Geelong Saleyards Precinct - Surface Water Management Strategy

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Synopsis: This report documents the Surface Water Management Strategy for the Geelong Saleyards Precinct. It is a high level report reflecting the planning stage of the development prior to concept design.

REVISION/CHECKING HISTORY

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0 - Draft	06/11/20	-	-	Paul Dubowski	[signature]
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Executive Summary

The City of Greater Geelong (CoGG) is in the process of finalising the *Geelong Saleyards Precinct Plan*. To support this plan, BMT has been commissioned to update the existing flood mapping to current standards and develop a strategy for surface water management for the Saleyards precinct. The *Geelong Saleyards Precinct - Surface Water Management Strategy* (the strategy) has been prepared to achieve the later of these aims, while the former will be presented in a separate report. The aim of the strategy is to demonstrate a workable solution to the management of stormwater quality and quantity, integrating water sensitive urban design principles.

The strategy also considers the planning controls documented in the draft *Geelong Saleyards Precinct Plan (CoGG 2020)* which need to be recognised in the planning of stormwater management. This strategy seeks to address these controls through the analysis of site opportunities and constraints and development of suitably responsive treatment solutions.

The proposed stormwater quality treatment strategy consists of the following:

- At-source treatments
  - Streetscape bioretention swales. These have been assumed to be the length of each road by 0.8 metres wide which is the minimum width considered in this report to support medium sized trees (to be confirmed by an arborist). The other planning controls set out in the precinct plan for the streetscape green corridors including managing the urban heat island effect, heritage conservation (i.e. bluestone paving), creating green links, amenity and habitat, have not been factored into this width. Achievement of these requirements would likely require greater widths.
- End-of-pipe treatments
  - Gross pollutant traps (GPTs). There are two end-of-pipe proprietary gross pollutant traps (GPT) identified as pre-treatment devices for downstream wetlands (described below). The products modelled are both the OceanSave OS1112 units which are supplied by Ocean Protect. There has been one GPT modelled for the northern subcatchment and one for the southern subcatchment. Consistent with the CoGG preferred modelling practice, it has been assumed that any GPT (regardless of supplier) would only treat gross pollutants and sediments and not treat nutrients (nitrogen or phosphorus).
  - Constructed wetlands. There is one assumed wetland for the northern subcatchment and one for the southern subcatchment. These have been sized as follows:
    - Northern wetland macrophyte zone surface area: 1344 m^2
    - Southern wetland macrophyte zone surface area: 2016 m^2.

    The overall size of these wetland is approximately double the macrophyte zone surface area which accounts for batters, high flow bypass (if requires) inlet pond etc. The northern wetland in particular has been sized and located to avoid the peak 1-year ARI flood levels.
- No treatment
  - The only areas not assumed to be treated are the three linear pocket parks. These have minimal impervious surfaces and would be expected to generate low pollutants loads. Nevertheless, they were still included in the model and assumed to discharge to the receiving environment.

This proposed strategy is schematically illustrated in Figure 3-3.

Based on the results of modelling using the industry standard MUSIC program, the proposed treatment strategy will significantly reduce pollutant loads when compared to those generated by the unmitigated site. Furthermore, the proposed treatment strategy is predicted to achieve the target water quality objectives of:

- Total suspended solids: 80% reduction
- Total phosphorus: 45% reduction
- Total nitrogen: 45% reduction
- Gross pollutants (5mm or larger): 70% reduction.

The proposed stormwater quantity management consists of the following:

- Surface collection inlets, to be designed and located along major roadways to collect stormwater during rainfall events that exceed the capacity of streetscape bioretention swales.
- Sub-surface piped drainage that aligns with the precinct concept layout, is sympathetic to the natural/existing site elevations, caters for the minor storm event (20% to 10% AEP) and minimises surface inundation.
- Provision for the conveyance of major flows via roadways and easements, in alignment with the precinct concept layout, that meet floodway safety criteria.

Key design issues for the concept and detailed design phases will include:

- Planning for connectivity, particularly using pathways/boardwalks integrated with the wetlands.
- The width of the streetscape bioretention swales could potentially be further reduced while still achieving these objectives, subject to the widths required to support trees in the bioretention swales and achieve the other planning controls documented in the precinct plan.
- The trunk diameter of mature trees in the bioretention swales needs to be considered as the trunks have the potential to effect flow conveyance and therefore stormwater quality treatment. If this is the case, the width of the swales may actually need to be wider.
- CoGG prefers that maintenance access be provided to all stormwater quality treatment assets without the need for traffic control.

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1 Introduction

1.1 Overview of the Report

The City of Greater Geelong (CoGG) is in the process of finalising the *Geelong Saleyards Precinct Plan (City of Greater Geelong 2020)*, hereafter referred to as the precinct plan, which proposes the vision for the future use of the precinct. The plan includes an indicative concept layout plan that addresses land-use, built form, access and movement, drainage and preferred public open space network. BMT has been commissioned to update the existing flood mapping to current standards and develop a surface water management strategy encompassing stormwater quality treatment and quantity management for the precinct i.e. this report.

The aim of this report is to demonstrate a workable solution to the management of stormwater that integrates water sensitive urban design principles. This includes the assessment of changes in stormwater quality as a result of the future redevelopment of the precinct and development of a strategy for the management of stormwater quality pollutants. Importantly, the strategy is required to consider the planning controls outlined in the precinct plan to implement the vision. These are described in further detail in Section 1.3. The precinct context plan provided in the precinct plan is reproduced in Figure 1-1. Given that this report relates to an indicative concept layout plan, the stormwater modelling and reporting are at a level commensurate with pre-concept design.

Figure 1-1 Precinct Context Plan from Precinct Plan

1.2 Site Description

The precinct plan consists of the Geelong Saleyards, Target Australia, Sphinx Hotel and associated landholdings and the industrial zone land to the north of these sites, but south of Victoria Street between Weddell Road and Thompson Road. The total precinct plan area included approximately 50 land parcels which make up approximately 25 hectares. The Precinct Land Use Context Plan provided in the precinct plan is shown in Figure 1-2.

Figure 1-2 Precinct Land Use Context Plan from Precinct Plan

The site to which this report relates excludes parts of the precinct and is shown on the *Indicative Concept Plan* shown in Figure 1-2. The site is approximately 12.4 hectares in area.

1.3 Precinct Plan Planning Controls

The precinct plan outlines as series of planning controls based on community consultation and design principles. Provisions directly relevant to the management of stormwater are summarised below.

COMMUNITY CONSULTATION

- Look and Feel
  - Green and spacious
    - Leafy tree-lined streets
    - Green buildings
    - Reinstated creeks
    - Retain and expand habitat

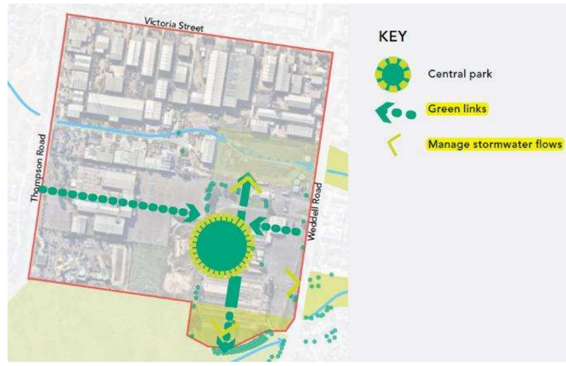
– Drainage reserves are natural waterways.

DESIGN PRINCIPLES

(1) Provide Spacious Public Open Space and Improved Habitat

Provide a multi-purpose open space that links to the surrounding open space network.

- *Manage stormwater overland flows*
- *Create green links that provide habitat for local species.*



(6) Create a Framework that Supports Best Practice Environmentally Sensitive Design

Ensure that the future urban design framework supports:

- *Water sensitive urban design in streets and public parks*
- *Minimise water use and maximise water reuse.*

FRAMEWORK PLAN

Public Domain - Open Space

The open spaces range from urban plazas, wetlands, to a planted central parkland.

Ecologically Sustainable Development

- *Developments with 10 or more dwellings or 5000 square metres or more of floor space should submit evidence that the project has been registered to seek a minimum 5 Star Green Star Design (or equivalent) with the Green Building Council of Australia.*
- *Other buildings and alterations of more than 50 square metres should submit evidence that they have been registered to seek a minimum 4 Star Green Star Design (or equivalent) with the Green Building Council of Australia.*

Urban Heat Island Effect Mitigation

- *Provide street tree, landscaped area plans indicating the approach to achieving at minimum 25% canopy coverage in streets and 40% in parking areas or demonstrate the maximum tree canopy coverage achievable as a % of canopy coverage. Include commentary on drought tolerant species selection.*
- *At least 70 per cent of the total site area should comprise building or landscape elements that reduce the impact of the urban heat island effect.*

Street Network

Streets will provide a significant stormwater management role by inclusion of water sensitive urban design elements such as swales on the major east west street and adjacent to parkland.

Main East West Street

- *The sunny southern side includes provision for a widened pedestrian path and swale for water treatment with large canopy trees.*
- *Planted swale with 'broken' kerbs to southern road edge. Regular pedestrian crossings over swale.*
- The accompanying figure shows 5.3-metre-wide swale with *'large evergreen trees and regular bridge crossing points *No electrical cabling etc. in this zone'.*

East West Parking Street

- No specific provisions are provided for this type of road although the accompanying figure shows a number of zones potentially commensurate with stormwater quality treatment including:
  - 1.0-metre-wide '*naturestrip/service zone*'
  - 2.3-metre-wide '*parking with dec. planting. Possible structural soil.*' This is shown either side of the road
  - 5.4 metre wide '*central 90 degree parking*'.

Local Streets

- *Street trees and planting within nature strips will provide shade and greenery and visually narrow the carriageways*
- *Trees and planting within nature strips. (Possible rain gardens or zone for public art etc.)*
- The accompanying figure shows 3.0-metre-wide '*Planted naturestrip with tree planting. Service zone*'.

Blue Stone Street

- *The blue stone street will be a low speed street which is raised along the entire length*
- *Street trees will be planted within planted nature strips to provide shade for footpaths and visually narrow the carriageways*
- The accompanying figure shows 3.0-metre-wide swale with '*WSUD treatment with pedestrian bridge crossings*'.

Park Street

- *It will be developed as slow speed street with street trees planted within planted nature strips to provide shade for footpaths and visually narrow the carriageways.*
- The accompanying figure shows 3.0-metre-wide swale with '*WSUD treatment with pedestrian bridge crossings*'.

Laneways

No specific provisions are provided for this type of road although the accompanying figure shows a 1.5-metre ‘*Nature strip/cross over/utility services*’.

The ‘indicative concept plan’ (Figure 1-3) further provides guidance on stormwater management for the drainage reserve and crown land as follows:

9 Drainage Reserve

- *The drainage reserve could be reshaped with landscape enhancements to improve its appearance and water treatment outcomes. Possible wetlands development with native planting and walking loops.*

10 Crown Land

- *This parcel of crown land could be developed to add to the public open space offering of the precinct and surrounding neighbourhood. It could include walking tracks, tree planting and re-vegetation/ water detention space.*

  There may be potential for some residential development.

Figure 1-3 Indicative Concept Plan from the Precinct Plan

2 Site Details

2.1 Site Topography and Drainage

The catchment of the Rippleside Main Drain (C152) is a large, predominantly urban catchment located to the north of the Geelong CBD. The catchment itself includes approximately 7 kilometres of overland flow paths and an overall catchment area of 770 hectares. Whilst the catchment discharges into Corio Bay at Rippleside Beach, the Melbourne-Geelong railway and the Princes Highway effectively block the overland flow path downstream of the Baxter Road retarding basin. Consequently, the catchment discharges via a box culvert from the retarding basin to Corio Bay, with little overland flow observed downstream of the Princes Highway.

