m^3 of water-quality treatment volume and 3,336 m^3 of detention storage.

The wetland is adequately sized for its current catchment.

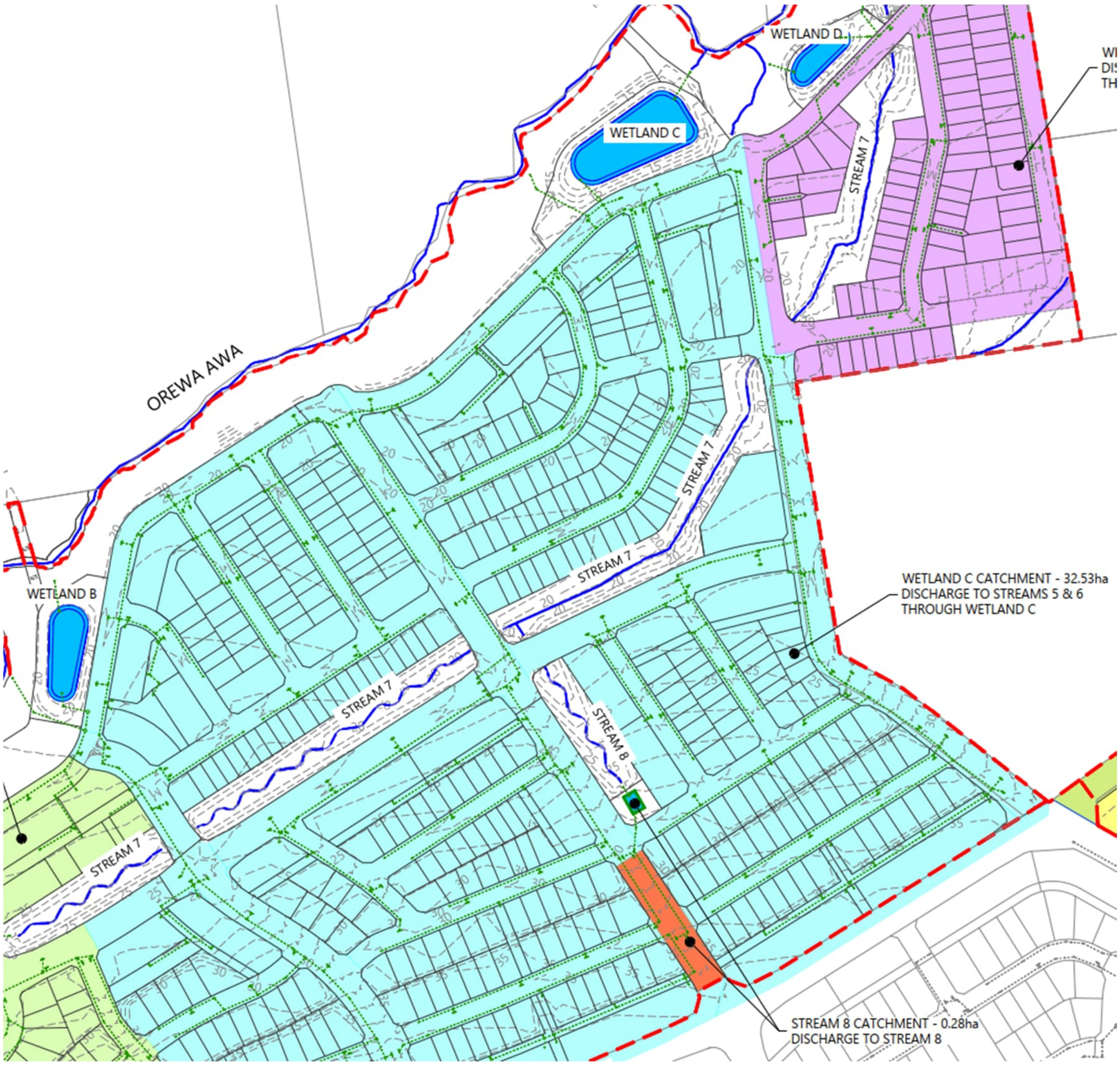

Image 4: Wetland C Catchment – Light Blue

7.5. Stream 8 recharge bioretention device

Stream 8 Catchment (through Stormwater Recharge Device)

- o Catchment Area – Roads: 2,800 m^2
- o Required detention volume: 53 m^3

A stream-recharge device is proposed beside the Collector Road at the head of Stream 8 – which is adequately sized to provide the required water-quality treatment capacity and detention storage.

Image 5: Stream 8 Catchment - Orange

7.6. Wetland D

Wetland D Catchment

- o Catchment Area – Road and Lots: 47,700 m^2
- o Required water quality treatment volume: 247 m^3
- o Required detention volume: 467 m^3

Wetland D is proposed beside the eastern part of the northern Stream Edge Road, adjacent to the Orewa Awa. The current design provides approximately 316 m^3 of water-quality treatment volume and 595 m^3 of detention storage.

The sizing of this device results surplus detention storage which may be used at detailed design through catchment adjustment to optimise the developments stormwater device designs.

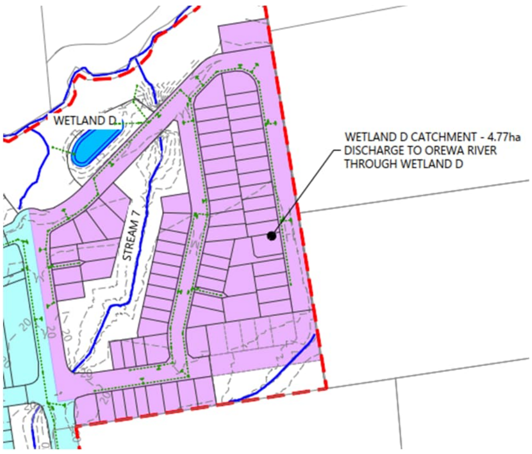

Image 6: Wetland D Catchment – Light Purple

7.7. Wetland E

The Wetland E catchment requires approximately 327.6 m³ of water-quality treatment volume and 603.1 m³ of detention storage.

