REPORT

Lot 1006 Boolaroo (Weemala)

Concept Stormwater Management Plan & Water Sensitive Urban Design Strategy for the Revised Lot Layout ("Smaller Lots")

Client: Hunter Development Brokerage Pty Ltd

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1 Introduction

Royal HaskoningDHV (RHDHV) has been previously engaged by Hunter Development Brokerage (HDB) on behalf of GreenCapital Pty Ltd to prepare a Concept Stormwater Management Plan (SMP) and Water Sensitive Urban Design (WSUD) Strategy for the residential subdivision proposed at Lot 1006, Boolaroo (herein referred to as the subject site).

The previously approved strategy (RHDHV, dated 24 November 2020) was the basis on which the detailed stormwater management network design for Stages 1-6 and Basins A and B has been developed. However, as the design of the future stages has evolved, the development density particularly in the upper reaches of Catchments A and B is proposed to be increased and thus so too has the site's overall impervious area. As a result, the current strategy no longer accurately reflects the proposed development and in order for the new Development Application (DA) for any future stages to be approved, Lake Macquarie City Council (LMCC) has requested that a revised stormwater / WSUD strategy be provided to confirm that the sites peak flow discharge limits are not exceeded and that the pollutant load reduction targets are still able to be achieved.

Contained herein is the revised Stormwater Management Plan (SMP) and Water Sensitive Urban Design (WSUD) Strategy for the newly proposed development layout on the subject site. As per the previous adopted strategy, this revised strategy has reviewed the:

- Existing and proposed topographic conditions,
- Basin catchment areas and the routing of stormwater runoff,
- Revised development layout and lot density, and
- Existing and proposed stormwater management systems (quantity and quality).

Note for increased accuracy, this strategy utilises and expands upon the existing DRAINS and MUSIC models developed for the detailed design of Stages 1-6 (including Basins A and B), enabling an in-depth review of the implications that the revised development layout has on the current stormwater management systems and what additional systems are required (if any).

Royal HaskoningDHV

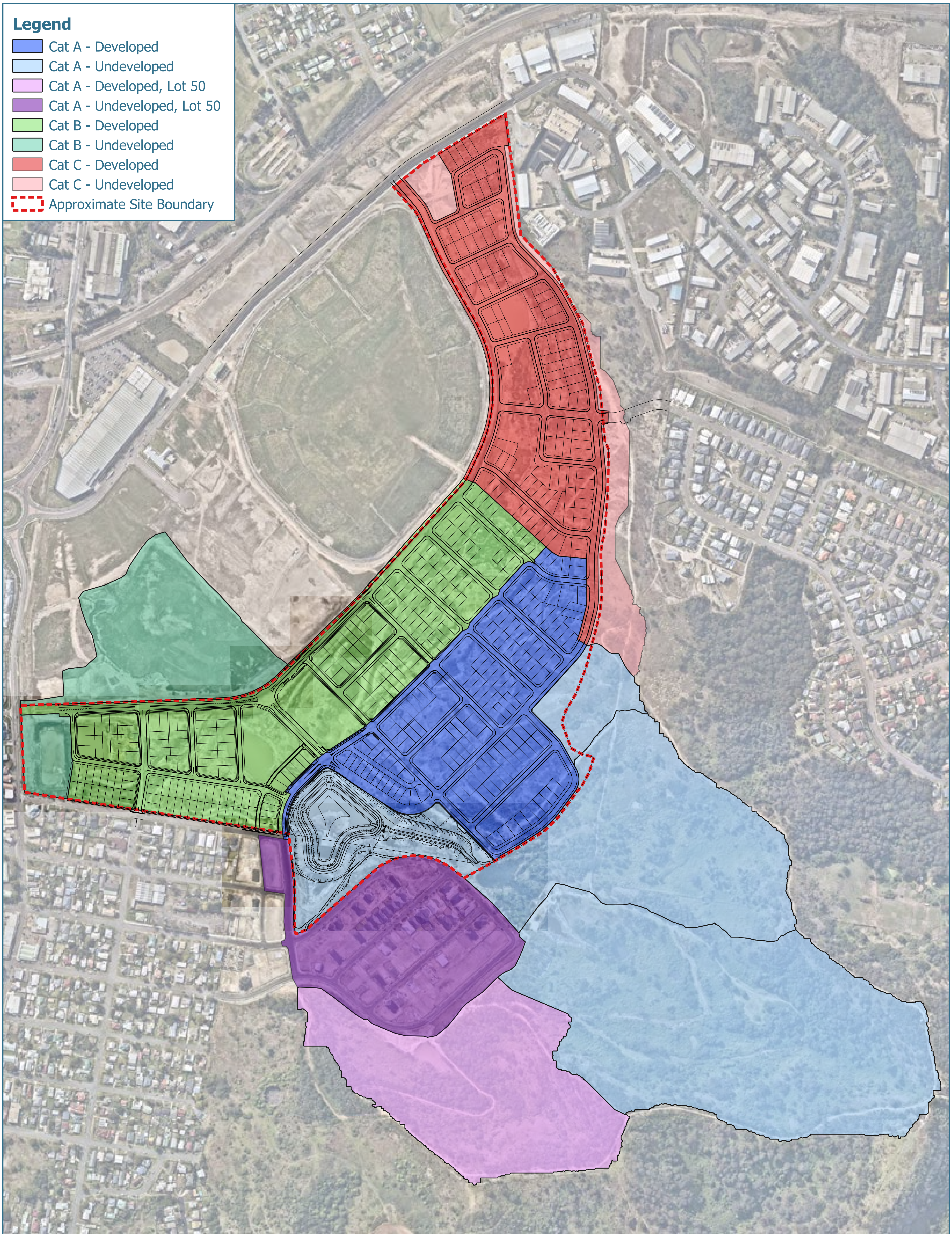
2 Description of the Proposed Development

The proposed residential development (Weemala at the Lake) is located at the intersection of Main Road and Munibung Road, Boolaroo. The development is to occur within Lot 1006, covering approximately 55.4 ha. Lot 1006 is bounded by Main Road to the west, Munibung Road to the north, and an existing residential development to the south. A steep undeveloped area is located to the east of the proposed development, which drains through the site towards Main Road. A recently constructed residential subdivision (Lot 50) exists to the south, and this development also drains to the north and into the proposed development area. Flows from this Lot 50 development have been captured and managed under the current Basin A design (the previous Lot 50 Basin has been included into an extended Basin A design footprint).

The revised development proposal now incorporates 549 residential lots (and 2 commercial areas) to be released in stages, where-as previously, only 509 residential lots (and 2 commercial areas) were proposed. Stages 1-6 have already been approved under the previous DA and Strategy and are now under construction. At the completion of these stages, 144 residential lots, 2 commercial areas, 2 detention basins and 1 park will have been provided, leaving 405 residential lots subject to future approvals.