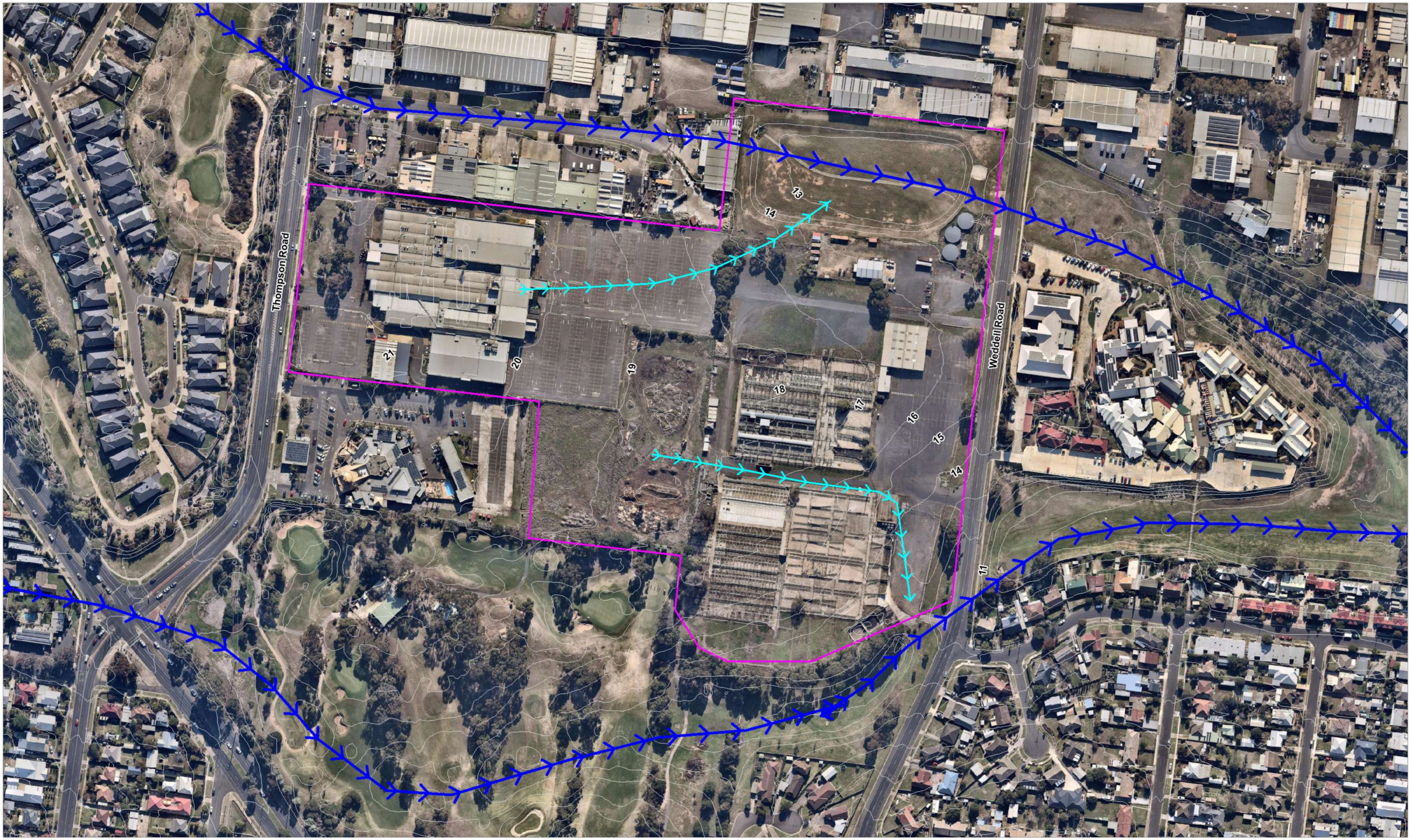
The site catchment forms part of this larger catchment, with drainage channels flowing immediately north and south of the site. These drainage channels flow from west to east and merge shortly downstream of the site, east of the adjacent aged care facility. From the convergence point, the flow path continues for approximately 1 kilometre before discharging to Corio Bay.

The topography of the site is very gentle and flows are split north/south roughly through the centre of the site. Approximately 40% of the site drains towards the north and 60% of the site drains to the south. The existing topography and drainage is shown in Figure 2-1.

Reflecting the present and recent past uses of the site, a significant proportion of the area is paved but understood to be generally lacking drainage infrastructure to manage major stormwater runoff. An element of the Saleyards precinct development plan is to provide for modern, integrated drainage management that accommodates principles of Water Sensitive Urban Design (WSUD).

2.2 Vegetation

The site has been completely cleared of remnant vegetation. Consequently, the site is devoid of any significant vegetation. As noted in section 1.3, there are strong provisions in the precinct plan related to restoring vegetation including in the stormwater quality treatment areas.



LEGEND

- Site Boundary
- Existing Site Flowpath
- Drainage Channels
- Contours (1m interval)

Aerial Image 20 April 2019 by nearmap.com

Title:

Existing Topography and Drainage

Figure: 2-1

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3 Stormwater Quality Management

3.1 Preamble

Modelling was completed to determine the size, configuration and performance of the proposed stormwater quality treatment system. This section explains how predicted stormwater pollutant loads from the developed site will compare to the given stormwater quality management objectives (SQMOs).

3.2 Opportunities and Constraints for Stormwater Quality Management

3.2.1 Site Opportunities

The major opportunities identified for the site with respect to the application of stormwater quality controls are as follows:

- **Integration of land uses** – the planning controls outlined in the precinct plan suggest that multiple land uses can be integrated within road corridors. This includes:
  - vehicular and pedestrian transport
  - the treatment and conveyance of stormwater
  - managing the urban heat island effect
  - heritage conservation (i.e. bluestone paving)
  - creating green links
  - amenity
  - habitat.

  The precinct plan demonstrates how the integration of all these uses and values can be achieved within the street network.

- **Street Network** – as noted in Section 1.3, the precinct plan has allowed for adequate width within each of the road types for the integration of the land uses noted above. This includes source control of stormwater which is especially important given the relatively flat nature of the site. Source control is likely to be an important part of the WSUD response for this site.
- **Private allotments** – the precinct plan envisages green roofs on private apartments which if implemented, would provide uses including potential volume and stormwater quality controls. These could also be fitted with rainwater tanks to achieve sustainability goals (e.g. the required green star ratings) as well as reduce stormwater volumes and some stormwater pollutant loads. Rainwater tanks could be implemented on a building-by-building basis or as a community scheme. The three existing rainwater tanks could potentially be re-purposed.

- **Public open space** – the precinct plan specifically notes the potential for stormwater management on the drainage reserve north of future development and on the crown land south of the future development. The northern drainage reserve is specifically mentioned as an area for a potential wetland while the community consultation section of the precinct plan specifically notes the potential for rehabilitating the drainage reserve as a natural waterway/creek re-instatement. The provisions for the southern crown land note the potential for '*re-vegetation / water detention space*'.

  The planned central parkland is also an area specifically reserved for the integration of multiple uses including stormwater quality controls. Linear pocket parks are another potential opportunity to locate stormwater quality treatment systems.

- **Private open space** – plazas and the courtyards between buildings provide an opportunity for stormwater quality treatment especially for roof runoff. This includes potential for both above and below ground treatment systems.

- **Topography** – the topography of the site is quite flat which typically requires source based controls such as streetscape bioretention swales/basins. Notwithstanding, there is adequate fall in the adjacent northern drainage corridor and southern crown land to enable the construction of stormwater quality treatment solutions. The topography therefore enables a combined source and end-of-pipe stormwater quality treatment strategy.

3.2.2 Site Constraints

The major constraints identified for the site with respect to the application of stormwater quality controls are as follows:

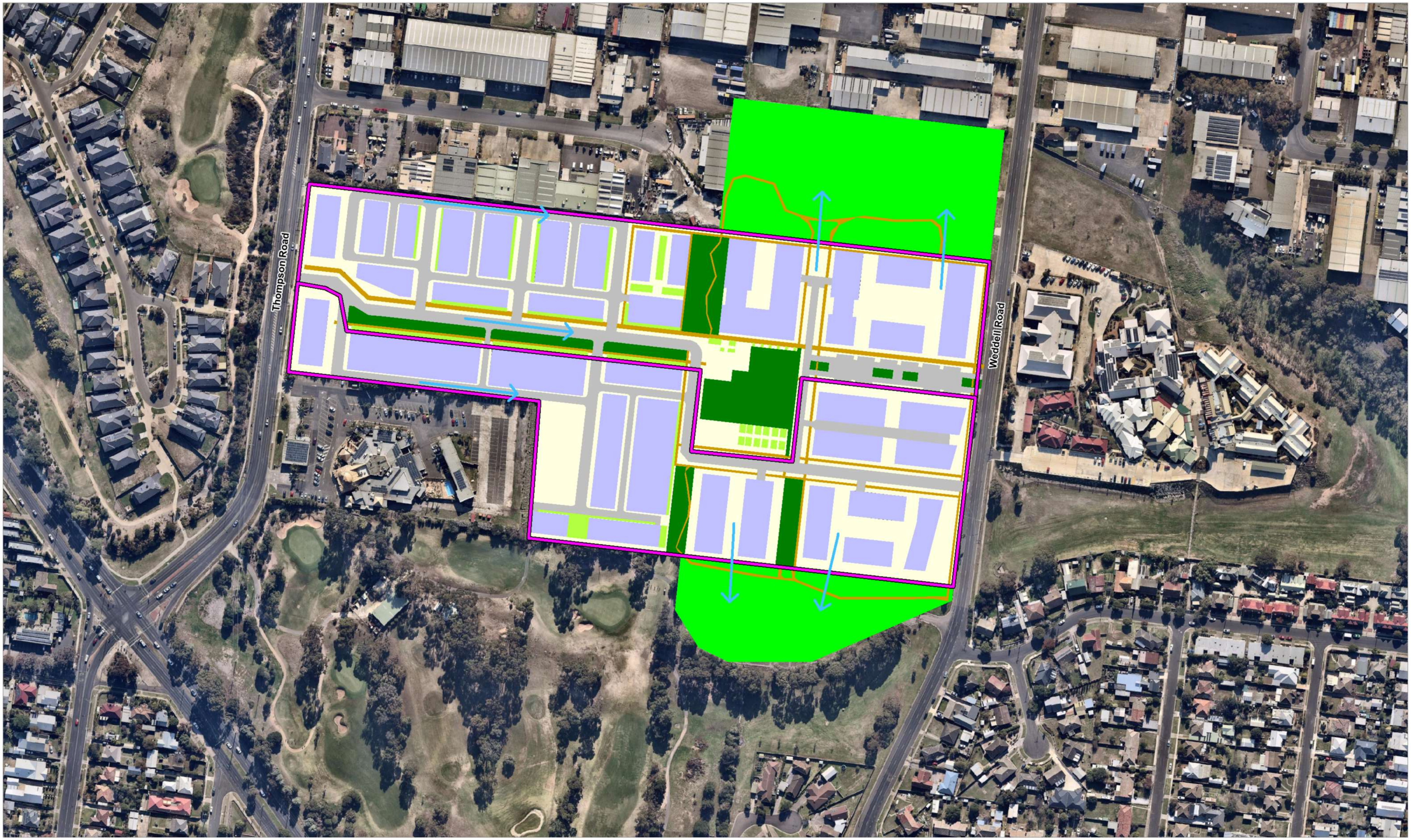
- **Uncertainty** – this strategy is based upon the Indicative Concept Plan presented in the precinct plan (Figure 1-3). The high level of layout design provides uncertainty with respect to the feasibility of numerous stormwater quality treatment solutions. For example, the total number of dwellings/units are unknown and therefore the overall water demand is unknown. As a result, modelling rainwater tanks is not feasible with a reasonable degree of certainty. The strategy therefore needs to focus on the treatment solutions which are most feasible with the knowledge available.