Wetland E Catchment

- o Catchment Area – Road and Lots: 70,200m^2
- o Required water quality treatment volume: 328 m^3
- o Required detention volume: 603 m^3

Wetland E is proposed along the eastern edge of Stage 16, adjacent to Waterloo Creek. The current design provides approximately 339 m³ of water-quality treatment volume and 622 m³ of detention storage before discharging to Waterloo Creek.

The sizing of this device results surplus detention storage that may be used to offset a shortfall within another contributing catchment.

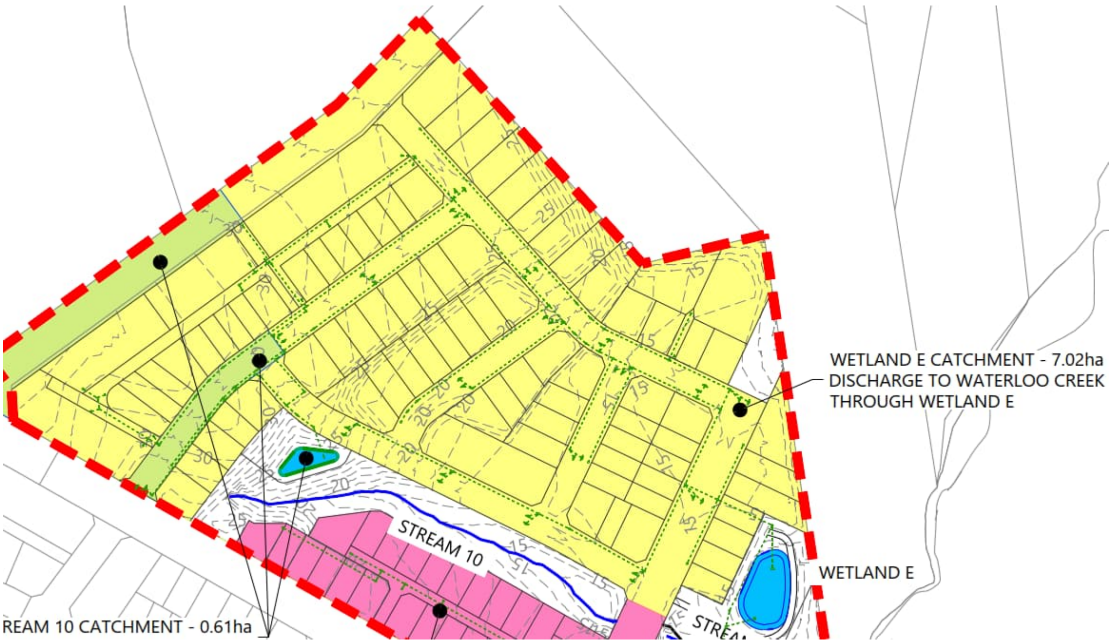

Image 7: Wetland E Catchment - Yellow

7.8. Stream 10 recharge bioretention device

Stream 10 Catchment (through Stormwater Recharge Device)

- Catchment Area – Roads: 6100 m^2
- Required detention volume: 116 m^3

A stream-recharge device is proposed beside the Stage 16 Stream Edge Road at the head of Stream 10. The device will provide the required water-quality treatment capacity and detention storage before discharging to Stream 10.

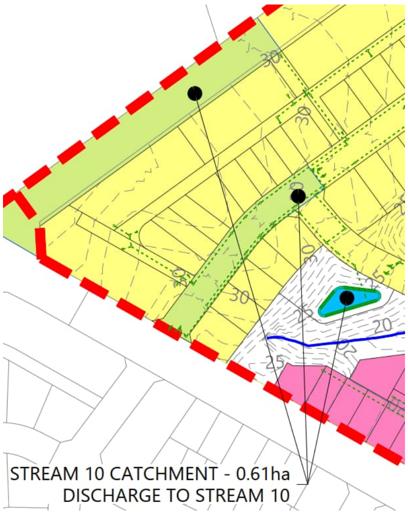

Image 8: Stream 10 Catchment – Lime Green

7.9. Communal Bioretention Device F

Bioretention Device Catchment F

- Catchment Area – Road and Lots: 14,500 m^2
- Required detention volume: 105 m^3

Communal Bioretention Device F is proposed north of Endsley Rise, southwest of the confluence of Stream 10 and Waterloo Creek. The device will provide the required water-quality treatment capacity and detention storage before discharging to Waterloo Creek.

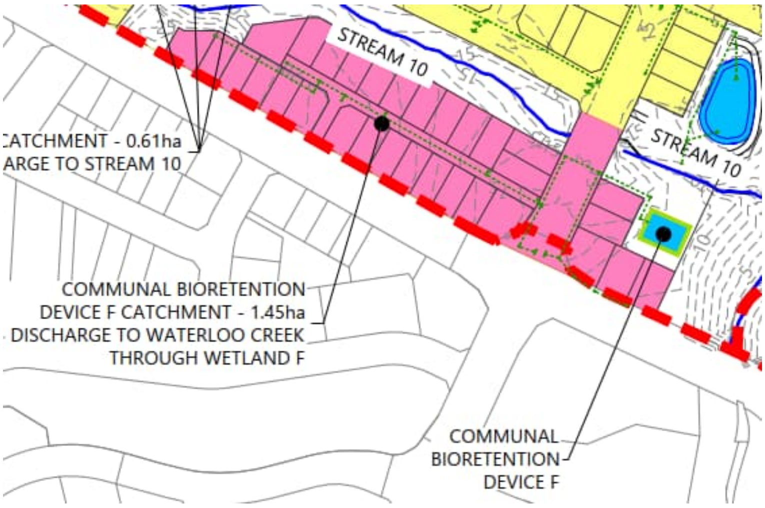

Image 9: Bioretention Device F Catchment – Pink

7.10. Communal Bioretention Device G

Bioretention Device Catchment G

- o Catchment Area – Road and Lots: 23,200 m^2
- o Required detention volume: 175m^3

Communal Bioretention Device G is proposed north of Endsley Rise, east of Waterloo Creek. The device will provide the required water-quality treatment capacity and approximately 193 m³ of detention storage before discharging to Waterloo Creek.