As per the previous strategy, the majority of residential lots are suitable for single detached dwellings although some higher density residential housing is also to be provided, primarily located around open space areas and the detention basins. Conventional pit and pipe drainage with kerb and gutter is proposed to manage stormwater from residential lots and roads. Open space areas and parks are proposed of which will be similar to that provided around Basin A which functions as a constructed wetland/detention basin located near the boundary between Lot 1006 and Lot 50. Footpath and cycleways are to provide connection between the open space area and the surrounding residential development.

A map of the revised development and its internal sub-catchments is shown in **Figure 2-1**. Note, the potential development within the currently E2 zoned land has also been included within this assessment so to avoid the need to update this plan upon any future rezoning.



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Weemala - Revised SMP

Figure 2-1
Catchment Delineation for the Proposed Development

PA2519
2022-08-08
GDA94, MGA-56
Scale at A3 = 1:6000

N

0 100 200 300 m

3 Expected Changes to Catchment Hydrology

Between the undeveloped and developed states, the proposed residential development will result in an increase in the extent of impervious surfaces within the subject site and thus increase the volume and peak discharge of runoff produced from the catchment. If left unmitigated, the following hydrologic changes are expected to occur:

- Increases in runoff volumes and peak flow rates from the developed area. Broadly, this will (if unmitigated) increase stormwater flooding risks in downstream areas.
- Increased potential for stormwater pollution due to higher runoff volumes and pollutant generation potentially associated with the increase of impervious areas and change in surface type/land use.

The magnitude of these hydrologic changes will be a function of the relative change in the impervious fraction between existing and developed conditions.

An assessment of the initial hydrologic impacts was provided in RHDHV's Concept Stormwater Management Plan and Water Sensitive Design Strategy, dated 24 November 2020. Since this initial assessment, the development layout has changed yielding an increased lot density. As a result, the site's overall impervious areas have also increased therefore the hydrologic assessment undertaken previously is no longer current. This revised strategy provides a reassessment of the proposed development whilst generally maintaining the previously adopted drainage strategy and philosophy i.e. conveyance of all stormwater runoff to detention and treatment areas via a formalised pit and pipe drainage network.

In summary the total catchment area of the subject site is 126.8 ha. However due to the complexities of the site and the upstream sub-catchments, this assessment requires individual consideration of the following:

- The undeveloped area north of Fotheringham Road (known as the "IKEA Site") that reports to Basin B (7.6 ha). For the purposes of this assessment, all future development on this site must ensure predeveloped discharge conditions are maintained (Qmax = 1.2m^3/s in the 10-year ARI event, and Qmax = 3.0m^3/s in the 100-year ARI event).
- The Lot 50 Subdivision (9.9 ha developed, 12.4 ha undeveloped). The runoff generated from this developed sub-catchment has been accounted for in the Basin A designs.
- The undeveloped Munibung Hill sub-catchment (42.4 ha). The majority of this sub-catchment (37.0 ha) reports to two upstream dams that are external to the subject site however the Basin A design makes provision for these catchments to report directly to it assuming "dam full" conditions upstream. The remainder of the undeveloped Munibung Hill catchment (5.4ha) is trapped by the topography and the proposed development. Runoff from this area will require conveying to Basins A and C via a combination of swale drains and the proposed pit and pipe network.
- The remaining internal undeveloped catchment (7.2 ha). This area is assumed to report directly to one of the onsite basins (Basins A, B or C) as either direct rainfall or uninhibited overland flow generated from the surrounding open space.
- The internal developed catchments reporting to either one of the onsite basins via the pit and pipe network (Basin A = 14.2 ha, Basin B = 19.0 ha and Basin C = 14.1 ha, Total = 47.3 ha). It is these catchment areas that are the subject of this revised strategy due to the proposed increases in the impervious fraction as a result of the increased lot density.

Figure 2-1 shows the extent of the above stormwater management sub-catchment areas which are applied to the calculations that are documented in **Section 0**. In addition, please note that similar to RHDHV's previous assessment, the impervious fractions for the existing and proposed site conditions were calculated based on a review of aerial photography, and the proposed development plans provided by HDB. The impervious fraction was determined based on the proposed surface types e.g. road, verge, park/basin and lots with the assumption that the lots are generally 55% paved, 5% supplementary and 40% grassed areas as per LMCC's Development Control Plan, refer **Section 4.2.1**.

4 Stormwater Management Guidelines, Objectives and Targets

4.1 Assessment objectives

The objective of this stormwater assessment is to establish stormwater management requirements for the ultimate development proposed within the subject site whilst also accounting for all other upslope catchment areas e.g. Munibung Hill and the Lot 50 Subdivision.

The stormwater management requirements detailed herein have been established with reference to the existing conditions on the basis that no further development (other than that allowed for here) occurs within the site or reporting catchment area. If subsequent changes are made, a revision of this assessment may be required.

4.2 Relevant Stormwater Management Guidelines and Treatment Targets

4.2.1 Lake Macquarie City Council Guidelines

Lake Macquarie Development Control Plan 2014 – Revision 23, April 2020

This guideline was published by LMCC in April 2020 and outlines Council's requirements and advice on the lodgement requirements for DA's for residential developments.

Details of the stormwater management systems and the measures proposed to mitigate the effects of stormwater quantity and quality impacts on adjoining or downstream sites are to be provided ensuring they follow Council's Water Cycle Management Guidelines. RHDHV has considered the stormwater management requirements that are specified in the guideline during the preparation of the conceptual stormwater management plan. Specifically, the objectives of stormwater management are to:

- Ensure that the development does not adversely affect water quality or availability,
- Ensure that watercourses and riparian vegetation are maintained to mitigate sedimentation and keep good water quality in downstream waterways,
- Minimise adverse impacts on downstream environments or nearby land due to increased development,
- Incorporate WSUD techniques into all new developments, and
- Minimise the volume and rate of stormwater leaving a development site.

Stormwater management objectives from this guideline are summarised in **Table 4-1**, which establishes recommended stormwater management objectives for the subject site.

Water Cycle Management Guidelines – LMCC - Revision 2, June 2013

The water cycle management guidelines were published by LMCC in 2013 and provide direction on how to achieve the water management objectives as outlined in Council's Development Control Plan (DCP). These guidelines provide practical advice for implementing Water Cycle Management (WCM) principles and explore practical water management options for residents, Council, developers and businesses. The guidelines also provide recommended stormwater modelling approaches and parameters. Stormwater management objectives from this guideline are summarised in **Table 4-1**, which establishes recommended stormwater management objectives for the subject site.