  Similarly, conceptual finished surface levels are unknown at this stage. The subcatchments presented in Figure 3-1 have therefore been assumed to be split according to the boundaries shown on Figure 1-3. These were based predominantly on existing levels (to minimise earthworks) although the central park is assumed to drain northwards to help manage the other limitations on the size of downstream treatment systems (available land area and flooding constraints).

- **Flooding** – flooding in the northern drainage corridor from the upstream catchment has the potential to effect stormwater quality treatment systems. Flooding may result in oversaturated treatment systems and in the case of green assets, plant mortality. Depending on velocities, flooding also has the potential to cause scouring. To address these issues, the following criteria should be observed:

- Flow velocities in excess of 1 m/s should not be allowed over the surface of green assets in the major flood event.
- Green assets should be located above the peak 1-year ARI flood level from the large external catchment as shown in Figure 3-2.

Similarly, the construction of any stormwater quality treatment solutions needs to avoid worsening of flooding upstream. Flooding therefore potentially limits the area available for stormwater quality treatment systems.



LEGEND

- Catchment Flows
- Subcatchments

Proposed Land Use

- Park/Open Space
- Garden Bed
- Path
- Building
- Reserve
- Not Specified Paving/Nature Strip

Aerial Image 20 April 2019 by nearmap.com

Title:

Assumed Finished Subcatchments

Figure: 3-1

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LEGEND

Site Boundary

6.0 8.0 10.0 12.0 14.0 16.0 18.0 20.0 22.0 24.0 26.0

Flood Level (m)

Aerial Image 20 April 2019 by nearmap.com

Title:

Peak 1-year ARI Flood Level from the Large External Catchment

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Figure: 3-2

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3.3 Stormwater Quality Management Objectives

The recommended stormwater pollutant reduction targets for urban stormwater discharge to Corio Bay are presented in Table 3-1. These water quality objectives (WQOs) are consistent with the *Infrastructure Design Manual* (LGIDA 2018) and *Urban Stormwater: Best Practice Environmental Management Guidelines* (Victoria Stormwater Committee 1999).

Table 3-1 Stormwater pollutant reduction targets

Pollutant	Criteria
Total Suspended Solids	80% reduction
Total Phosphorus	45% reduction
Total Nitrogen	45% reduction
Gross Pollutants (5mm or larger)	70% reduction

3.4 MUSIC Modelling

The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) software, version 6.3, was used to assess the generation, conveyance and management / treatment of flows and pollutant loads from the site. MUSIC modelling was undertaken for the site for the following scenarios:

- Developed site without the proposed stormwater management strategy in place
- Developed site with the proposed stormwater management strategy in place.

Appendix A provides a detailed description of the MUSIC modelling methodology applied for the assessment. MUSIC modelling was undertaken in accordance with the *MUSIC – modelling approach and parameters - design note 3* (CoGG 2019) and the *MUSIC Guidelines: Input parameters and modelling approaches for MUSIC users in Melbourne Water's service area* (Melbourne Water 2018).

3.5 Proposed Stormwater Quality Strategy

The proposed stormwater quality strategy has been designed to balance the opportunities and constraints discussed above according to the expected finished catchments (Figure 3-1). The strategy consists of the following combined at-source and end-of-pipe stormwater quality treatment solutions:

- At-source treatments
  - Streetscape bioretention swales

    These treatment systems have been assumed to treat all road types except laneways. The bioretention swales have been modelled extending the full length of each road. They require inlets to be designed to ensure inflows are evenly distributed across the bioretention surface area. This may be achieved using flush kerbs, kerb cut outs or multiple, frequent inlets.

While the precinct plan shows green corridors on roads ranging in width between 3.0 metres and 5.3 metres (as described in Section 1.3), bioretention swales have been modelled to be a minimum of 0.8 metres on all road types. This is the minimum width considered in this report to achieve the WQOs for the overall site and support an average size tree. Wider widths may be required subject to the advice of an arborist subject to species selection. Structural soils or similar products located beneath adjoining surfaces may potentially be used to further encourage tree growth in the bioretention swales.

The other planning control set out in the precinct plan for the streetscape green corridors including managing the urban heat island effect, heritage conservation (i.e. bluestone paving), creating green links, amenity and habitat, have not been factored in this width. Achievement of these requirements would likely require greater widths.

The extended detention depth (depth to the invert of the surface of the bioretention swales) was assumed to be only 100 millimetres. The key reason for this shallow depth is to minimise safety issues associated with deeper systems. Avoiding deeper extended detention also means that there is no need for any additional safety measures for pedestrians, such as fencing or bollards, as the depth is no greater than that of a typical kerb and channel. Unlike a typical kerb and channel however, the batters should be designed at least at a 1 in 4 grade so the total width of the bioretention swales will need to be slightly wider but with an added layer of safety. As these systems will need to be densely vegetated, they will provide a lower risk to pedestrians than typical kerb and channel.

- End-of-pipe treatments
  - Gross pollutant traps (GPTs)

    These treatment systems have been modelled to treat all of the site apart from stormwater either treated through or bypassing from the streetscape bioretention systems.

    There are two end-of-pipe proprietary gross pollutant traps (GPT) identified as pre-treatment devices for downstream wetlands (described below). The products modelled are both the OceanSave OS1112 units which are supplied by Ocean Protect. There has been one GPT modelled for the northern subcatchment and one for the southern subcatchment (Figure 3-1). Consistent with the CoGG preferred modelling practice, it has been assumed that any GPT (regardless of supplier) would only treat gross pollutants and sediments and not treat nitrogen or phosphorus. Sizing details for both GPTs are as follows:

    – Treatment flow rate:155 L/s
    – Maximum flow (online):765 L/s – if the design capacity exceeds this flow, the system will need to be offline
    – Sediment capacity: 2.5 m^3
    – Recommended pipe size: 600-750 mm
    – Typical depth below invert: 2.0 m.

    Note that sizing is preliminary only and would need to be refined once flow rates and drainage designs have been completed.

- Constructed wetlands

  These treatment systems have been modelled to treat all of site including the treated stormwater and overflows from the streetscape bioretention swales and all stormwater from the GPTs.

  There is one wetland for the assumed northern subcatchment and one for the southern subcatchment (Figure 3-1). It has been assumed in the model that the depth of extended detention is only 200 millimetres thereby minimising earthworks and minimising the risk that the wetland would need to be lowered to a depth which would be affected by the peak 1-year ARI flood level from the large external catchment.

- No treatment
  - The only areas not assumed to be treated are the three linear pocket parks. These have minimal impervious surfaces and would be expected to generate low pollutants loads. Nevertheless, they were still included in the model and assumed to discharge to the receiving environment.

This proposed strategy is schematically illustrated in Figure 3-3 below. Further details of the stormwater management measures proposed for use on the site are presented in Appendix A.

The streetscape bioretention swales are proposed to be located in the same location as shown in the precinct plan subject to any potential road corridor width adjustments. A GPT and constructed wetland are proposed to be located in each of the northern drainage corridor and the southern crown land. The approximate location of the treatment systems and indicative size of the constructed wetlands is provided in Figure 3-4 below. The figure also provides an indication of the total footprint of the wetlands accounting for batters etc., nominally sized at twice the modelled macrophyte area.

Key design issues for the concept and detailed design phases will include:

- Planning for connectivity particularly using pathways/boardwalks integrated with the wetlands.
- The width of the streetscape bioretention swales could potentially be further reduced while still achieving these objectives subject to the widths required to support trees in the bioretention swales and achieve the other planning controls documented in the precinct plan.
- The trunk diameter of mature trees in the bioretention swales needs to be considered as the trunks have the potential to effect flow conveyance and therefore stormwater quality treatment. If this is the case, the width of the swales may actually need to be wider.
- CoGG prefers that maintenance access be provided to all stormwater quality treatment assets without the need for traffic control.

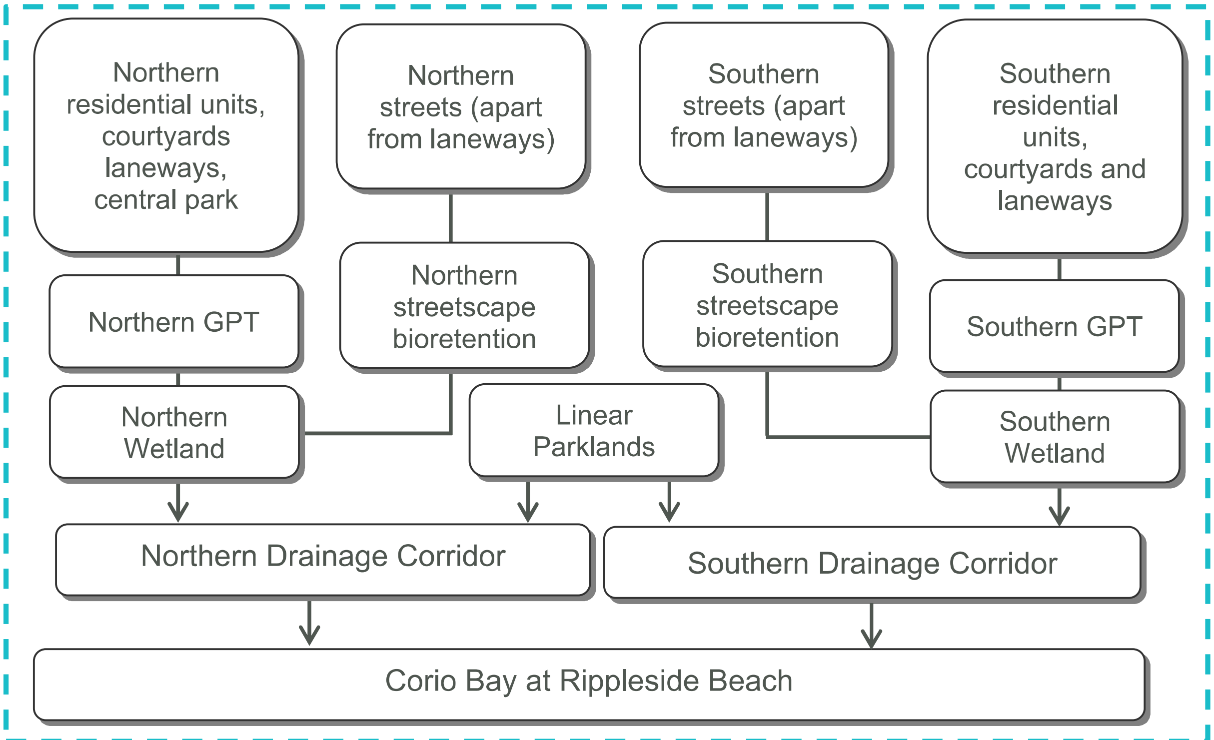
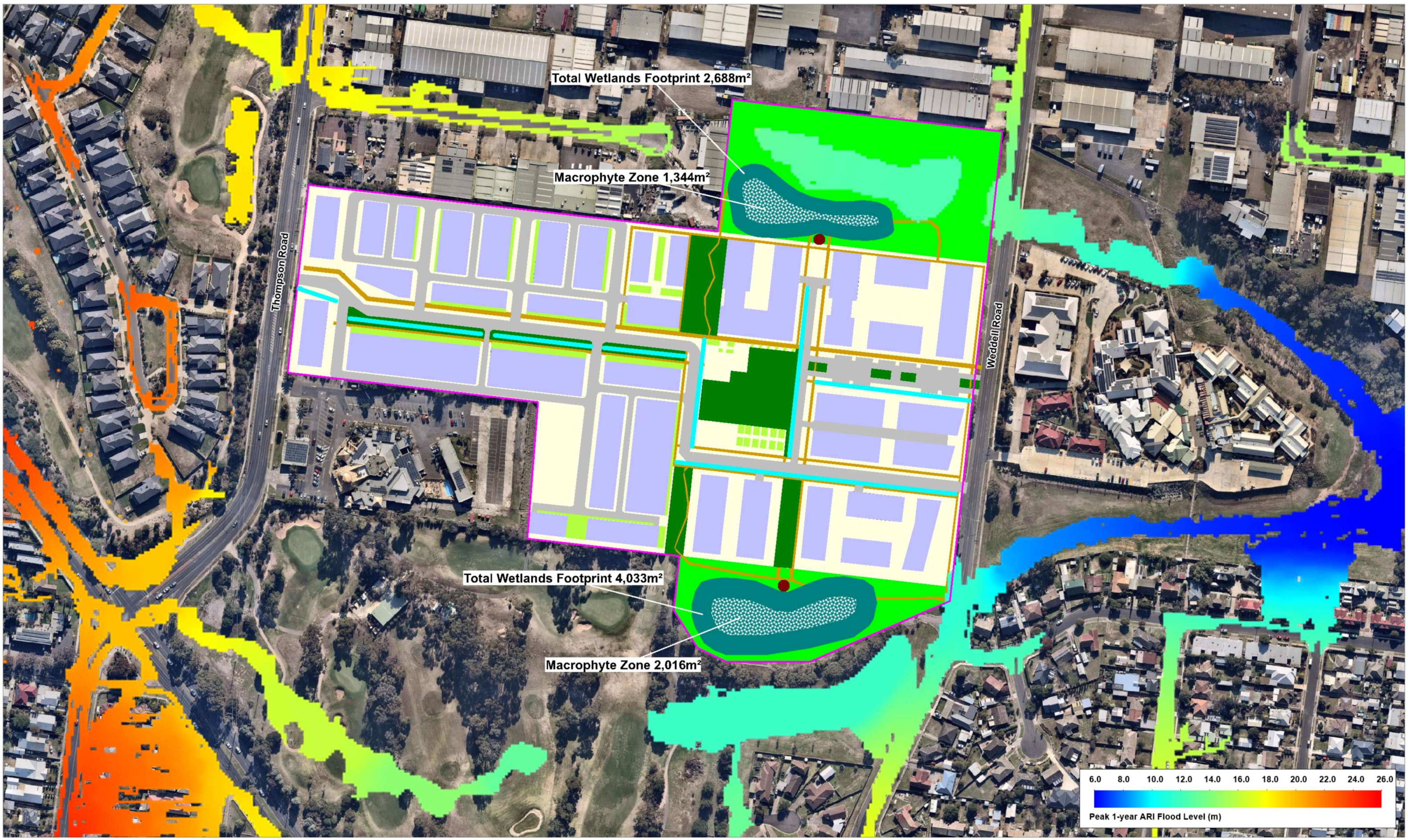