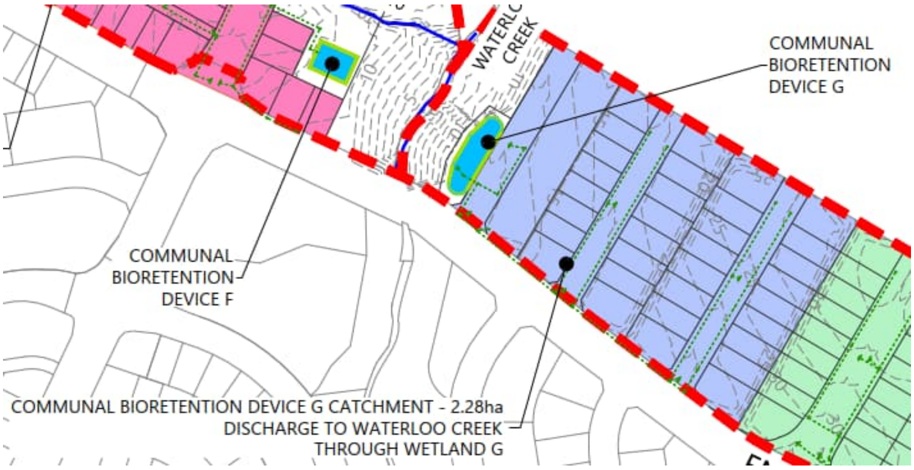

Image 10: Bioretention Device G Catchment – Blue

7.11. Wetland H

Wetland H Catchment

- o Catchment Area – Road and Lots: 40,500m^2
- o Required water quality treatment volume: 164m^3
- o Required detention volume: 290 m^3

Wetland H is proposed north of Endsley Rise, adjacent to Permanent Watercourse P3. The current design provides approximately 173 m³ of water-quality treatment volume and 368 m³ of detention storage.

Image 11: Wetland H – Green

8. Conclusion

The proposed stormwater design adopts an integrated, catchment-based approach informed by the stormwater systems implemented through earlier Milldale stages, the wider Wainui East SMP framework and the Stormwater Assessment – Milldale Stages 14-17.

The proposed stormwater-management approach comprises:

- Private roof-water reuse tanks providing at-source retention and non-potable reuse;
- Constructed wetlands providing water-quality treatment and detention for the larger downstream catchments;
- Communal bioretention devices providing treatment and hydrology mitigation for isolated catchments where constructed wetlands are less practical;
- Stream-recharge devices providing treatment, applicable hydrology mitigation and controlled discharge to selected retained or realigned streams;
- The primary stormwater network conveying flows from events up to the 10% AEP event; and
- The secondary stormwater network conveying excess runoff from larger events up to the 1% AEP event.

The consent-level design is consistent with the stormwater-management framework established through the Milldale North and Wainui West SMP V7 and applied to the proposed development through the Stormwater Assessment – Milldale Stages 14-17. The proposed approach provides water-quality treatment for runoff from all applicable impervious areas, retention of roof runoff at source, detention where required and safe discharge to the receiving watercourses.

The communal devices and principal stormwater networks have been sized at consent level for their anticipated ultimate contributing catchments, including the future development of the residential superlots. The supporting catchment calculations demonstrate the required water-quality treatment and detention capacity for each proposed device, subject to the outstanding checks and refinements identified in this memorandum.

Final device dimensions, network alignments, contributing flow splits, outlet controls, bypass arrangements, planting, maintenance access and asset-ownership requirements will be confirmed through the applicable Engineering Approval process. Private roof-water tanks and internal property drainage will be confirmed through the relevant building-consent and building-development processes.

Appendix A: Drawings (bound separately)

Appendix B: Wetland and Bioretention Device Catchment Calculations

Wetland Design Calculations

MDL North Fast Track - Wetland A

Catchment info

Total Road Catchment area	36057	m^2
Impermeable Road Percentage (%)	0.8	
Impermeable Road Catchment Area (m2)	28845.6	m^2
Permeable Road Catchment Area (m2)	7211.4	m^2
Total Lot Catchment area	48874	m^2
Impermeable Lot Hardstand Percentage (%)	0.15	
Impermeable Lot Roof Percentage (%)	0.55	
Impermeable Lot Hardstand Catchment Area (m2)	7331.1	m^2
Impermeable Lot Roof Catchment Area (m2)	26880.7	m^2
Permeable Lot Catchment Area (m2)	14662.2	m^2
Total Impermeable Catchment Area excl. Roofs (m2)	36176.7	m^2
Total Permeable Catchment Area (m2)	21873.6	m^2
TP-108 parameters		
Impermeable Surface CN:	98	
Permeable Surface CN:	74	
Water Quality Flow Composite Catchment CN	88.96	
Catchment Length	2.0	km
Catchment Slope	0.01	m/m
Channelisation, C	0.60	
Tc	0.62	hrs
Impermeable Soil Storage (S)	5.18	
Permeable Soil Storage (S)	89.24	
Impermeable Initial Abstraction (Ia)	0.00	mm
Permeable Initial Abstraction (Ia)	5.00	mm