Engineering Design Guidelines, LMCC - July 2016

The engineering design guidelines were published by LMCC in 2016. Section 0074 Stormwater Drainage (Design) outlines the design requirements for stormwater drainage systems design and the subsequent documentation. The requirements are generally as follows:

- To reduce the frequency of flooding of private and public buildings in flood-prone areas,
- Control of surface flows to prescribed velocity/depth limits,
- Control of surface flows to minimise the effect on pedestrians and traffic in more frequent stormwater conditions,
- Within each catchment, retention of incident rainfall and runoff consistent with the planned use of the area,
- Conformance with the Australian Rainfall & Runoff (ARR) ‘major/minor’ system concept,
- A constant average recurrence interval (ARI) for existing and reconstructed works, and
- Adoption of WSUD principles.

Specifically, the guidelines assist with the planning and design of stormwater drainage using WSUD principles including on-site detention (OSD), capture and use of stormwater as an alternative source of water to conserve potable water, use of vegetation for filtering purposes, water-efficient landscaping, protection of water-related environmental, recreational and cultural values, localised water harvesting for re-use, and localised wastewater treatment systems.

Handbook on Drainage Design Guidelines, LMCC - December 2013

The handbook on drainage design guidelines was published by LMCC in 2013, and states that it must be read in conjunction with the following:

- Lake Macquarie Development Control Plan 2014 (DCP 2014) – *now superseded (April 2020)*
- Section 0074 Stormwater Drainage (Design) of Part 1 of the Engineering Guidelines
- Part 3 of the Engineering Guidelines (Stormwater Quality Improvement Device Guidelines), and
- The drainage drawings of Part 6 of the Engineering Guidelines (Engineering Standard Drawings)

The handbook provides the requirements and guidance for the drainage of public assets or infrastructure that will become a public asset. Specifically, the document includes reference to the site discharge index (SDI)[1], general principles and requirements for on-site stormwater management and alternate discharge options.

Stormwater Quality Improvement Devices (SQID) Guidelines, LMCC - December 2013

The stormwater quality improvement devices (SQID) guidelines were published by LMCC in 2013. These guidelines were prepared to assist development applicants with identifying and arranging appropriate SQID’s to incorporate into their development. These guidelines should be considered along with Council’s requirements for stormwater management that are specified in the Water Cycle Management Guidelines (WCMGs).

The proposed development type and scale determines whether SQIDs are required for a particular development. The WCMGs outline the type and scale of development that requires a development applicant

[1] Defined as the ratio of the impermeable area that drains directly (DC) to a drainage system to the total site area (S). DCP 2014 sets a performance criteria of 0.1 (10%) for the maximum allowable SDI. On this basis, 90% of stormwater runoff from any site must be managed through suitably designed stormwater source controls.

to prepare a WCMP. The WCMGs reflect the requirements of Council's DCP 2014 and LEP 2014 that are relevant to the provision of SQIDs within development.

4.2.2 Industry Guidelines

Australian Runoff Quality

Australian Runoff Quality (ARQ) is an industry guideline document published in 2005 by the Institution of Engineers Australia (IEAust). The document provides guidance on all aspects of WSUD, including preventative measures, source controls, conveyance controls and end of pipe controls.

Australian Rainfall and Runoff

Australian Rainfall and Runoff (IEAust, 2019) (or AR&R 2019) refers to a series of documents and data that has been prepared by the Institution of Engineers, Australia and the Bureau of Meteorology. AR&R 2019 was prepared to provide designers with the best available information on design flood estimation and is widely accepted as a design guideline for all flood and stormwater-related investigation and design in Australia.

Stormwater Bioretention Systems – Adoption Guidelines

The Adoption Guidelines for Stormwater Biofiltration Systems were developed by the Facility for Advancing Water Biofiltration in 2009. This guideline contains design recommendations for biofiltration systems.

4.3 Recommended stormwater management objectives

Table 4-1 provides a summary of the stormwater management objectives that are specified in the LMCC guidelines for stormwater system design, OSD design and stormwater quality treatment. These objectives were applied to establish stormwater management requirements for the subject site.

LMCC DCP 2014 and the Water Cycle Management Guidelines were adopted to assess stormwater quality pollutant reduction targets for post-construction stormwater runoff and are presented in **Table 4-1**.

Table 4-1: Proposed stormwater management objectives for development with the subject site

Guideline Objectives Summary	
Minor stormwater system criteria (piped network)	• RHDHV have generally adopted the 10-year ARI event as the design criteria for the minor piped drainage system. However, in certain parts of the site where overland gap flows (i.e. 100-year ARI minus 10-year ARI flows) needs to be directed towards the detention basins against the natural falls, then RHDHV have increased the trunk drainage network size to closer to the 20-year ARI capacity, to maximise the amount of flow entering the detention basins. • For the south-western (main) catchment discharging under Main Road – a pre-determined outlet discharge rate of 6.5 m^3/s (via the existing Ø1200 RCP and 1800w x 600h RCBC) has been applied for the 10-year event. The minor system is to achieve this discharge rate during the 10-year ARI event in addition to being sufficiently sized to capture approximately the 20-year ARI event, for the reasons outlined above. • Otherwise parity[2] with peak flow rates at other outlet locations for the undeveloped catchment condition. • Flows above the 10-year ARI event shall be diverted to the basins via the road network and associated overland flow paths. For some parts of the upper Basin A catchment, there are areas that can't physically drain to Basin A. Therefore, the trunk drainage capacity is to be increased as noted above to ensure sufficient flow is captured by the piped network to maintain safe overland flow conditions. • As outlined earlier, approximately the 20-year ARI event has been adopted for the sizing of the pipe network in a number of areas of the site so as to reduce the overland flows produced during the 100-year ARI event. This will help maintain a safe Velocity-Depth product for the gap flows. Note gap flows are defined as the excess stormwater flows produced during the 100-year event not captured by the minor stormwater system. i.e. the overland flows within the developed catchment (100-year minus 10 or 20-year ARI).
Major stormwater system criteria (overland flows)	• The major stormwater management system has been designed to cater for the 100-year ARI event. • The major stormwater management system incorporates the road network and designated overland flow routes to direct the 'gap flow' to the basins (where possible). • All basins to have sufficient capacity to accommodate the 100-year ARI critical duration storm. • For the south-western catchment discharging under Main Road – a predetermined outlet discharge rate of 8.6 m^3/s (via the existing Ø1200 RCP and 1800w x600h RCBC) has been applied for the 100-year event. • Otherwise parity with undeveloped conditions at other outlet locations.[2] • Velocity x Depth (VD) product of overland flows ≤0.4 m^2/s for the 100-year ARI event. • Subdivision house pads that are located in proximity to overland flow paths are to be set at a level such that sufficient 500mm of freeboard above the 100-year ARI flood levels is provided as per the LMCC DCP (2014/2020).