Figure 3-3 Stormwater Treatment Train for the Site



LEGEND

- Site Boundary
- Bioretention Swale
- Gross Pollutant Trap
- Wetlands
- Macrophyte Zone

Proposed Land Use

- Park/Open Space
- Garden Bed
- Path
- Building
- Road
- Reserve
- Not Specified Paving/Nature Strip

Aerial Image 20 April 2019 by nearmap.com

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Location of Stormwater Quality Treatment Systems

Figure: 3-4

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3.6 Model Results

Total annual flow and pollutant loads for the site are presented in Table 3-2. These values represent the pollutant loads that are predicted to discharge from the site.

Table 3-2 Predicted Pollutant Loads for the Site (1971-1980)

Parameter	Unmitigated Development	Developed Site with Treatment	% Removal	% Removal Target*
Flow (ML/yr)	38.3	32.7	14.5	N/A
TSS (kg/yr)	4600	465	89.9	80
TP (kg/yr)	10.4	3.61	65.4	45
TN (kg/yr)	82.1	44.6	45.6	45
Gross Pollutants (kg/yr)	1550	4.94	99.7	90

* See Table 3-1

As shown in the table above, the proposed treatment strategy will achieve the operational phase pollutant load removal targets (given in Table 3-1) for total suspended solids (TSS), total phosphorus (TP), total nitrogen (TN) and gross pollutants.

3.7 Water Quality Monitoring

No water quality monitoring is recommended for stormwater discharges from the site.

Although stormwater from the development will discharge to the Corio Bay, no uncertain or untested stormwater quality best management practices are proposed, and stormwater quality monitoring is not considered to be required. The measures proposed for stormwater quality treatment are well understood and demonstrated in Melbourne.

Additionally, the level of treatment proposed is considered to be best practice and little improvement in the treatment train proposed would be possible should monitoring prove the treatment train was not operating as proposed.

3.8 Maintenance

A maintenance plan should be prepared in accordance with the guideline *Maintaining Vegetated Stormwater Assets* (Water by Design 2012).

3.9 Construction and Establishment

For the construction phase, it will be necessary to complete works in accordance with a detailed Erosion and Sediment Control Plan. It is considered that the completion of construction activities in accordance with the plan will result in compliance to applicable best practice standards.

The bioretention systems and wetlands will need to be constructed and established in accordance with:

- *Design guide for bioretention systems in Melbourne water development services schemes* (Melbourne Water 2019)

- *Wetland design manual* (Melbourne Water 2017)
- *Construction and establishment guidelines: swales, bioretention systems and wetlands guideline* (Water by Design 2010b).

The appropriate construction and establishment of the proposed treatment systems will be critical to maximising their ability to protect waterway health and minimise operational difficulties (and maintenance requirements).

3.10 Asset Hand-over

The bioretention systems, GPTs and constructed wetlands will all need to be handed over to CoGG. The most useful guidance for asset handover is provided in the *Transferring ownership of vegetated stormwater* guideline (Water by Design 2012b).

4 Stormwater Quantity Management

4.1 Preamble

With reference to the precinct plan, hydrologic and hydraulic modelling of site stormwater runoff has been completed for the purposes of developing and assessing a pre-concept drainage plan to manage minor to major flows. The modelling was carried out using newly revised models for the Rippleside main drain catchment, completed as part of the Rippleside Catchment Drainage Flood Study (2021).

4.2 Stormwater Quantity Objectives

The identified objectives of this component of the strategy are as follows:

- With regard to existing site flood conditions, assess site flood risk, both local catchment and regional, for the ultimate development state indicated by the precinct plan.
- Assess the potential impact of the site development on the receiving catchment (i.e. to the Rippleside outlet).
- Identify a pre-concept drainage plan to manage stormwater (quantity) runoff from the site.
  - Includes provision for conveyance of stormwater runoff of the 20% to 10% AEP event within the underground drainage system.
  - Includes provision for major flooding, being that in excess of the 10% AEP, along major roadways and open space.
  - For overland flow (i.e. major flooding), the applicable floodway safety criteria (Melbourne Water, 2017) are:
    - Roadways: average depth ≤300 mm and average velocity-depth product ≤0.35.
    - Drainage reserve (open space): actual depth ≤400 mm and actual velocity-depth product ≤0.35.

4.3 Minimum Development Levels

In accordance with drainage planning guidelines (Melbourne Water, 2017), site filling such that future allotment ground levels are above the 1% AEP flood level plus 300 millimetres freeboard has been assumed in order to establish the minimum development levels. Newly revised flood modelling for the ultimate catchment development state including the Saleyards precinct (flood modelling reported separately) has established regional catchment flood levels adjacent to the site on the northern and southern drains, shown in Table 4-1.

Table 4-1 Saleyards Precinct Minimum Development Levels

Location	Minimum Development Levels*
Northern Drain, Weddell Road	14.7 m AHD plus freeboard
Southern Drain, Weddell Road	13.3 m AHD plus freeboard
* Based on regional 1% AEP peak flood levels.	

The majority of the site is presently at an elevation greater than 15.0 m AHD (1% AEP plus 300 mm freeboard), hence from the perspective of flooding, minimum development levels of the site would necessitate some filling along the eastern fringe of the site's existing ground levels only.

Together with the existing site topography and minimum development levels, these indicative surface levels have been used as the basis for the concept drainage layout. All buildings have been raised to be free from inundation and roadways are above the minimum development levels.

4.4 Modelling Update

4.4.1 Site Layout and Impervious Fraction

The delineation of land use provided by the precinct plan, reproduced in Figure 3-1, together with required assumptions regarding approximate site fraction imperviousness prescribed in the study brief (section 5.5), have informed the revision to the modelling for the Saleyards precinct in its ultimate development state. The fraction impervious assigned to land use types of the site precinct plan are shown in Table 4-2. The site effective impervious fraction by subcatchment is shown in Figure 4-1.

Table 4-2 Precinct Development Fraction Impervious

Site Land Use	Fraction Impervious
Buildings	100%
Paths	100%
Roads	90%
Unspecified paving and mixed courtyard use	80%
Open space	5%
Garden	0%

The developed state subcatchment fraction imperviousness has been added to a revision of the RORB hydrologic model simulated for the 10% and 1% AEP events.

4.4.2 Rational Method Comparison

In order to provide a comparison and 'sanity' check of calculated subcatchment flows rates, the developed case peak flows produced by the RORB hydrologic model for the subcatchments spanning the Saleyards precinct have been compared to those predicted by the Rational Method. The comparison of peak flows is shown in Table 4-3.

Peak flows predicted by the Rational Method are very similar to those predicted by the hydrologic model, providing confidence in the predicted flows used for this assessment.

Table 4-3 Rational Method, Comparison of Site Peak Flows

Event AEP / Subcatchment	Peak Flow (m^3/s)		
10% AEP (15 minutes storm)	**RORB**	**Rational**	**Difference**
Saleyards northern subcatchment (“BA”)	0.84	0.84	+0%
Saleyards southern subcatchment (“BB”)	0.73	0.72	-1.4%
1% AEP (15 minutes storm)	**RORB**	**Rational**	**Difference**
Saleyards northern subcatchment (“BA”)	1.80	1.71	-5.0%
Saleyards southern subcatchment (“BB”)	1.50	1.46	-2.7%

For reference, the calculated Rational Method parameters for the precinct subcatchments are provided in Table 4-4.

Table 4-4 Rational Method Parameters

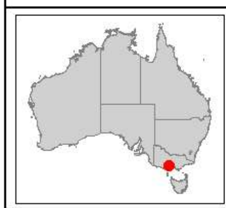
Parameter	Value
Saleyards northern subcatchment (“BA”)	
Subcatchment area	5.29 ha
Runoff coefficient C10	0.83
Flowpath length	420 m
Time of concentration	9 minutes
Q10 rainfall intensity	68.8 mm/h
Q100 rainfall intensity	117.0 mm/h
Saleyards southern subcatchment (“BB”)	
Subcatchment area	4.52 ha
Runoff coefficient C10	0.83
Flowpath length	430 m
Time of concentration	9 minutes
Q10 rainfall intensity	68.8 mm/h
Q100 rainfall intensity	117.0 mm/h

4.4.3 Roughness

Surface roughness, as represented in the hydraulic model by Manning’s ‘n’ coefficient, has been assigned to the precinct according to land use. Roughness values are based upon recommendations from *Table 5.2* in Melbourne Water (2018). Table 4-5 shows the Manning’s ‘n’ values added to the hydraulic model for the precinct development.