Wetland Design Calculations

MDL North Fast Track - Wetland A

Water Quality Design Storm (90%AEP, 24hr)		
Rainfall Depth	26.5	mm
Impermeable Catchment Runoff Depth	22.16	mm
Permeable Catchment Runoff Depth	4.17	mm
Impermeable Catchment Runoff Volume	801.84	m3
Permeable Catchment Runoff Volume	91.30	m3
Total Water Quality Event Runoff Volume	893.14	m3
Wetland Permanent Water Volume*	446.57	m3
**PWV halved due to provision of live storage*		
Required Wetland Area Footprint	893.14	m2
Required Maintenance Area Footprint (10% of PWV)*	44.66	m2
**Assuming 1m height of soil*		
Detention Design Storm (95%AEP, 24hr)		
Rainfall Depth	37	mm
Impermeable Catchment Runoff Depth	32.45	mm
Permeable Catchment Runoff Depth	8.45	mm
Required Detention Storage Depth	24.01	mm
Required Detention Volume	868.51	m3
Required Detention Depth above PWV	0.88	m2

Wetland Design Calculations

MDL North Fast Track - Wetland B

Catchment info

Total Road Catchment area	45430	m^2
Impermeable Road Percentage (%)	0.8	
Impermeable Road Catchment Area (m2)	36344	m^2
Permeable Road Catchment Area (m2)	9086	m^2
Total Lot Catchment area	106745	m^2
Impermeable Lot Hardstand Percentage (%)	0.15	
Impermeable Lot Roof Percentage (%)	0.55	
Impermeable Lot Hardstand Catchment Area (m2)	16011.75	m^2
Impermeable Lot Roof Catchment Area (m2)	58709.75	m^2
Permeable Lot Catchment Area (m2)	32023.5	m^2
Total Impermeable Catchment Area excl. Roofs (m2)	52355.75	m^2
Total Permeable Catchment Area (m2)	41109.5	m^2
TP-108 parameters		
Impermeable Surface CN:	98	
Permeable Surface CN:	74	
Water Quality Flow Composite Catchment CN	87.44	
Catchment Length	2.0	km
Catchment Slope	0.01	m/m
Channelisation, C	0.60	
Tc	0.63	hrs
Impermeable Soil Storage (S)	5.18	
Permeable Soil Storage (S)	89.24	
Impermeable Initial Abstraction (Ia)	0.00	mm
Permeable Initial Abstraction (Ia)	5.00	mm

Wetland Design Calculations

MDL North Fast Track - Wetland B

<u>Water Quality Design Storm (90%AEP, 24hr)</u>		
Rainfall Depth	26.5	mm
Impermeable Catchment Runoff Depth	22.16	mm
Permeable Catchment Runoff Depth	4.17	mm
Impermeable Catchment Runoff Volume	1160.43	m3
Permeable Catchment Runoff Volume	171.59	m3
Total Water Quality Event Runoff Volume	1332.03	m3
Wetland Permanent Water Volume*	666.01	m3
*PWV halved due to provision of live storage		
Required Wetland Area Footprint	1332.03	m2
Required Maintenance Area Footprint (10% of PWV)*	66.60	m2
*Assuming 1m height of soil		
<u>Detention Design Storm (95%AEP, 24hr)</u>		
Rainfall Depth	37	mm
Impermeable Catchment Runoff Depth	32.45	mm
Permeable Catchment Runoff Depth	8.45	mm
Required Detention Storage Depth	24.01	mm
Required Detention Volume	1256.93	m3
Required Detention Depth above PWV	0.85	m2

Wetland Design Calculations

MDL North Fast Track - Wetland C

Catchment info

Total Road Catchment area	137384	m^2
Impermeable Road Percentage (%)	0.8	
Impermeable Road Catchment Area (m2)	109907.2	m^2
Permeable Road Catchment Area (m2)	27476.8	m^2
Total Lot Catchment area	187919	m^2
Impermeable Lot Hardstand Percentage (%)	0.15	
Impermeable Lot Roof Percentage (%)	0.55	
Impermeable Lot Hardstand Catchment Area (m2)	28187.85	m^2
Impermeable Lot Roof Catchment Area (m2)	103355.45	m^2
Permeable Lot Catchment Area (m2)	56375.7	m^2
Total Impermeable Catchment Area excl. Roofs (m2)	138095.05	m^2
Total Permeable Catchment Area (m2)	83852.5	m^2
TP-108 parameters		
Impermeable Surface CN:	98	
Permeable Surface CN:	74	(Soil Group C)
Water Quality Flow Composite Catchment CN	88.93	
Catchment Length	2.0	km
Catchment Slope	0.01	m/m
Channelisation, C	0.60	
Tc	0.62	hrs
Impermeable Soil Storage (S)	5.18	
Permeable Soil Storage (S)	89.24	
Impermeable Initial Abstraction (Ia)	0.00	mm
Permeable Initial Abstraction (Ia)	5.00	mm

Wetland Design Calculations

MDL North Fast Track - Wetland C

<u>Water Quality Design Storm (90%AEP, 24hr)</u>		
Rainfall Depth	26.5	mm
Impermeable Catchment Runoff Depth	22.16	mm
Permeable Catchment Runoff Depth	4.17	mm
Impermeable Catchment Runoff Volume	3060.80	m3
Permeable Catchment Runoff Volume	350.01	m3
Total Water Quality Event Runoff Volume	3410.80	m3
Wetland Permanent Water Volume*	1705.40	m3
*PWV halved due to provision of live storage		
Required Wetland Area Footprint	3410.80	m2
Required Maintenance Area Footprint (10% of PWV)*	170.54	m2
*Assuming 1m height of soil		
<u>Detention Design Storm (95%AEP, 24hr)</u>		
Rainfall Depth	37	mm
Impermeable Catchment Runoff Depth	32.45	mm
Permeable Catchment Runoff Depth	8.45	mm
Required Detention Storage Depth	24.01	mm
Required Detention Volume	3315.31	m3
Required Detention Depth above PWV	0.87	m2