[2] *Required detention volume was estimated to achieve parity with pre-developed conditions, although it is noted that there may be additional capacity within the downstream drainage and detention system that may enable higher discharge rates to occur (to be confirmed with LMCC). If this is the case, the Basin C detention requirements may be reduced.*

Detention storage requirements	• To be provided to mitigate any increase in peak flows associated with re-development. • Detention storage volumes and outlet controls sized to reduce peak flows from the proposed development site to satisfy the minor/major design criteria defined above.
Stormwater quality	• Water quality controls are designed to achieve the following pollutant load reductions for the subject site: o 80% reduction in the average annual load of TSS o 45% reduction in the average annual load of TP o 45% reduction in the average annual load of TN.

5 Conceptual Stormwater Management Plan

5.1 Overview of Revised Development Density

The revised development proposal will increase the area of roof, road pavement and other paved landscaping surfaces within the subject site. This will result in an increase in stormwater runoff volumes and peak flow rates compared to the existing conditions with a related reduction in evapotranspiration and groundwater recharge volumes. These changes have the potential (without mitigation) to result in stormwater quantity and quality impacts on the local receiving environment.

Given the proposed changes to the development layout, the revised SMP presented in the following sections includes an updated:

- General arrangement of stormwater management measures at the subject site both for the existing and proposed development,
- Details of the relationship between the development layout, stormwater drainage system and detention storages, and
- WSUD options for stormwater quantity and quality control following LMCC's Development Control Plan (DCP) 2014/2020.

Specifically, the WSUD Strategy seeks to provide the following (LMCC, 2016):

- Updated management strategies for land and water use and practices,
- Confirm the continued performance of the previously designed water quantity and quality controls for Catchments A and B and identify areas for augmentation or flow diversion if required,
- Integrate permanent stormwater management features into the overall development,
- Identify legal point(s) of discharge,
- Identify pollutants of concern and their sources for both the construction and operational phases of the development,
- Identify an optimum combination of structural and non-structural Stormwater Quality Best Management Practices to limit the pollutant export potential of the site for both the construction and operational phases of development, and
- Outline maintenance requirements.

The initial SMP made recommendations on stormwater management and set objectives for the development of the subject site. Noting that the design has been finalised for Stages 1-6 and Basins A & B under the initial SMP, refer **Figure 5-1**, this revised edition extends on the previous approach whilst taking into consideration the current works and the revised development layout so to confirm (or otherwise) the continued performance of the previously designed pit and pipe network as well as detention Basins A and B during large infrequent storm events as per **Table 4-1**. The assessment of Catchment C is less critical as no works have taken place here and so the assessment will simply confirm if there are any additional requirements, further to those previously set out, to accommodate the higher development density.

This analysis has been completed using the stormwater drainage system design and analysis program (DRAINS) using a site wide model that fully represents the pit and pipe network within Catchments A and B. The analysis of Catchment C however only consists of a lumped representation of the proposed network, as there is no specific stormwater management infrastructure in place at this stage (except the outlet structure under Munibung Road).

As noted in RHDHV's previous WSUD Strategy, the basins also incorporate either a constructed wetland or bio-retention feature to provide a stormwater quality treatment function for the small frequent rainfall events (e.g. up to the 1-year ARI storm). The performance of the existing features within Catchments A and B will be reassessed for the newly proposed development and so too will the need for any additional treatment measures within Catchment C.

The revised assessment noted above has been completed under the assumptions that:

- rainwater tanks on all new dwellings are provided to reduce potable water demands, and to reduce stormwater runoff volumes, and
- Gross Pollutant Traps (GPT's) are provided upstream of any discharge points from residential areas into the proposed basins. The GPT's are proposed to capture gross pollutants such as litter and leaf matter, plus hydrocarbons, as well as coarse sediment to assist in pollutant load reduction (note that both the Basin A and B Designs completed by RHDHV to date include large GPT units on the upstream side).

A conceptual WSUD strategy is presented consistent with recommended stormwater quality targets to mitigate potential stormwater quality impacts. The Model for Stormwater Urban Improvement Conceptualisation (MUSIC) was used to demonstrate the quality of stormwater from the development that can be appropriately managed within the subject site.

The WSUD strategy targets reductions to the load of common stormwater pollutants (total suspended solids, total nitrogen, total phosphorus and gross pollutants). The WSUD Strategy includes a concept plan to illustrate how the water quality requirements are to be addressed showing the indicative size and location of stormwater quality control measures at the subject site.

5.2 Stormwater quantity

5.2.1 Trunk Drainage System

Under the currently approved DA and SMP & WSUD strategy, the design of the piped stormwater drainage system for Stages 1-6 and Basins A and B have been completed and is currently under construction. In order for the revised development layout to gain approval, the following must be demonstrated such that requirements as set out in **Table 4-1** are still being achieved:

- The changes to the development layout and overall increase of the impervious fraction and subsequent increase in rainfall runoff does not exceed the conveyance, detention and water quality treatment capacity of the current infrastructure, or
- If it is possible to divert and redistribute flow to the constructed devices, such that the current infrastructure capacities are not exceeded.

Similarly to the previously provided strategy, the piped drainage system will be integrated with the road network and will connect into the proposed basins via GPT's. The treated stormwater will then be discharged into the existing stormwater drainage system downstream of the site via the nominated discharge points under Munibung and Main Roads.

To date, the trunk drainage systems have been designed to meet the requirements listed for the minor and major stormwater system as provided in **Table 4-1.** All subsequent designs must comply with these requirements noting that the minor (piped) stormwater system may be required to not only achieve a 10-year ARI conveyance capacity but also (in some areas), achieve approximately a 20-year ARI capacity so as to minimise the 'gap flow' in the major system. The capacity of the piped network is required to be increased to reduce gap flows during the major (100-year ARI) event such that they remain within the acceptable limits as specified within LMCC's Engineering Design Guidelines (2016), and to ensure that sufficient flow is directed into the basins to allow peak flow attenuation to occur. These 'gap flows' are to be conveyed to the basins via some areas of over-sized piped drainage, and overland flow via the road network and designated overland flow routes i.e. the major ('Trunk) stormwater drainage system. To facilitate this, RHDHV has prescribed sags points, crests and roadway features in the civil design that have since been adopted.

From RHDHV's revised modelling, which accounts for the existing infrastructure as well as the proposed increase in development density, it can be confirmed that during the 100-yr ARI flood event, overland flows can continue to be suitably managed within Catchments A and B as per LMCC's requirement such that Flow Depth and the Velocity x Depth limits are not exceeded i.e.

- Depth < 0.3m
- Velocity x Depth product < 0.4 m^2/s or $0.6m^2/s$ (where only vehicles are affected).

Figure *5-2* shows the peak flow V x D product and overall discharge expected within the main overland flow paths. Overland flow estimation within Catchment C has been excluded from this Figure because no pit and pipe network has been designed here to date (these details can be provided at a later date, once development design commences for Catchment C).