Table 4-5 Hydraulic Model Manning's 'n' Values

Material ID	Land Use Type	Manning's 'n' Value
3	Roads and paved surface	0.020
4	Open space	0.030
20	Unspecified paved	0.025
21	Mixed surface/garden	0.030
22	Urban building (medium-high density)	0.200



LEGEND

Catchment Flows

Subcatchments

Proposed Land Use

- Park/Open Space
- Garden Bed
- Path
- Building
- Reserve
- Not Specified
- Paving/Nature Strip

Aerial Image 20 April 2019 by nearmap.com

Title:

Saleyards Precinct Development Impervious Fraction

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Figure: 4-1

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4.4.4 Drainage Network

A concept underground piped drainage network to support the developed precinct is shown on Figure 4-2. Developed through iterative hydraulic modelling, the underground component of the drainage network is sized to cater for flows up to the 10% AEP event. The network consists of pipes that generally follow the gradient of the land and, within major roadways, are intended to be aligned with the streetscape bioretention swales such that excess runoff during events that exceed the capacity of the bioretention swales flows to the roadway kerb and to inlet pits.

A design blockage factor of 50% has been applied to all inlet pits (Melbourne Water, 2019). The inlet pits and pipes included in the concept drainage plan are listed in Table 4-6.

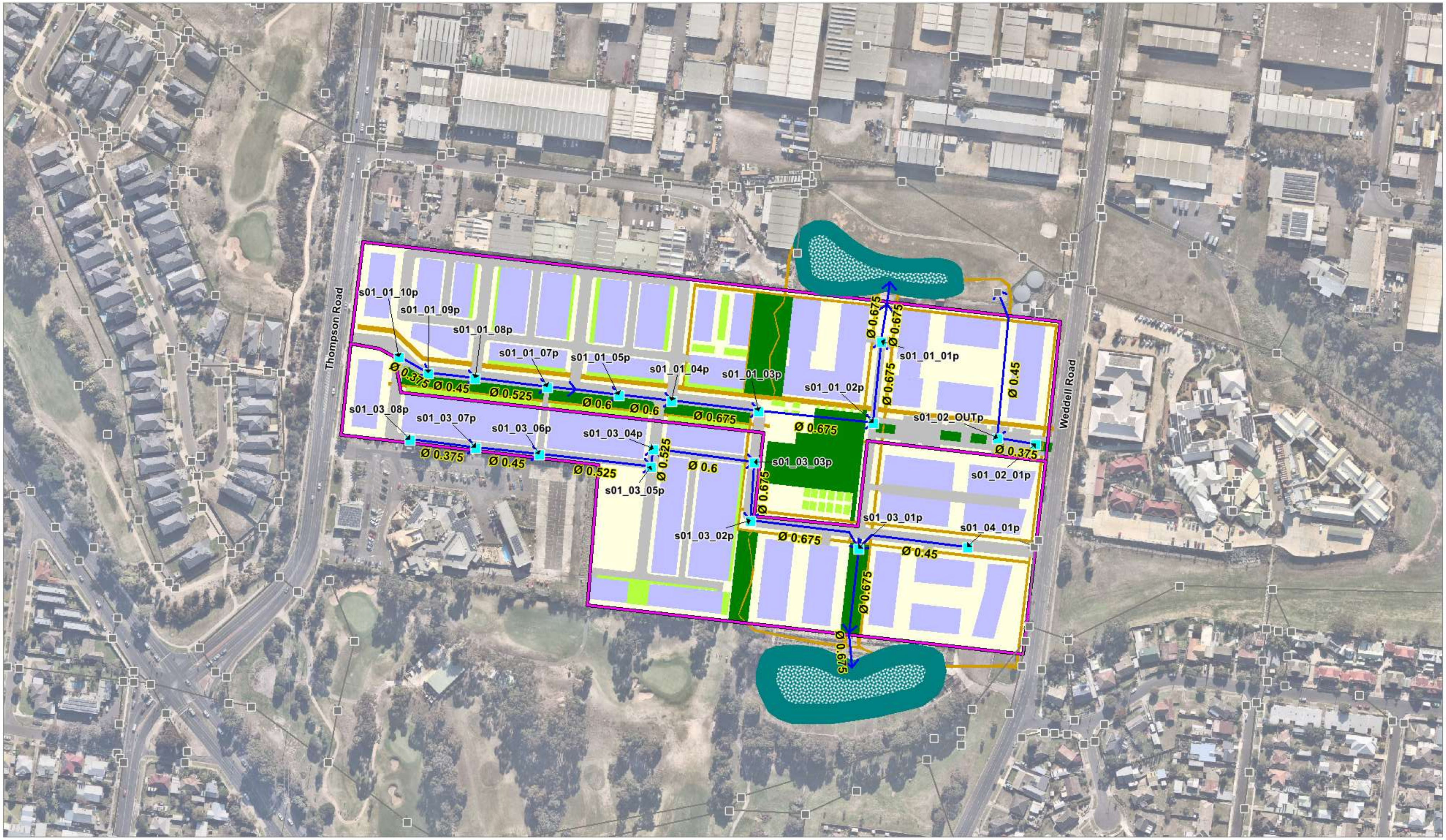
The sizing and locations of structures are at this stage indicative and would be subject to completion of detailed design. Of note is the floodway/road reserve that includes the blue stone street. The location of underground stormwater infrastructure at this location would need to accommodate this heritage asset.

Table 4-6 Concept Piped Drainage Infrastructure

Item Label	Quantity & Dimension
Stormwater Pipes	
s01_01_01	1x 675 dia.
s01_01_02	1x 675 dia.
s01_01_03	1x 675 dia.
s01_01_04	1x 675 dia.
s01_01_05	1x 600 dia.
s01_01_06	1x 600 dia.
s01_01_07	1x 525 dia.
s01_01_08	1x 525 dia.
s01_01_09	1x 450 dia.
s01_01_10	1x 375 dia.
s01_01_OUT	1x 675 dia.
s01_02_01	1x 375 dia.
s01_02_OUT	1x 450 dia.
s01_03_01	1x 675 dia.
s01_03_02	1x 675 dia.
s01_03_03	1x 675 dia.
s01_03_04	1x 600 dia.
s01_03_05	1x 525 dia.
s01_03_06	1x 525 dia.
s01_03_07	1x 450 dia.
s01_03_08	1x 375 dia.
s01_03_OUT	1x 675 dia.

Item Label	Quantity & Dimension
s01_04_01	1x 450 dia.
Inlets	
s01_01_10p	1x 1.2m grated side entry inlet
s01_01_08p	2x 1.2m grated side entry inlet
s01_01_07p	2x 1.2m grated side entry inlet
s01_01_05p	2x 1.2m grated side entry inlet
s01_01_04p	2x 1.2m grated side entry inlet
s01_01_03p	2x 1.2m grated side entry inlet
s01_01_02p	2x 1.2m grated side entry inlet
s01_01_01p	2x 1.2m grated side entry inlet
s01_02_OUTp	2x 1.2m grated side entry inlet
s01_02_01p	2x 1.2m grated side entry inlet
s01_03_08p	2x 1.2m grated side entry inlet
s01_03_07p	2x 1.2m grated side entry inlet
s01_03_06p	2x 1.2m grated side entry inlet
s01_03_04p	2x 1.2m grated side entry inlet
s01_03_03p	2x 1.2m grated side entry inlet
s01_03_02p	2x 1.2m grated side entry inlet
s01_03_01p	2x 1.2m grated side entry inlet
s01_04_01p	2x 1.2m grated side entry inlet
s01_03_05p	2x 1.2m grated side entry inlet
s01_01_09p	2x 1.2m grated side entry inlet
* Shown on Figure 4-2 are inlet labels and pipe diameters, with inlet labels ending with ‘p’. The stormwater pipes referred to in this table may be found adjacent (downstream) of the inlets of the same name, for example, inlet S01_01_10p adjoins pipe S01_01_10.	

For runoff that exceeds the capacity of the pipe network, runoff is intended to flow along roadways, generally following the natural fall of the ground prior to discharging to the precinct discharge points, being the northern basin and southern crown land. It is assumed that the site topography is maintained such that the park area central to the site is maintained as a floodway (overland flow path) to contribute to conveyance of major storm events.



LEGEND

Subcatchment Boundary

Saleyards Inlet Pit

Saleyards Stormwater Pipe (diameter in metres)

Regional Catchment Stormwater Inlet/Junction

Regional Catchment Stormwater Pipe

Aerial Image 20 April 2019 by nearmap.com

Title:

Saleyards Precinct Development Concept Drainage Network

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4.5 Impact Assessment

4.5.1 Design Events

The ensemble of 10% and 1% AEP events and durations, between 10 minutes and 24 hours have been simulated through the hydraulic model in order to identify the critical duration events that produce peak regional flooding (i.e. the Rippleside main drains) and local flooding originating from the site. Table 4-7 provides a summary of the critical duration events for the site that have been used for this assessment, together with base and developed case peak flows (combined piped and overland flow, if any).

Table 4-7 Peak Flow Summary

Event AEP and Location	Critical Duration (Temporal Pattern)	Base Case Peak Flow (m^3/s)	Saleyards Precinct Developed Case Peak Flow (m^3/s)
10% AEP Event			
Local – Saleyards northern subcatchment	15 min (TP17)	0.58	0.75
Local – Saleyards southern subcatchment	15 min (TP17)	0.37	0.64
Regional – Weddell Road Crossing	2 hr (TP17)	2.85	2.85
1% AEP Event			
Local – Saleyards northern subcatchment	15 min (TP29)	1.02	1.28
Local – Saleyards southern subcatchment	15 min (TP29)	0.86	0.95
Regional – Weddell Road Crossing	2 hr (TP17)	9.56	9.03