Wetland Design Calculations

MDL North Fast Track - Wetland D

Catchment info

Total Road Catchment area	18900	m^2
Impermeable Road Percentage (%)	0.8	
Impermeable Road Catchment Area (m2)	15120	m^2
Permeable Road Catchment Area (m2)	3780	m^2
Total Lot Catchment area	28800	m^2
Impermeable Lot Hardstand Percentage (%)	0.15	
Impermeable Lot Roof Percentage (%)	0.55	
Impermeable Lot Hardstand Catchment Area (m2)	4320	m^2
Impermeable Lot Roof Catchment Area (m2)	15840	m^2
Permeable Lot Catchment Area (m2)	8640	m^2
Total Impermeable Catchment Area excl. Roofs (m2)	19440	m^2
Total Permeable Catchment Area (m2)	12420	m^2
<u>TP-108 parameters</u>		
Impermeable Surface CN:	98	
Permeable Surface CN:	74	
Water Quality Flow Composite Catchment CN	88.64	
Catchment Length	2.0	km
Catchment Slope	0.01	m/m
Channelisation, C	0.60	
Tc	0.62	hrs
Impermeable Soil Storage (S)	5.18	
Permeable Soil Storage (S)	89.24	
Impermeable Initial Abstraction (Ia)	0.00	mm
Permeable Initial Abstraction (Ia)	5.00	mm

Wetland Design Calculations

MDL North Fast Track - Wetland D

Water Quality Design Storm (90%AEP, 24hr)		
Rainfall Depth	26.5	mm
Impermeable Catchment Runoff Depth	22.16	mm
Permeable Catchment Runoff Depth	4.17	mm
Impermeable Catchment Runoff Volume	430.88	m3
Permeable Catchment Runoff Volume	51.84	m3
Total Water Quality Event Runoff Volume	482.72	m3
Wetland Permanent Water Volume*	241.36	m3
*PWV halved due to provision of live storage		
Required Wetland Area Footprint	482.72	m2
Required Maintenance Area Footprint (10% of PWV)*	24.14	m2
*Assuming 1m height of soil		
Detention Design Storm (95%AEP, 24hr)		
Rainfall Depth	37	mm
Impermeable Catchment Runoff Depth	32.45	mm
Permeable Catchment Runoff Depth	8.45	mm
Required Detention Storage Depth	24.01	mm
Required Detention Volume	466.71	m3
Required Detention Depth above PWV	0.87	m2

Wetland Design Calculations

MDL North Fast Track - Wetland E

Catchment info

Total Road Catchment area	22449	m^2
Impermeable Road Percentage (%)	0.8	
Impermeable Road Catchment Area (m2)	17959.2	m^2
Permeable Road Catchment Area (m2)	4489.8	m^2
Total Lot Catchment area	47743	m^2
Impermeable Lot Hardstand Percentage (%)	0.15	
Impermeable Lot Roof Percentage (%)	0.55	
Impermeable Lot Hardstand Catchment Area (m2)	7161.45	m^2
Impermeable Lot Roof Catchment Area (m2)	26258.65	m^2
Permeable Lot Catchment Area (m2)	14322.9	m^2
Total Impermeable Catchment Area excl. Roofs (m2)	25120.65	m^2
Total Permeable Catchment Area (m2)	18812.7	m^2
TP-108 parameters		
Impermeable Surface CN:	98	
Permeable Surface CN:	74	
Water Quality Flow Composite Catchment CN	87.72	
Catchment Length	2.0	km
Catchment Slope	0.01	m/m
Channelisation, C	0.60	
Tc	0.63	hrs
Impermeable Soil Storage (S)	5.18	
Permeable Soil Storage (S)	89.24	
Impermeable Initial Abstraction (Ia)	0.00	mm
Permeable Initial Abstraction (Ia)	5.00	mm

Wetland Design Calculations

MDL North Fast Track - Wetland E

Water Quality Design Storm (90%AEP, 24hr)		
Rainfall Depth	26.5	mm
Impermeable Catchment Runoff Depth	22.16	mm
Permeable Catchment Runoff Depth	4.17	mm
Impermeable Catchment Runoff Volume	556.78	m3
Permeable Catchment Runoff Volume	78.53	m3
Total Water Quality Event Runoff Volume	635.31	m3
Wetland Permanent Water Volume*	317.65	m3
*PWV halved due to provision of live storage		
Required Wetland Area Footprint	635.31	m2
Required Maintenance Area Footprint (10% of PWV)*	31.77	m2
*Assuming 1m height of soil		
Detention Design Storm (95%AEP, 24hr)		
Rainfall Depth	37	mm
Impermeable Catchment Runoff Depth	32.45	mm
Permeable Catchment Runoff Depth	8.45	mm
Required Detention Storage Depth	24.01	mm
Required Detention Volume	603.08	m3
Required Detention Depth above PWV	0.85	m2

Wetland Design Calculations

MDL North Fast Track - Wetland H

Catchment info

Total Road Catchment area	9222	m^2
Impermeable Road Percentage (%)	0.8	
Impermeable Road Catchment Area (m2)	7377.6	m^2
Permeable Road Catchment Area (m2)	1844.4	m^2
Total Lot Catchment area	31263	m^2
Impermeable Lot Hardstand Percentage (%)	0.15	
Impermeable Lot Roof Percentage (%)	0.55	
Impermeable Lot Hardstand Catchment Area (m2)	4689.45	m^2
Impermeable Lot Roof Catchment Area (m2)	17194.65	m^2
Permeable Lot Catchment Area (m2)	9378.9	m^2
Total Impermeable Catchment Area excl. Roofs (m2)	12067.05	m^2
Total Permeable Catchment Area (m2)	11223.3	m^2
TP-108 parameters		
Impermeable Surface CN:	98	
Permeable Surface CN:	74	
Water Quality Flow Composite Catchment CN	86.43	
Catchment Length	2.0	km
Catchment Slope	0.01	m/m
Channelisation, C	0.60	
Tc	0.64	hrs
Impermeable Soil Storage (S)	5.18	
Permeable Soil Storage (S)	89.24	
Impermeable Initial Abstraction (Ia)	0.00	mm
Permeable Initial Abstraction (Ia)	5.00	mm