As per the previous strategy, with the increased capacity of the pit and pipe network, the risk of blockage is still expected to be fairly low as all inflows into the trunk drainage system will be through either kerb inlet pits, grated inlet pits or screened headwalls, which will prevent large debris entering the piped drainage system. In addition, a Course Debris Collector has been provided within the Basin A Inlet channel, to prevent large debris (such as tree branches / shopping trolleys etc) from entering Basin A, and potentially blocking the Basin A outlet control structure.

5.2.2 Stormwater Detention

From **Section 3** it can be deduced that approximately 45% of the catchment is proposed to be developed. This figure is consistent with our previous study, however the purpose of this revised strategy is to confirm that with the increased lot density and thus the increased imperviousness of the developed area (primarily within Catchment's A and B) does not impact upon the existing infrastructure's ability to maintain the site discharge requirements. Increased imperviousness will increase runoff volumes and peak flow rates, but with existing detention facilities in place, and those that are proposed within Catchment C, there is the potential for the peak flows leaving the site to remain within acceptable limits. This is possible through flow attenuation and a flattening of the peak flow hydrograph i.e. peak flows may be elevated for a longer duration but will still remain within peak discharge limits.

The hydrologic and hydraulic modelling software DRAINS has again been used to calculate runoff hydrographs from the combined stormwater management areas (total area of 126.8 ha) as depicted in **Figure 2-1**. For Catchments A and B, the detailed pit, pipe and catchment model that was developed for the detailed design of Stages 1-6 and Basins A and B, was updated and augmented to assess the increase in lot density relative to the existing infrastructure. In contrast, for Catchment C a lumped model has been retained at this stage, as this is sufficient to estimate the revised detention volume required as only an interim basin and no trunk drainage network services this area (i.e. this catchment is still considered a greenfield site thus an approximation is sufficient here with the final Basin C detention volume to be confirmed at the detailed design stage).

The DRAINS modelling simulated the 10-year ARI (minor) and 100-year ARI (major) design storm events for a full range of storm durations as per the AR&R2019 ensemble storm method.

For catchments A & B the modelling confirmed that the existing designs for the pit and pipe network and the basins are sufficient and can accommodate the additional runoff generated through the increased development density, refer **Table 5-1** and **Table 5-2**. It should be noted that these peak outflow rates are lower than that previously advised, this can be attributed to a more accurate representation of design conditions and conservative assumptions having previously been made for the upstream catchment areas for flow concentration and conveyance times. e.g. the peaks of the hydrographs for the various parts of the catchment were previously more aligned, subsequently yielding a higher peak flow at the discharge point.

Table 5-1: Assessment of Detention Basin Performance during the 10-year ARI event

Storage	Design Volume (m^3)	Peak Volume (m^3)	Spill Level (m)	Peak Water Level (m)	Outflow Rate (m^3/s)	Critical Duration
Basin A	**69,720**	35,590	**30.1**	28.45	2.68	3hr
Basin B	**12,290**	6,510	**10**	9.10	**4.76** (<6.5)	1hr

Table 5-2: Assessment of Detention Basin Performance during the 100-year ARI event

Storage	Design Volume (m^3)	Peak Volume (m^3)	Spill Level (m)	Peak Water Level (m)	Outflow Rate (m^3/s)	Critical Duration
Basin A	**69,720**	67,210	**30.1**	30.00	3.30	6hr
Basin B	**12,290**	10,540	**10**	9.75	**8.49** (<8.6)	45min

*Note: Figures shown in **Green** are the newly modelled discharge rates from the basins. These are slightly reduced from those previously reported and as demonstrated by the bracketed figures, which are the site discharge limits, these discharge rates are within Councils' requirements.*

A pre and post-development peak flow parity assessment is not required for Catchments A and B (those areas reporting to Basin B), because the post developed scenario simply needs to satisfy the maximum discharge requirements for the minor and major events as stated in **Table 4-1**, due to the presence of pre-existing outlets from Basin B located under Main Road (Ø1200 RCP and 1800x600 RCBC). However for Catchment C the detention requirements have been approximated such that the peak discharge at the Munibung Road outfall (2x Ø1200 RCP's) is at parity with the pre-developed site conditions. The estimated undeveloped and developed peak flows from Catchment C are provided in **Table 5-3** and a comparison with the previous and currently proposed Basin C design parameters are provided in **Table 5-4**.

Table 5-3: Peak flow analysis for Basin C

ARI (years)	Modelled Peak Flow (m^3/s)		
	Existing Conditions	Development Conditions (no OSD)	Development Conditions (with OSD)
10	3.3	6.8	2.6
100	7.9	11.7	6.7

Table 5-4: Estimated Basin C Design Parameters

Basin C	10-year ARI Event Requirements		100-year ARI Event Requirements	
	Previous	Revised	Previous	Revised
Outlet Level (m AHD)	19.915 m			
Top Water Level (m AHD)	22.0 m			
Volume (m^3)	1,170	2,690	2,150	5,020
Outflow (m^3/s)	2.9	2.6	6.2	6.7
Peak Water Level (m)	21.46	21.2	21.94	21.9
Surface Area (m^2)	1,750	3,120	2,500	3,650

5.3 Stormwater Quality

5.3.1 Water quality control options

Water quality controls are required to improve the quality of stormwater runoff from the development area. **Table 4-1** established that water quality controls are to be designed to achieve the following pollutant load reductions:

- 80% reduction in average annual load of total suspended solids (TSS),
- 45% reduction in average annual load of total phosphorus (TP), and
- 45% reduction in average annual load of total nitrogen (TN).

A stormwater detention system is not to be regarded as a “source control” when calculating the site drainage index (SDI). The following controls can also be deployed in residential lots to assist meeting the above-mentioned pollutant load reductions (by reducing the effective impervious area within the site):

- Porous paving (note: not accepted by Council within public open space areas),
- Grading of hardstand areas toward grass of soft landscaping areas to reduce directly connected impervious area,
- Infiltration devices (where soils are appropriate), and
- Rainwater tanks and associated water re-use.

The following water quality treatment controls arranged in a ‘treatment train’ are considered to be capable of meeting the abovementioned pollutant load reductions:

- Rainwater harvesting (via rainwater tanks),
- Gross pollutant traps,

- Bioretention basins, and
- Constructed wetland.