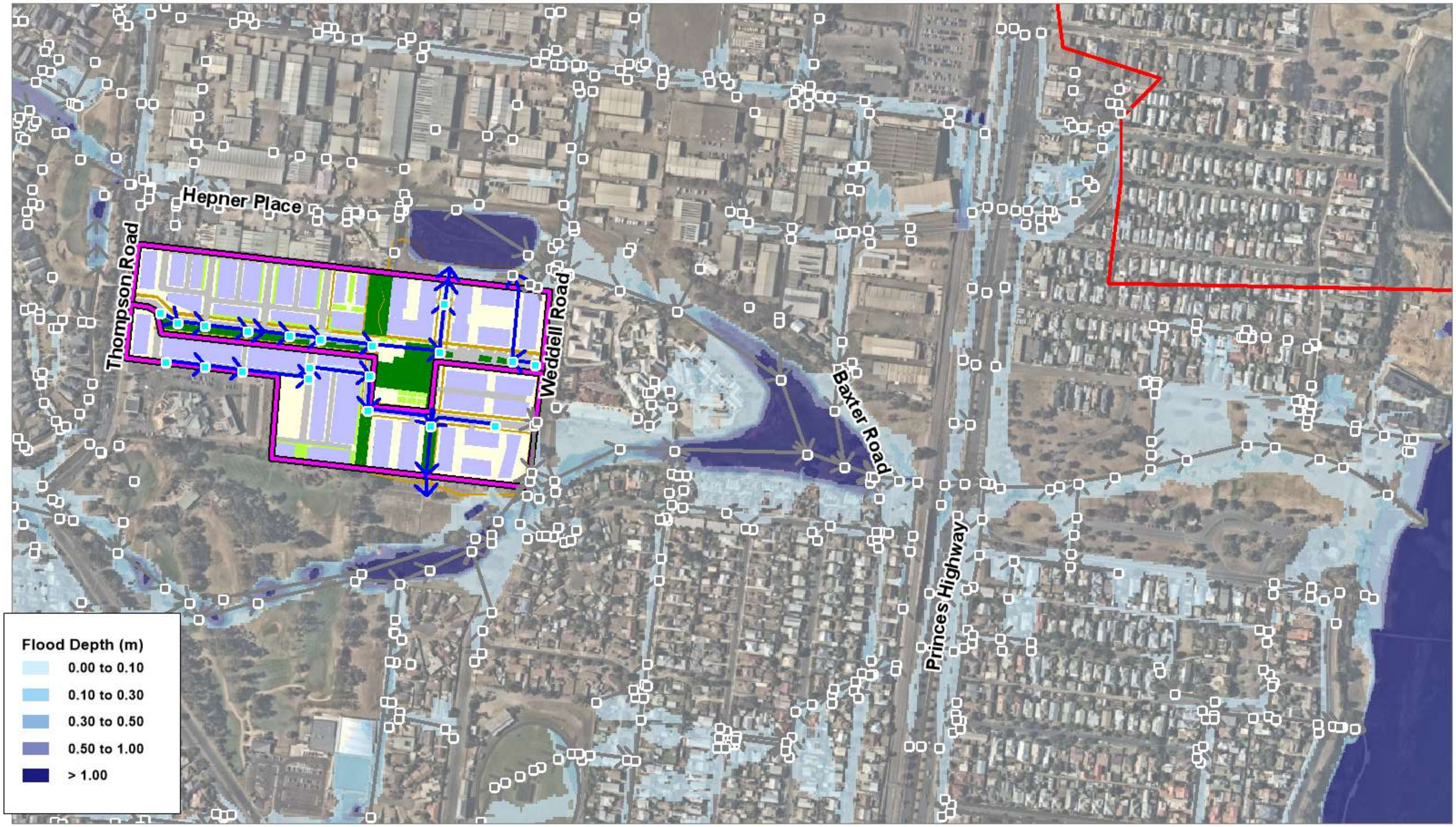
4.5.2 Impacts

The peak flood depths for the ensemble 10% and 1% AEP events following development and with the above drainage measures in place are shown on Figure 4-3 and Figure 4-4. Furthermore, potential impacts of the pre-concept drainage plan on downstream receiving drains to the catchment outlet have been assessed.

As shown on Figure 4-5 to Figure 4-8, the site pre-concept drainage plan is not predicted to have an adverse impact to flooding in the downstream regional catchment. Whilst the provision of piped drainage for the site results in an overall increase to runoff peak flow, the relatively small increase that occurs in the short storm duration does not propagate or worsen flooding in the catchment downstream of the site. Runoff volumes are unchanged.

Furthermore, the provision of the proposed detention storage to the northern basin and southern crown land would aid in reducing peak flows along the main drains passing Weddell Road. Impacts downstream of the site on crown land and due to the proposed Saleyards development are contained to crown land. The extent of inundation predicted across Weddell Road, adjacent to the site, is reduced in the 1% AEP event.

Visible on Figure 4-8, there are small, isolated instances where the hydraulic model indicates afflux in the Rippleside drain floodplain. The model results have been thoroughly reviewed however and where such modelling artefacts occur, it is a modelling artefact unrelated to the site development.



LEGEND

- Rippleside Catchment
- Saleyards Subcatchments
- Saleyards Inlet Pit
- Saleyards Stormwater Pipe
- Regional Catchment Stormwater Inlet/Junction
- Regional Catchment Stormwater Pipe

Title:

Saleyards Precinct Concept Drainage Plan
10% AEP Peak Flood Depth

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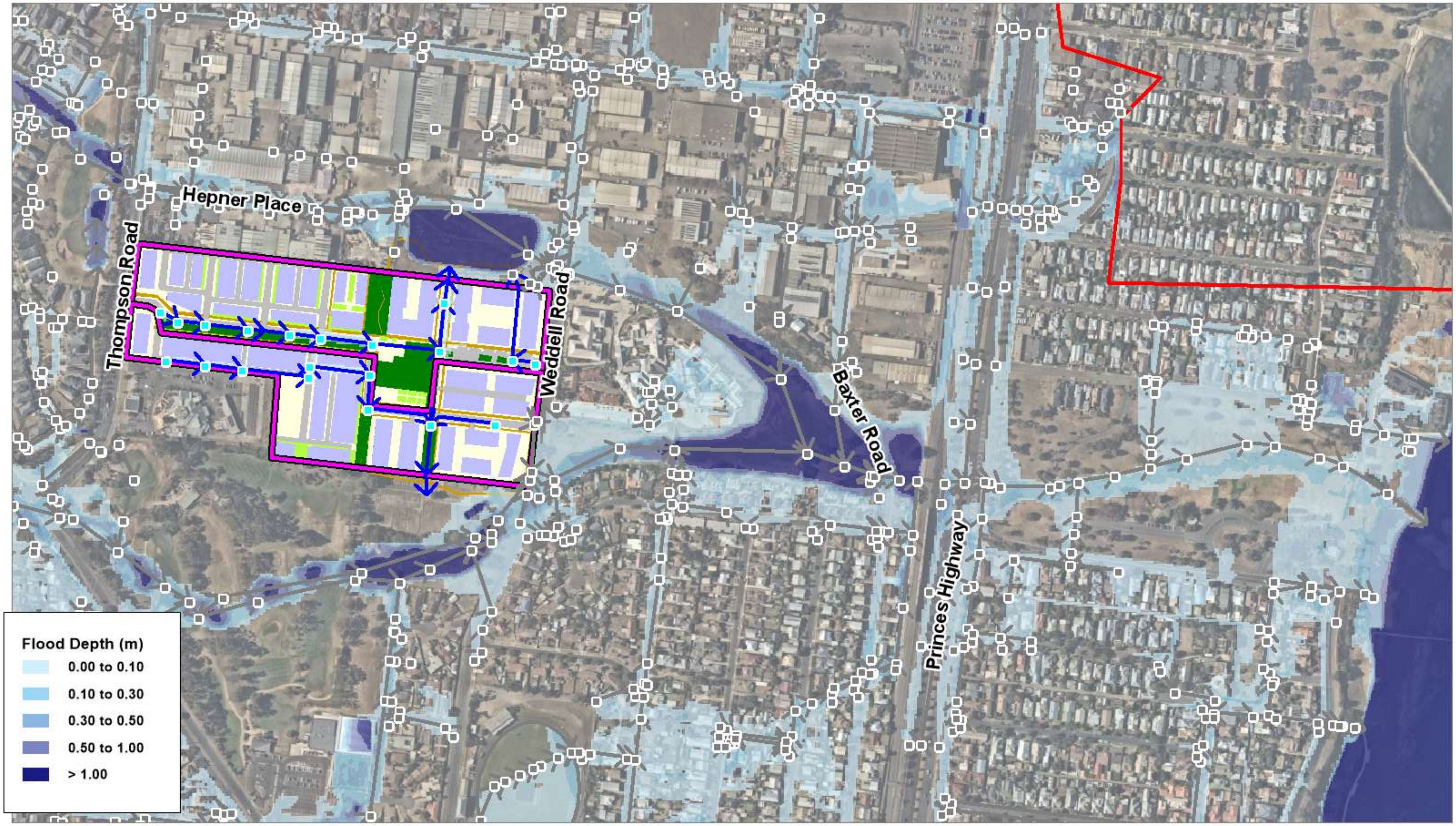

LEGEND

- Rippleside Catchment
- Saleyards Subcatchments
- Saleyards Inlet Pit
- Saleyards Stormwater Pipe
- Regional Catchment Stormwater Inlet/Junction
- Regional Catchment Stormwater Pipe

Title:

Saleyards Precinct Concept Drainage Plan
1% AEP Peak Flood Depth

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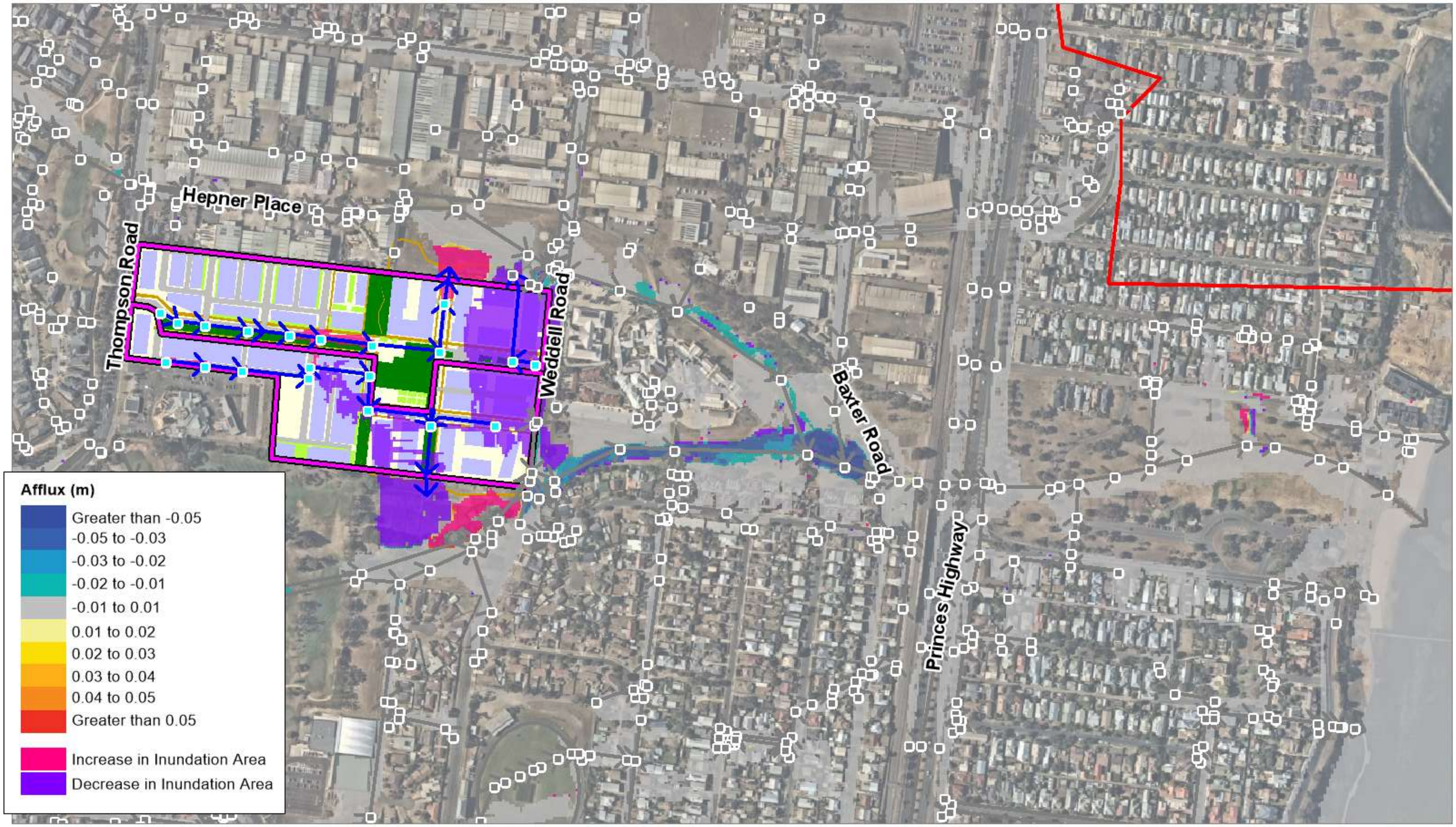

LEGEND

- Rippleside Catchment
- Saleyards Subcatchments
- Saleyards Inlet Pit
- Saleyards Stormwater Pipe
- Regional Catchment Stormwater Inlet/Junction
- Regional Catchment Stormwater Pipe

Title:

Saleyards Precinct Concept Drainage Plan
10% AEP Local Catchment Event Afflux

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LEGEND

- Rippleside Catchment
- Saleyards Subcatchments
- Saleyards Inlet Pit
- Saleyards Stormwater Pipe
- Regional Catchment Stormwater Inlet/Junction
- Regional Catchment Stormwater Pipe