Wetland Design Calculations

MDL North Fast Track - Wetland H

Water Quality Design Storm (90%AEP, 24hr)		
Rainfall Depth	26.5	mm
Impermeable Catchment Runoff Depth	22.16	mm
Permeable Catchment Runoff Depth	4.17	mm
Impermeable Catchment Runoff Volume	267.46	m3
Permeable Catchment Runoff Volume	46.85	m3
Total Water Quality Event Runoff Volume	314.31	m3
Wetland Permanent Water Volume*	157.15	m3
*PWV halved due to provision of live storage		
Required Wetland Area Footprint	314.31	m2
Required Maintenance Area Footprint (10% of PWV)*	15.72	m2
*Assuming 1m height of soil		
Detention Design Storm (95%AEP, 24hr)		
Rainfall Depth	37	mm
Impermeable Catchment Runoff Depth	32.45	mm
Permeable Catchment Runoff Depth	8.45	mm
Required Detention Storage Depth	24.01	mm
Required Detention Volume	289.70	m3
Required Detention Depth above PWV	0.83	m2

Raingarden Sizing spreadsheet - Milldale

LOCATION	Stream 4&7 Recharge

TP108 Calculations		
95th %ile Rainfall Depth (mm)	37	mm
Pervious Curve Number	74	
Impervious Area (m^2)	11760.0	m^2
Imeprvious Area (%)	80%	
Total Area (m^2)	14700.0	m^2
Impervious Runoff (TP108)		
Storage (mm)	5.2	mm
Runoff depth (mm)	32.45	mm
Impervious Runoff Available (m3)	381.65	m^3
Pervious Runoff (TP108)		
Storage (mm)	89.2	mm
Runoff Depth (mm)	8.45	mm
Pervious runoff available (m3)	24.83	m^3
Hydrology Management Runoff Depth (mm)	24.0	mm
Hydrology Management Volume required (m^3)	282.33	m^3
Detention Volume Achieved (m^3)	**282.33**	m^3
Offset volume Achieved/ Required	0.00	m^3

Rain garden designed to meet SMAF requirements for its catchment

Raingarden Length		
Raingarden Design Length	34.78	m
Available Length	22.50	m

Raingarden Design		
Raingarden Type	Type A	
Type A - Triangular		
Width	26	m
Side slopes	100	%
Media Slope	50	%
Longitudinal fall	2.5	%
Ponding depth	0.2	m
Media depth	0.5	m
Drainage layer (inc transition layer)	0.4	m
Berm crossfall	3	%
Kerb Height	0.15	m
Max Base Width	23.34	m
Raingarden Internal Length	33.10	m
Height change over length	0.83	m
Check Dam height	0.05	m
Maximum drop	0.35	m
Number of check dams	5	

Raingarden Volumes		
Ponding Volume	135.95	m^3
Media Volume	472.30	m^3
Media voids	30	%
Media Storage	141.69	m^3
Drainage Volume	13.40	m^3
Drainage voids	35	%
Drainage Storage	4.69	m^3
Total Raingarden Storage Volume	282.33	m^3

Raingarden Setout		
Checkdam Height	0.14	m
Total Length	34.78	m
1st cutout	0.7	m
1st check dam peak	6.99	m
Checkdam/ Cutout Spacing	6.79	m

Raingarden Sizing spreadsheet - Milldale

LOCATION	Stream 8 Recharge	
TP108 Calculations		
95th %ile Rainfall Depth (mm)	37	mm
Pervious Curve Number	74	
Impervious Area (m^2)	2225.6	m^2
Imeprvious Area (%)	80%	
Total Area (m^2)	2782.0	m^2
Impervious Runoff (TP108)		
Storage (mm)	5.2	mm
Runoff depth (mm)	32.45	mm
Impervious Runoff Available (m3)	72.23	m^3
Pervious Runoff (TP108)		
Storage (mm)	89.2	mm
Runoff Depth (mm)	8.45	mm
Pervious runoff available (m3)	4.70	m^3
Hydrology Management Runoff Depth (mm)	24.0	mm
Hydrology Management Volume required (m^3)	53.43	m^3
Detention Volume Achieved (m^3)	**53.43**	m^3
Offset volume Achieved/ Required	0.00	m^3

Rain garden designed to meet SMAF requirements for its catchment

Raingarden Length		
Raingarden Design Length	15.62	m
Available Length	22.50	m

Raingarden Design		
Raingarden Type	Type A	
Type A - Triangular		
Width	11	m
Side slopes	100	%
Media Slope	50	%
Longitudinal fall	1	%
Ponding depth	0.2	m
Media depth	0.5	m
Drainage layer (inc transition layer)	0.4	m
Berm crossfall	3	%
Kerb Height	0.15	m
Max Base Width	9.24	m
Raingarden Internal Length	13.94	m
Height change over length	0.14	m
Check Dam height	0.05	m
Maximum drop	0.35	m
Number of check dams	0	

Raingarden Volumes		
Ponding Volume	26.80	m^3
Media Volume	82.09	m^3
Media voids	30	%
Media Storage	24.63	m^3
Drainage Volume	5.74	m^3
Drainage voids	35	%
Drainage Storage	2.01	m^3
Total Raingarden Storage Volume	53.43	m^3

Raingarden Setout		
Checkdam Height	0.14	m
Total Length	15.62	m
1st cutout	0.7	m
1st check dam peak	15.42	m
Checkdam/ Cutout Spacing	15.22	m