5.3.2 Effectiveness of Stormwater Quality Controls

The WSUD strategy was modelled (refer to **Appendix C**) using the MUSIC model to estimate the treatment effectiveness of water quality controls in addressing the stormwater quality targets outlined in **Table 4-1**. The concept for the proposed residential development should accommodate conventional pit and pipe drainage for the conveyance of stormwater runoff from roads, residential lots, and other development areas to the stormwater treatment measures. The effectiveness of water quality controls was assessed based on the following assumptions:

- All building roof areas could be directed to a rainwater tank located within each lot (note this is a BASIX requirement).
- An average occupancy rate of residential households is three (3).
- Average typical potable water use for a household is around 200 L/person/day. Toilet flushing and clothes washing has a relatively constant demand throughout the year and typically accounts for around 20% and 12% of household water use respectively (Sydney Water, 2019).
- Average outdoor water use is around 20% of annual household water use. The distribution of the annual outdoor water demand is greatest during the warmer months and least during the cooler months (i.e. we have applied a scaling factor according to the daily PET and rainfall distribution).
- A GPT is to be installed immediately upstream of inlets to the bioretention basins and constructed wetland.
- The ‘super lots’ on the respective corners of Fotheringham Rd and Vicat St are assumed to be commercially developed with an effective imperviousness of 90%. Under these assumptions, RHDHV’s modelling demonstrates that no WSUD measures are required on these lots in order for the site’s overall pollutant load reduction targets to be achieved.
- A bioretention system or constructed wetland could be constructed into the base of the stormwater basins to provide final treatment prior to discharge from the subject site.
- Stormwater outflows from Basin A are to bypass the Basin B bioretention as these flows have already been treated for water quality, refer **Figure 5-3**.

The size and configuration of the stormwater quality treatment measures modelled are summarised in **Table** 5-5. Mean annual pollutant loads and treatment effectiveness for the subject site are shown in **Table** 5-6. The results demonstrate that Council’s stormwater quality targets continue to be achieved for the site and the revised development layout using the existing (Catchments A & B) and proposed (Catchment C) water quality control measures which are a combination of the above.

Table 5-5: Summary of stormwater treatment measures

Stormwater Treatment Measure	Potential Configuration
Constructed wetland – Basin A	Surface area = 11,661 m^2 Permanent Water Level = 26.4 m Extended detention depth = 0.75 m Extended detention level = 27.15 m Permanent pool volume = 6,864 m^3 Exfiltration rate = 0 mm/hr Evaporative loss as % of PET = 125% Equivalent outlet pipe diameter = 160 mm
Bioretention basin – Basin B	Surface area = 1,203 m^2 Extended detention depth = 0.20m Extended detention level = 8.3m Total biofilter area = 1,127 m^2 Biofilter depth = 0.50 m (0.4 m Filter, 0.1 m Transition) Saturated hydraulic conductivity = 200 mm/hr TN content of filter media = 800 mg/kg Orthophosphate content of filter media = 55 mg/kg Exfiltration rate = 0mm/hr
Bioretention basin – Basin C	Surface area = 1,000 m^2 Extended detention depth = 0.30 m Total biofilter area = 700 m^2 Biofilter depth = 0.50 m Saturated hydraulic conductivity = 200 mm/hr TN content of filter media = 800 mg/kg Orthophosphate content of filter media = 55 mg/kg Exfiltration rate = 0mm/hr
Gross Pollutant Trap (HumeGuard or similar)	Number of GPTs = 3 High flow by-pass = 0.035 m^3/s Flow reduction = 0% TSS concentration reduction = 50% TP concentration reduction 40% TN concentration reduction = 26%
Rainwater tanks/basement storage	Number of tanks = 549 (one per residential lot) Individual tank properties: *Volume below overflow pipe = 3 kL* *Depth above overflow = 0.2 m* *Surface area = 1.5 m^2* *Initial volume = 1.5 kL* *Overflow pipe diameter = 100 mm* *Max drawdown height = 2 m* Re-use demand for each tank: Constant daily demand Outdoor water use (distribution PET-Rain)

Table 5-6: Mean annual pollutant load and treatment effectiveness

Parameter	Mean Annual Load and Treatment Effectiveness		
	Source	Residual	% Reduction
Flow (ML/yr)	334	281	11
Total Suspended Solids (kg/yr)	39 400	7 420	82
Total Phosphorus (kg/yr)	90.5	36.2	59
Total Nitrogen (kg/yr)	722	329	49

5.4 Other engineering works and catchment treatment

A summary of the Stormwater Management Plan and WSUD Strategy is shown on **Figure 5-3**. Detailed design plans for the works currently under construction are provided in the following plan sets:

- Basin A Stage 1: PA2519-RHD-S1-A1-01 to A11-06, Rev 2 dated 08 February 2022,
- Basin A outlet structure and pipeline (Line C): PA2519-RHD-CV-C1-01 to C5-02, dated 30 September 2021
- Basin A Stage 2: PA2519-RHD-S2 S1-01 to S2-70, Rev C dated 29 June 2022, Rev D pending design finalisation and approval.
- Basin B: PA2519-RHD-CV-B1-01 to B11-01, Rev 3 dated 03 February 2022,

Considering the stormwater management system in Catchment C is yet to be designed, some concept plans and sections are provided below in **Figure 5-4**.

Other engineering works that would be required to manage stormwater within the subject site so as to achieve the above outcomes are as follows:

- Piped trunk drainage systems designed to the 10-year ARI capacity and in some instances to a 20-year ARI capacity to direct sufficient stormwater runoff to the proposed basins. Any future works within Catchments A and B are required to tie into existing, capturing and directing runoff into the respective basins as appropriate.
- Overland flow paths (generally utilising proposed roadways) to act as overland flow paths for major storm events (maximum velocity-depth criteria to be 0.4 m^2/s for the 100-year ARI major storm event).
- Subdivision house pads that are located in proximity to overland flow paths are to be set at a level such that 0.5m of freeboard above the 100-year ARI flood levels is provided as per the LMCC DCP (2014/2020).
- Significant excavation and earthworks within the footprint of Basin C to achieve the required surface areas, volumes and stable batters to provide a constructed wetland and detention storage. The existing basin's water retaining embankment is to be assessed by a suitably qualified geotechnical engineer and any design required to augment the basin are to be completed by a suitably qualified civil and geotechnical engineer using appropriate imported clean low permeability clay fill. An appropriately sized spillway shall be incorporated into the embankment design to allow the safe discharge of stormwater in the event of either blockage of the piped outlet, or for events above the 100-year ARI event. Additional requirements may eventuate as a result of a Dam Safety Assessment (as required by Dams Safety NSW).