Title:

Saleyards Precinct Concept Drainage Plan
10% AEP Regional Catchment Event Afflux

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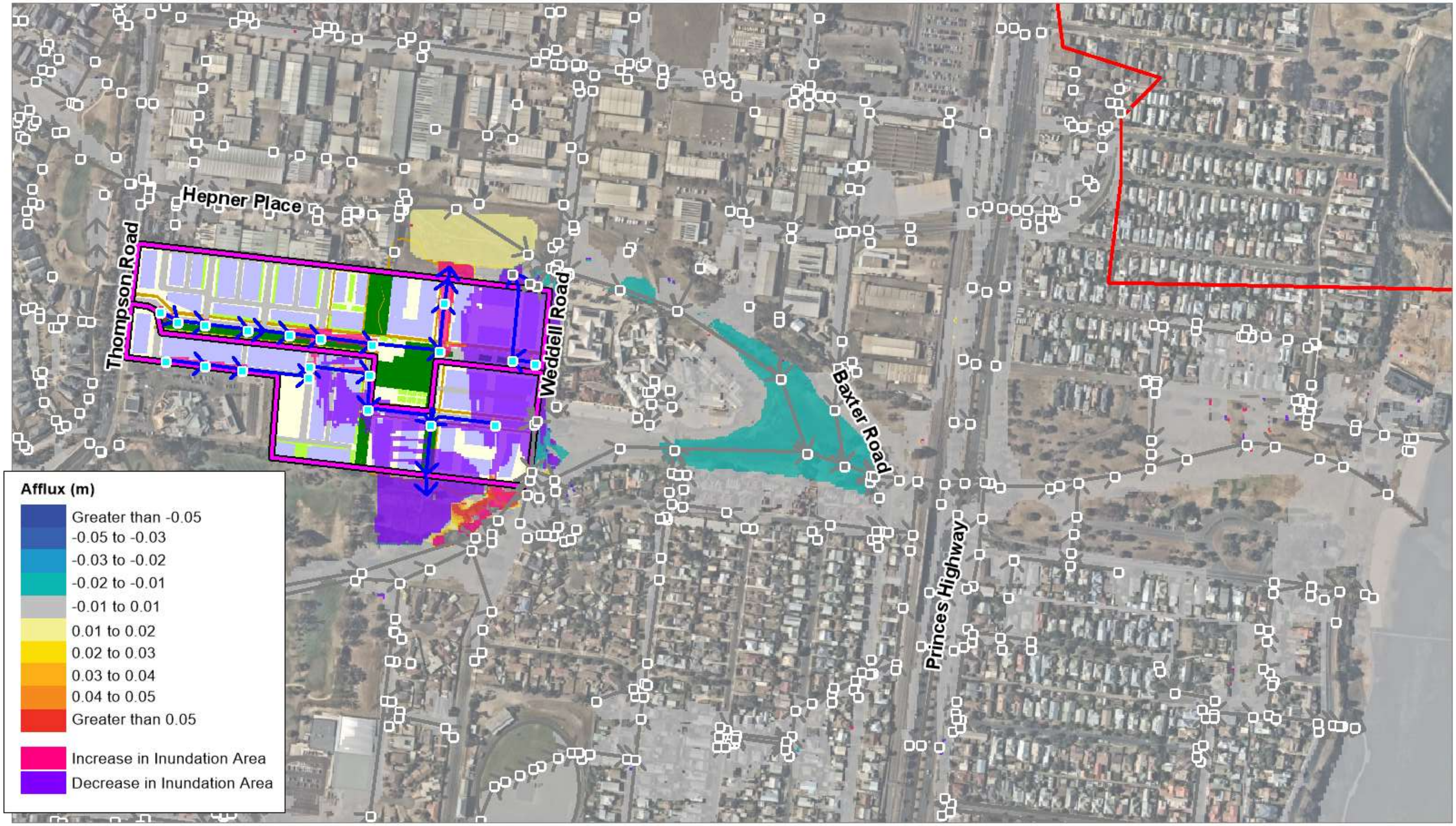

LEGEND

- Rippleside Catchment
- Saleyards Subcatchments
- Saleyards Inlet Pit
- Saleyards Stormwater Pipe
- Regional Catchment Stormwater Inlet/Junction
- Regional Catchment Stormwater Pipe

Title:

Saleyards Precinct Concept Drainage Plan
1% AEP Local Catchment Event Afflux

Figure: **4-7**

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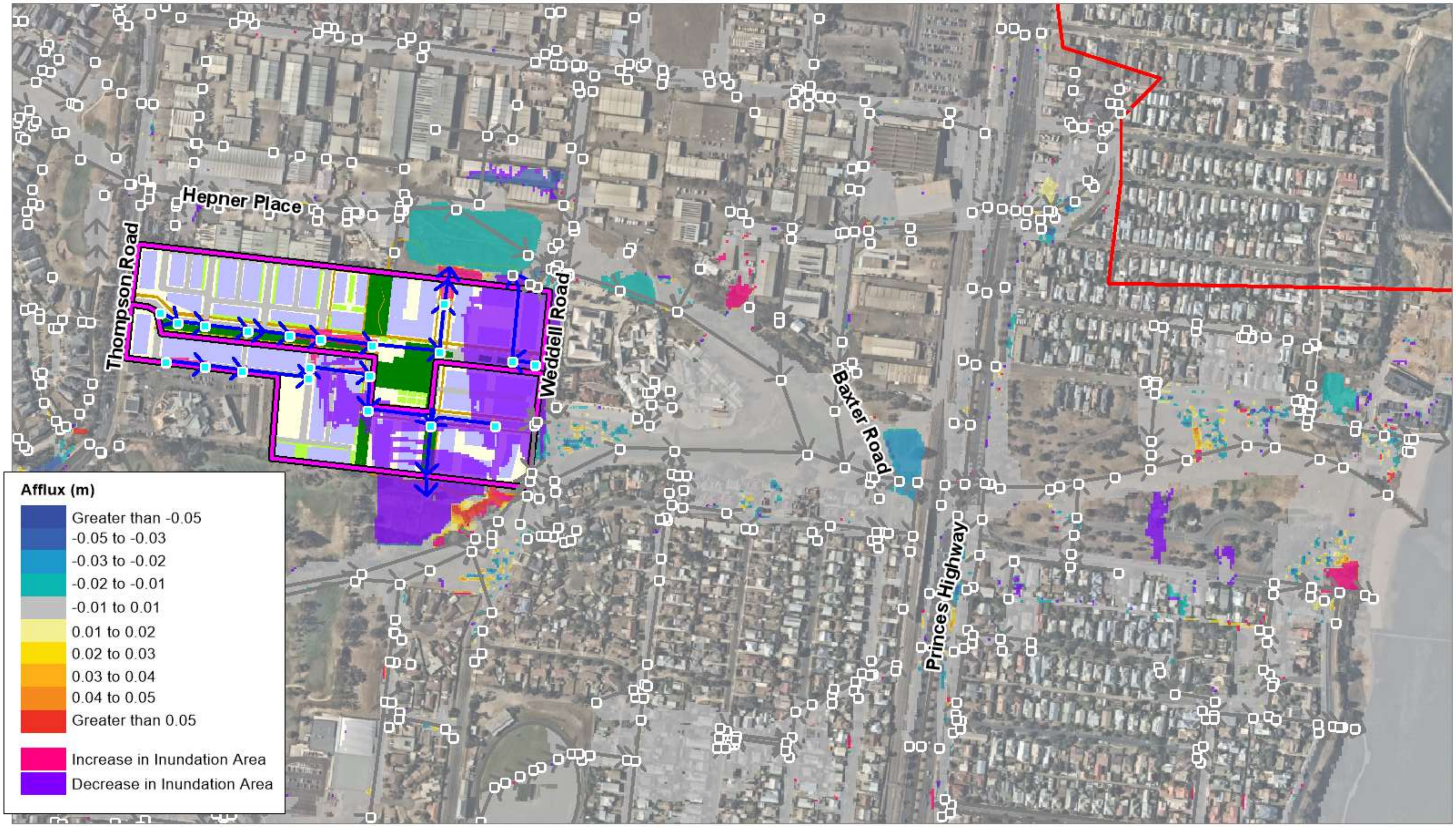

LEGEND

- Rippleside Catchment
- Saleyards Subcatchments
- Saleyards Inlet Pit
- Saleyards Stormwater Pipe
- Regional Catchment Stormwater Inlet/Junction
- Regional Catchment Stormwater Pipe

Title:

Saleyards Precinct Concept Drainage Plan
1% AEP Regional Catchment Event Afflux

Figure: **4-8**

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5 Conclusion

The assessment described in this report presents the changes to stormwater quality and quantity predicted as a result of the future redevelopment of the Geelong Saleyards precinct. A proposed strategy for the management of stormwater quality pollutants and runoff leaving the site is provided, prepared in accordance with best practice standards.

The strategy has highlighted the planning controls from the precinct plan relevant to stormwater management, site opportunities and constraints. A stormwater quality management strategy has been developed which responds to the various planning controls by striking a balance between the opportunities and constraints identified and developing responsive treatment systems.

The pre-concept design stormwater quality modelling described in this report determined that the proposed treatment strategy will result in a decrease in stormwater pollutant loads, with stormwater quality objectives being met for TSS, TP, TN and GP. The stormwater quantity modelling has quantified the magnitude of runoff flows predicted for the site and identified a strategy of underground piped drainage and overland floodways to manage flooding on-site and avoid adverse flood impact to the downstream Rippleside drain.

Further refinement of the strategy will be required as the design of the site progresses.

6 References

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Appendix A MUSIC Modelling Methodology & Results, & Treatment Strategy Details

As described in Section 3.4, the MUSIC modelling software was used to assess the generation, transportation and management / treatment of flows and pollutant loads from the site.

This appendix provides a detailed description of the modelling methodology applied.

A.1 Software

The performance of possible stormwater treatment strategies in managing stormwater pollutants (during the operational phase) has been assessed using the MUSIC software package (Version 6.2.1) developed by the CRC for Catchment Hydrology and now supported by the eWater CRC. MUSIC is well suited to the assessments required for the proposed development, i.e. prediction of annual discharge loads of total suspended solids (TSS) total phosphorus (TP), total nitrogen (TN) and gross pollutants (GP). The software has been specifically designed to allow comparisons to be made between different stormwater management systems and thereby function as a decision support tool.

A.2 Meteorological Data

In accordance with the CoGG guidelines, meteorological data was obtained from CoGG's website i.e. '*10year_GeelongNorth_1971-1980_6min*'. Modelling of the site was performed for a period of ten years (from 1 January 1971 to 31 December 1980) at 6-minute time steps.

A.3 Modelling Scenarios

The following two scenarios were modelled:

- **Developed Case – Unmitigated Site**. The developed case without mitigation is essentially an assessment of what would occur if the site were developed without any integration of stormwater treatment devices or pollution control measures. For consistency, the unmitigated site has been modelled using identical source node parameters as that of the scenario for modelling the developed site incorporating treatment solutions.
- **Developed Case – Mitigated with Stormwater Quality Treatment Solutions**. This case is an assessment of the fully developed site with all stormwater quality treatment solutions installed and working at their 'design' capacities. The option assessed includes a series of at-source and end-of-pipe treatment systems.

A.4 Source Nodes

The user is required to specify source nodes within MUSIC. The source nodes represent the pollutant generating areas of the site. A summary of the source node properties used in the MUSIC modelling (and the methodology used to derive them) is provided below.