Raingarden Sizing spreadsheet - Milldale

LOCATION	**Stream 10 Recharge**	
TP108 Calculations		
95th %ile Rainfall Depth (mm)	37	mm
Pervious Curve Number	74	
Impervious Area (m^2)	4840.0	m^2
Imeprvious Area (%)	80%	
Total Area (m^2)	6050.0	m^2
Impervious Runoff (TP108)		
Storage (mm)	5.2	mm
Runoff depth (mm)	32.45	mm
Impervious Runoff Available (m3)	157.07	m^3
Pervious Runoff (TP108)		
Storage (mm)	89.2	mm
Runoff Depth (mm)	8.45	mm
Pervious runoff available (m3)	10.22	m^3
Hydrology Management Runoff Depth (mm)	24.0	mm
Hydrology Management Volume required (m^3)	116.20	m^3
Detention Volume Achieved (m^3)	**116.20**	m^3
Offset volume Achieved/ Required	0.00	m^3

Rain garden designed to meet SMAF requirements for its catchment

Raingarden Length		
Raingarden Design Length	30.69	m
Available Length	22.50	m

Raingarden Design		
Raingarden Type	Type A	
Type A - Triangular		
Width	10	m
Side slopes	100	%
Media Slope	50	%
Longitudinal fall	0.1	%
Ponding depth	0.2	m
Media depth	0.8	m
Drainage layer (inc transition layer)	0.4	m
Berm crossfall	3	%
Kerb Height	0.15	m
Max Base Width	8.3	m
Raingarden Internal Length	29.23	m
Height change over length	0.03	m
Check Dam height	0.05	m
Maximum drop	0.35	m
Number of check dams	0	

Raingarden Volumes		
Ponding Volume	49.77	m^3
Media Volume	207.58	m^3
Media voids	30	%
Media Storage	62.27	m^3
Drainage Volume	11.85	m^3
Drainage voids	35	%
Drainage Storage	4.15	m^3
Total Raingarden Storage Volume	116.20	m^3

Raingarden Setout		
Checkdam Height	0.03	m
Total Length	30.69	m
1st cutout	0.7	m
1st check dam peak	30.49	m
Checkdam/ Cutout Spacing	30.29	m

Raingarden Sizing spreadsheet - Milldale

LOCATION	Bioretention Device F	

TP108 Calculations		
95th %ile Rainfall Depth (mm)	37	mm
Pervious Curve Number	74	
Impervious Area (m^2)	4375.0	m^2
Impervious Area (%)	30%	
Total Area (m^2)	14485.0	m^2

Rain garden designed to meet SMAF requirements for its catchment

Raingarden Length		
Raingarden Design Length	22.37	m
Available Length	22.50	m

Impervious Runoff (TP108)		
Storage (mm)	5.2	mm
Runoff depth (mm)	32.45	mm
Impervious Runoff Available (m3)	141.98	m^3
Pervious Runoff (TP108)		
Storage (mm)	89.2	mm
Runoff Depth (mm)	8.45	mm
Pervious runoff available (m3)	85.39	m^3
Water Quality Treatment Volume required (m^3)	105.03	m^3
Water Quality Treatment Volume Achieved (m^3)	**105.03**	m^3
Offset volume Achieved/ Required	0.00	m^3

Raingarden Design		
Raingarden Type	Type A	
Type A - Triangular		
Width	17	m
Side slopes	100	%
Media Slope	50	%
Longitudinal fall	2.1	%
Ponding depth	0.2	m
Media depth	0.5	m
Drainage layer (inc transition layer)	0.4	m
Berm crossfall	3	%
Kerb Height	0.15	m
Max Base Width	14.88	m
Raingarden Internal Length	20.68	m
Height change over length	0.43	m
Check Dam height	0.05	m
Maximum drop	0.35	m
Number of check dams	2	

Raingarden Volumes		
Ponding Volume	57.77	m^3
Media Volume	191.99	m^3
Media voids	30	%
Media Storage	57.60	m^3
Drainage Volume	8.43	m^3
Drainage voids	35	%
Drainage Storage	2.95	m^3
Total Raingarden Storage Volume	118.32	m^3

Raingarden Setout		
Checkdam Height	0.14	m
Total Length	22.37	m
1st cutout	0.7	m
1st check dam peak	8.38	m
Checkdam/ Cutout Spacing	8.18	m

Raingarden Sizing spreadsheet - Milldale

LOCATION		Bioretention Device G
TP108 Calculations		
95th %ile Rainfall Depth (mm)	37 mm	
Pervious Curve Number	74	
Impervious Area (m^2)	7289.7 m^2	
Impervious Area (%)	31%	
Total Area (m^2)	23239.0 m^2	
Impervious Runoff (TP108)		
Storage (mm)	5.2 mm	
Runoff depth (mm)	32.45 mm	
Impervious Runoff Available (m3)	236.57 m^3	
Pervious Runoff (TP108)		
Storage (mm)	89.2 mm	
Runoff Depth (mm)	8.45 mm	
Pervious runoff available (m3)	134.71 m^3	
Water Quality Treatment Volume required (m^3)	175.01 m^3	
Water Quality Treatment Volume Achieved (m^3)	**175.01** m^3	
Offset volume Achieved/ Required	0.00 m^3	

Rain garden designed to meet SMAF requirements for its catchment

Raingarden Length	
Raingarden Design Length	62.98 m
Available Length	22.50 m

Raingarden Design	
Raingarden Type	Type A
Type A - Triangular	
Width	10 m
Side slopes	100 %
Media Slope	50 %
Longitudinal fall	2.1 %
Ponding depth	0.2 m
Media depth	0.5 m
Drainage layer (inc transition layer)	0.4 m
Berm crossfall	3 %
Kerb Height	0.15 m
Max Base Width	8.3 m
Raingarden Internal Length	61.29 m
Height change over length	1.29 m
Check Dam height	0.05 m
Maximum drop	0.35 m
Number of check dams	8

Raingarden Volumes	
Ponding Volume	91.54 m^3
Media Volume	309.13 m^3
Media voids	30 %
Media Storage	92.74 m^3
Drainage Volume	24.68 m^3
Drainage voids	35 %
Drainage Storage	8.64 m^3
Total Raingarden Storage Volume	192.92 m^3