- Details around the basin maintenance and access points are to be provided within detailed design plans as follows:
  - Maintenance access tracks with a minimum width of 3.0 m are to be provided around the perimeter of Basin C. Concrete access ramps to all inlet and outlet structures shall be provided as per LMCC standard drawing EGSD-418.
  - Batters to have a maximum slope of 1V:4H where maintenance access is required.
  - Access tracks to all inlet and outlet structures to be provided (minimum width of 1.2 m, however within Basin A the width provided was 3.6 m).
  - GPT access pads as per LMCC standard drawing EGSD-424.
- Upslope diversion drains are required to intercept runoff from the external catchment areas upstream of the subject site. The diversion drains in combination with an increase in the capacity of the pit and pipe network (up to 20-year ARI capacity), are to be used to convey the intercepted overland flows to the basins.
- Bioretention and subsoil drainage to be installed in the base of Basin C at the inlet similar to that provided within Basin B.
- A new outlet control structure is required in Basin C to satisfy the minor/major discharge criteria (i.e. parity with pre-existing conditions). This structure as depicted in **Figure 5-4** is to be in addition to the existing 2xØ1200 RCPs and would include the construction of a grated concrete weir (length of 7.5 m) with a low-level orifice outlet (800 mm diameter) situated at the invert of the basin (RL 19.915 m) and high flow weir level of RL 21.5m.
- Additional excavation is also required within the invert of Basin C to provide the required storage capacity. To be confirmed during detailed design.
- The road design for Catchment C shall be prepared so as to enable the direction of overland flows into the basin. The key design features that are to be included within the detailed design plan set are generally as follows:
  - Creation of sag points adjacent to Basin C.
  - Moving road crests and adjusting cross fall to direct flow but also delineate sub-catchments.
  - Regrading of Fotheringham Road and the intersection adjacent to Basin C (done in combination with a sag point) to direct overland flows into the Basin.
  - As outlined above, these measures in combination with increasing particular sections of the proposed trunk piped drainage network to the 20-year ARI capacity, are sufficient to ensure that the peak discharge rates leaving the site meet parity with existing conditions, and that 100-year ARI overland flows do not exceed safe conditions (i.e. maximum 0.4 m^2/s in a 100-year ARI event in accordance with LMCC guidelines).

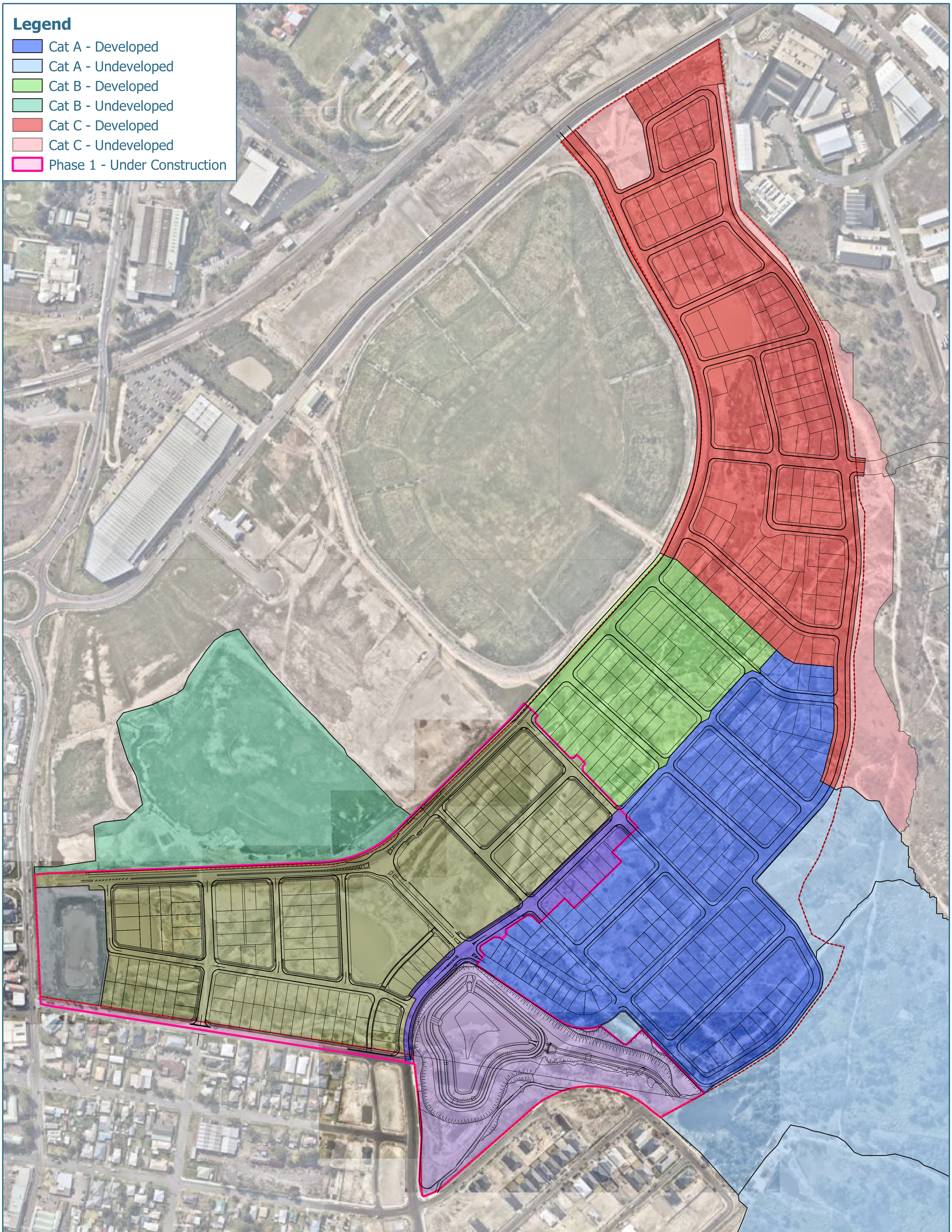

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Figure 5-1
Existing and Proposed Development Areas