A.4.1 Source Node Categories and Areas

Land use categories were selected to represent, as accurately as possible, how the development will generate stormwater. This was based on the Indicative Concept Plan from the Precinct Plan (Figure 1-3). The land use categories and source node areas adopted for the MUSIC modelling are summarised in Table A-3. The imperviousness adopted for each of these source nodes is provided in Table A-2.

Table A-1 Land Use Categories and Source Node Areas

Block*	Total Area (Ha)	Land Use Category	Area (Ha)	Percentage (%)
1	2.143	Building	0.946	44.12
1		Landscaping	0.103	4.80
1		Courtyards/paving	0.532	24.83
1		Path	0.104	4.85
1		Road	0.459	21.43
2	0.467	Building	0.291	62.19
2		Courtyards/paving	0.138	29.50
2		Path	0.037	7.83
2		Road	0.002	0.48
3	0.861	Building	0.413	47.96
3		Courtyards/paving	0.410	47.60
3		Path	0.036	4.19
3		Road	0.002	0.28
4	2.390	Building	1.111	46.47
4		Landscaping	0.138	5.79
4		Courtyards/paving	0.572	23.95
4		Park	0.162	6.78
4		Path	0.060	2.51
4		Road	0.349	14.61
5	0.718	Building	0.351	48.84
5		Courtyards/paving	0.260	36.25
5		Path	0.035	4.83
5		Road	0.073	10.11
6	0.437	Building	0.222	50.65
6		Courtyards/paving	0.202	46.23
6		Path	0.009	2.08
6		Road	0.005	1.06
7	0.775	Building	0.307	39.57

Block*	Total Area (Ha)	Land Use Category	Area (Ha)	Percentage (%)
7		Courtyards/paving	0.429	55.35
7		Path	0.035	4.48
7		Road	0.005	0.61
8	0.591	Landscaping	0.038	6.37
8		Courtyards/paving	0.240	40.67
8		Park	0.299	50.69
8		Path	0.013	2.16
8		Road	0.001	0.11
9	1.834	Path	0.040	2.21
9		Reserve	1.794	97.80
10	1.002	Path	0.035	3.45
10		Reserve	0.967	96.55
Bluestone Street	0.202	Courtyards/paving	0.034	16.92
Bluestone Street		Park	0.081	40.13
Bluestone Street		Path	0.004	1.89
Bluestone Street		Road	0.083	41.05
East/West Parking Street	0.290	Courtyards/paving	0.048	16.47
East/West Parking Street		Park	0.029	9.91
East/West Parking Street		Path	0.037	12.82
East/West Parking Street		Road	0.177	60.81
East/West Street	0.220	Park	0.001	0.36
East/West Street		Road	0.220	99.97
Park Street	0.359	Building	0.000	0.01
Park Street		Courtyards/paving	0.020	5.70
Park Street		Park	0.241	67.15
Park Street		Path	0.035	9.68
Park Street		Road	0.063	17.48
UnNamed	0.140	Courtyards/paving	0.000	0.01
UnNamed		Road	0.140	99.99

* Refer to Figure 3-1.

Table A-2 Summary of Source Node Adopted Imperviousness

Parameter	MUSIC Zoning/Surface Type	Adopted Imperviousness (%)
Roads	Sealed road	90
Laneways	Sealed road	100
Landscaping/garden	Residential	0
Paths	Residential	100
Buildings	Roofs	100
Courtyards/paving	Residential	100
Paving	Residential	100

A.4.2 Rainfall-runoff Parameters

Rainfall-runoff have been applied in accordance with the *MUSIC – modelling approach and parameters - design note 3* (CoGG 2019) and Melbourne Water's *MUSIC guidelines* (2018). The source node properties adopted for the MUSIC modelling are summarised Table A-3.

Table A-3 Adopted Rainfall Runoff Parameters

Parameter	Adopted Value
Rainfall threshold (mm/day)	1.0
Soil storage capacity (mm)	120
Initial storage (% of capacity)	25
Field capacity (mm)	50
Infiltration capacity coefficient – a	200.0
Infiltration capacity exponent – b	1.00
Initial depth (%)	10
Daily recharge (%)	25.00
Daily baseflow rate (5)	5.0
Daily deep seepage rate (%)	0.00

A.4.3 Pollutant Export Characteristics

Pollutant export characteristics modelling using the spilt catchment approaching using parameters in accordance with the *MUSIC – modelling approach and parameters - design note 3* (CoGG 2019) and Melbourne Water's *MUSIC guidelines* (2018). The source node properties adopted for the MUSIC modelling are summarised Table A-4.

Table A-4 Adopted Pollutant Export Characteristics

Pollutant	Surface type	Storm flow		Base flow	
		Mean (log mg/L)	SD (log mg/L)	Mean (log mg/L)	SD (log mg/L)
Total suspended solids (TSS)	Roof	1.301	0.333	n/a*	n/a
	Road	2.431	0.333	n/a	n/a
	All other urban	1.882	0.333	0.96	0.401
Total phosphorus (TP)	Roof	-0.886	0.242	n/a	n/a
	Road	-0.301	0.242	n/a	n/a
	All other urban	-0.680	0.242	-0.731	0.360
Total Nitrogen (TN)	Roof	0.301	0.205	n/a	n/a
	Road	0.342	0.205	n/a	n/a
	All other urban	0.224	0.205	0.346	0.309

A.5 Treatment Nodes

As noted in Section 3.5, the treatment strategy consists of streetscape bioretention swales, gross pollutant traps and wetlands. The treatment node parameters for each of these is provided in the below tables. Modelling of treatment nodes was undertaken in accordance with *MUSIC – modelling approach and parameters - design note 3* (CoGG 2019) and Melbourne Water's *MUSIC guidelines* (2018). Given the level of modelling is for the planning stage (pre-concept design), assessment against the MUSIC Auditor tool was not undertaken.

Table A-5 Summary of Adopted Treatment Node Parameters

Treatment system	Description

Streetscape Bioretention Swales	• The properties modelled in MUSIC were:
	  • Surface areas and filter area: 0.8 metres wide (minimum width assumed to support trees) multiplied by road length
	  • Unlined filter media perimeter: 0.10 m
	  • Saturated hydraulic conductivity: 100 mm
	  • Filter depth: 0.9 metres (minimum depth required to support trees)
	  • TN content of filter media: 800 mg/kg
	  • Orthophosphate content of filter media: 55 mg/kg
	  • Exfiltration rate:0.00 mm/hr
	  • Base is lined
	  • Vegetated with effective nutrient removal plants
	  • Overflow weir: width 1.0 m
	  • Underdrainage present
	  • Submerged zone: 0.45 m deep with carbon present

<table>
<tr><th>Treatment system</th><th colspan="2">Description</th></tr>
<tr><td>Gross pollutant traps</td><td colspan="2">
The properties modelled in MUSIC for both GPTs were:

High flow bypass: 0.155 m^3/sec
Total suspended solids: 70% load reduction
Total phosphorus: 30% load reduction
Total nitrogen: 0% load reduction
Gross pollutants: 100% load reduction
</td></tr>
<tr><td rowspan="2">Constructed wetlands</td><td colspan="2">The properties modelled in MUSIC were:</td></tr>
<tr><td>Northern wetland

Inlet pond volume: 66 m^3
Surface area: 1344 m^2
Extended detention depth: 0.20 m
Permanent pool volume: 394 m^3
Initial volume: 394 m^3
Exfiltration rate: 0.00 m/hr
Evaporative loss as % of PET: 125%
Equivalent pipe diameter: 38 mm
Overflow weir width: 3.0 m
Notional detention time: 73 hrs
</td><td>Southern Wetland

Inlet pond volume: 99 m^3
Surface area: 2016 m^2
Extended detention depth: 0.20 m
Permanent pool volume: 592 m^3
Initial volume: 592 m^3
Exfiltration rate: 0.00 m/hr
Evaporative loss as % of PET: 125%
Equivalent pipe diameter: 46 mm
Overflow weir width: 3.0 m
Notional detention time: 72.8 hrs
</td></tr>
</table>

A.6 MUSIC Model

A copy of the MUSIC model schematic is provided Figure A-1. This figure provides an indication of how the model was set up including the how each sub-catchment source nodes were configured and drainage of source nodes into treatment nodes according to the assumed catchment shown in Figure 3-1.

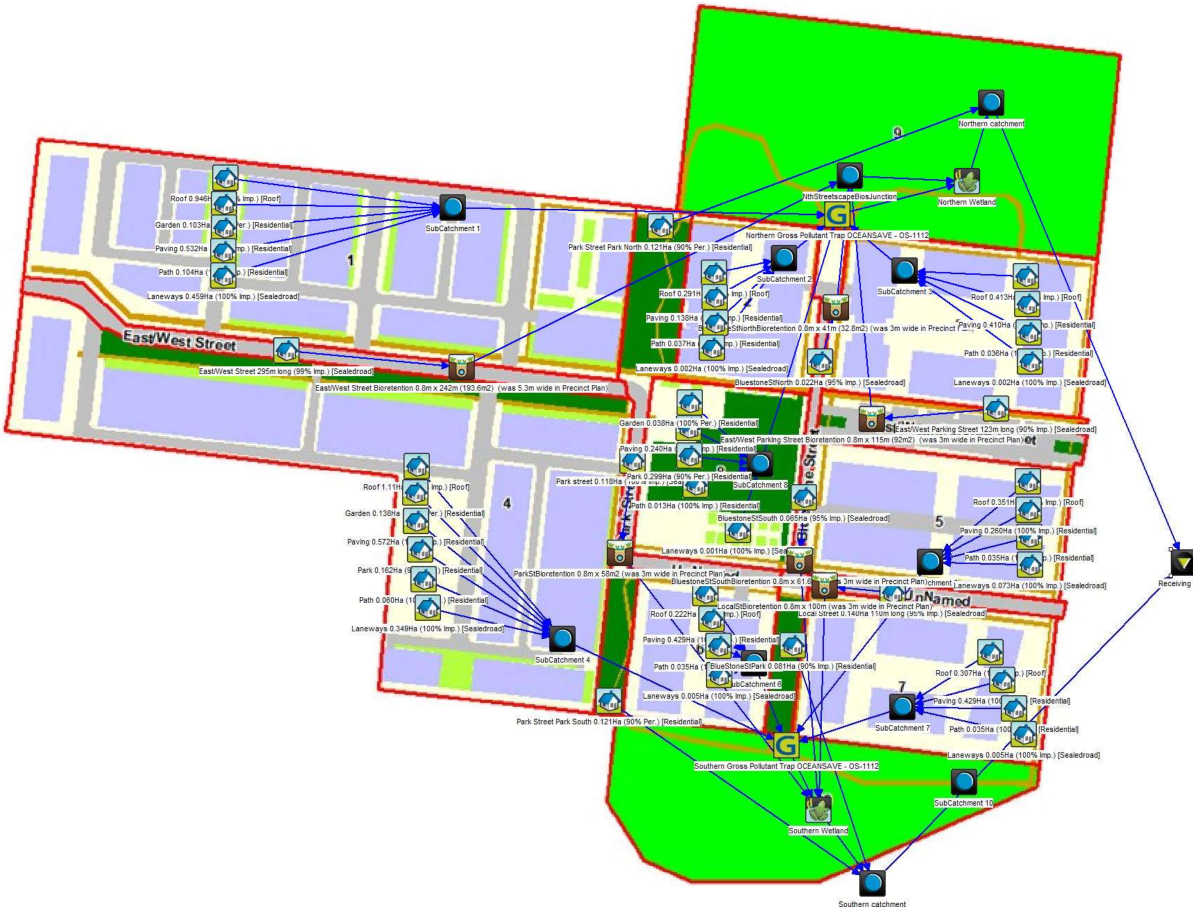

Figure A-1 MUSIC Model Schematic

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