Raingarden Setout	
Checkdam Height	0.14 m
Total Length	62.98 m
1st cutout	0.7 m
1st check dam peak	8.30 m
Checkdam/ Cutout Spacing	8.10 m

Appendix C: Wetland Safety in Design

Safety In Design - Risk Register

Name:	**Wetlands and Outlets**	**JOB #**	**P25-609**
Project name:	**Milldale Civil Stages 14 to 17**		
Date:	**20/07/2026**		

Project Description

Communal Stormwater Device risk register to accompany the Operation and Maintenance Manuals

IDENTIFIED SAFETY RISK							TREATMENT PLAN	RESIDUAL RISK				
				Pre-Treatment			1. Eliminate, 2. Substitution 3. Isolation 4. Engineering Control 5. Administrative Control 6. Personal Protective Equipment	Post-treatment				
Risk ID	**Risk Title**	**Risk description**	**Status**	**Likelyhood**	**Consequence**	**Risk rating**		**Likelyhood**	**Consequence**	**Risk rating**	**Residual controls**	**Notes**
1. CONSTRUCTION												
1.01	Falls - Batter Slopes	Rolling construction plant, workers slipping.	Open	Possible	Moderate	**Medium**	Slopes designed at 1:3 maximum to minimise the risk of falls	Unlikely	Minor	**Low**	Construction monitoring, ensuring soil strength is adequate for walls and that it has been accounted for in the design. Ensuring safety education on site for workers near walls and steep slopes. Requiring JSA and SWMS for specific activities	
1.02	Drainage	Manhole and wingwall requiring construction methodologies. Tipping, rolling or breaking during construction	Open	Unlikely	Minor	**Low**	Manholes and wingwalls have been reduced to their minimum possible sizes allowable by standards to reduce requirements for lifting plant or unfamiliar construction methodologies to the workers	Highly Unlikely	Minor	**Low**	Construction monitoring	
1.03	Mucking out Existing Sediment Pond	Incidents invoved with the process of removing silt and sediment that has built up inside the existing sediment retention pond.	Open	Possible	Moderate	**Medium**	Desilting to be done using best construction practises.	Highly Unlikely	Minor	**Low**	Construction monitoring. All wetlands to be maintained during construction works.	
1.04	Work around Streams	Incidents involved with working around an active stream including drowning and slipping due to wet ground.	Open	Possible	Major	**High**	Design to avoid works within stream where possible.. Where unavoidable specific design and risk assessment to be undertaken.	Highly Unlikely	Minor	**Low**	Machinery and staff to stay out of the stream at all times. Stream is to be fenced off for the duration of the works. Contractor H&S Plan. Engineer Site inspections and Audits.	
1.05	Planting near watercourses	Falls into water, drowning, slips, falls	Open	Unlikely	Moderate	**Medium**	Slopes have been reduced to 1:3 maximum or flatter to reduce risk of falling and the damage caused by a fall.	Rare	Hospitalisation	**Medium**	JSA for landscaping activities	
1.06	Planting on steep slopes	Risk of slips and falls	Open	Possible	Minor	**Low**	Slopes have been reduced to 1:3 maximum or flatter to reduce risk of falling and the damage caused by a fall.	Rare	Minor Injury	**Low**	JSA for landscaping activities	
2. OPERATION/MAINTENANCE												
2.01	Falls: Internal slopes	Falls associated with internal slopes	Open	Highly Unlikely	Minor	**Low**	Batter slopes modelled to 1:3 grade; Batter slopes will be landscaped with suitable vegetation to deter access onto slope.	Highly Unlikely	Serious	**Low**	No residual controls	
2.02	Ponding Depth/Flood depth in basin	Drowning due to falling into wetland. Permanent water level in wetland up to 1.5m deep. Depth of water in wetland whilst in operation further increased by up to 800mm.	Open	Unlikely	Catastrophic	**Extreme**	Dense vegetative planting around wetland, planting to deter and restrict access into wetland. Provision of 3m wide safety bench around permanent water areas. Selection of plant species to minimise maintenance and reduce clogging of SW structure	Highly Unlikely	Major	**High**	No residual controls	
2.03	Stormwater Overland Flow Management	Mitigation of stormwater overland flows during large rainfall event	Open	Highly Unlikely	Serious	**Low**	Design in accordance with SWCOP. Design model ensures no private property in 1% AEP flow.	Highly Unlikely	Minor	**Low**	No residual controls	
2.04	Safe access for Maintenance Operations	Safe access for maintenance operations.Consideration for both stormwater operations teams and landscapers	Open	Highly Unlikely	Moderate	**Low**	Vehicle access is provided around and into basin to ensure maintenance can conduct all required operations.	Highly Unlikely	Moderate	**Low**	No residual controls	
2.05	Overland Flow	In major storm events the wetland will be inundated with storm flows.	Open	Unlikely	Moderate	**Medium**	Appropriate riprap is provided in the upstream to prevent erosion during extreme event.	Unlikely	Moderate	**Medium**	No residual controls	
2.06	Maintenance of plants	Poison, minor injuries, cuts, scrapes, infections	Open	Highly Likely	Moderate	**High**	Appropriate planting plan, non-poisonous species, low maintenance plant species.	Highly Unlikely	Moderate	**Low**	No residual controls	
3. DECOMMISSION												
3.01	Decomisioning temporary Basin and outlet	Risks associated during the removal of the temporary basin and the outlet	Open	Possible	Moderate	**Medium**	Outlet location situated where plant can access while staying on the access track.	Highly Unlikely	Moderate	**Low**		
3.02	Decomisioning temporary Swale	Risks associated with the removal of the drainage swale that discharges into the temporary basin such as slipping, fall	Open	Possible	Moderate	**Medium**	Proposed swale to consist of a geotextile liner pined onto ground so decommission work is minimal	Highly Unlikely	Moderate	**Low**		