PA2519
2022-08-10
GDA94, MGA-56
Scale at A3 = 1:4250

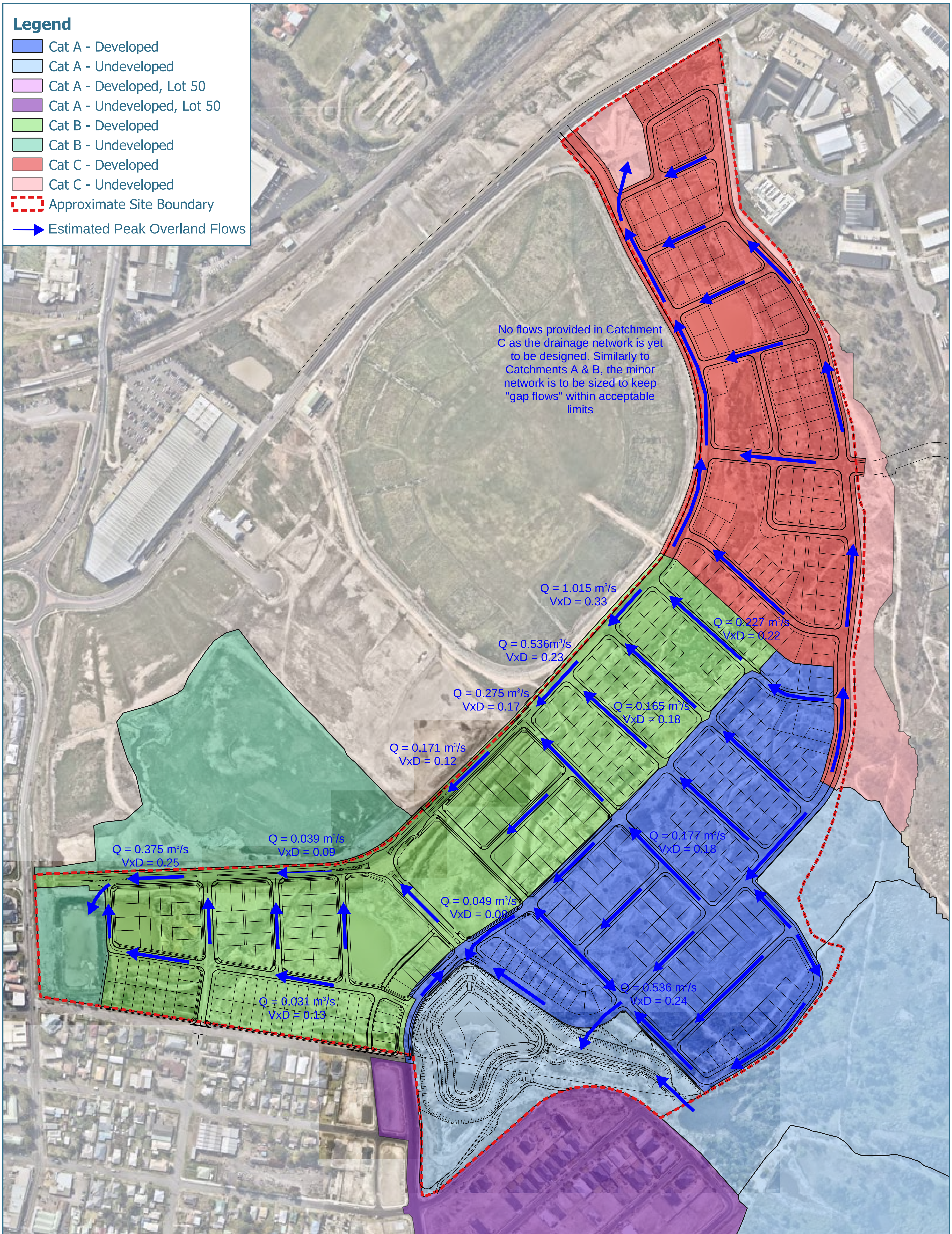

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Figure 5-2
Estimated Peak Overland Flows During the 100-year ARI Event

PA2519
2022-08-08
GDA94, MGA-56
Scale at A3 = 1:4250

N

0 80 160 240 m

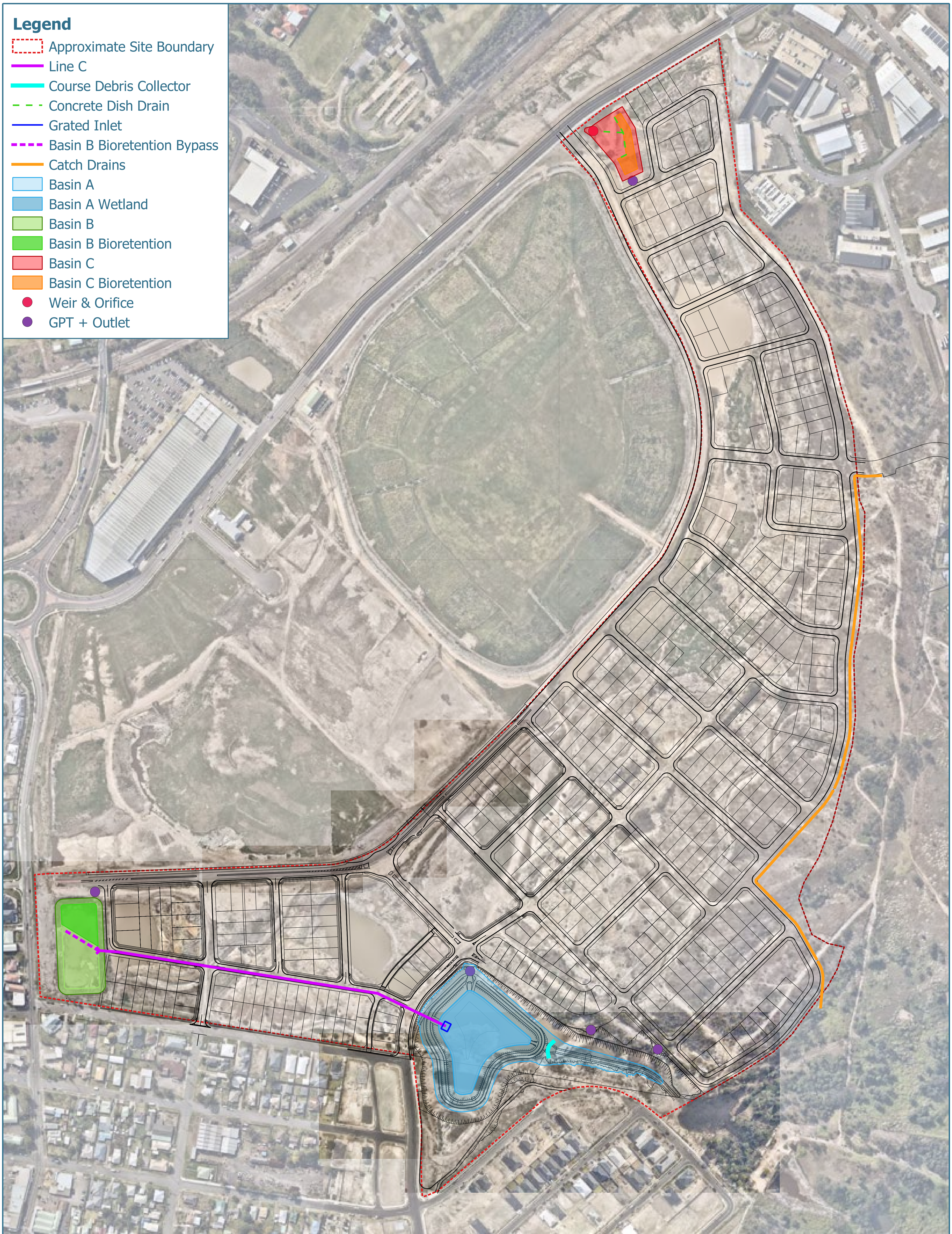

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Figure 5-2
Estimated Peak Overland Flows During the 100-year ARI Event

PA2519
2022-08-09
GDA94, MGA-56
Scale at A3 = 1:4250

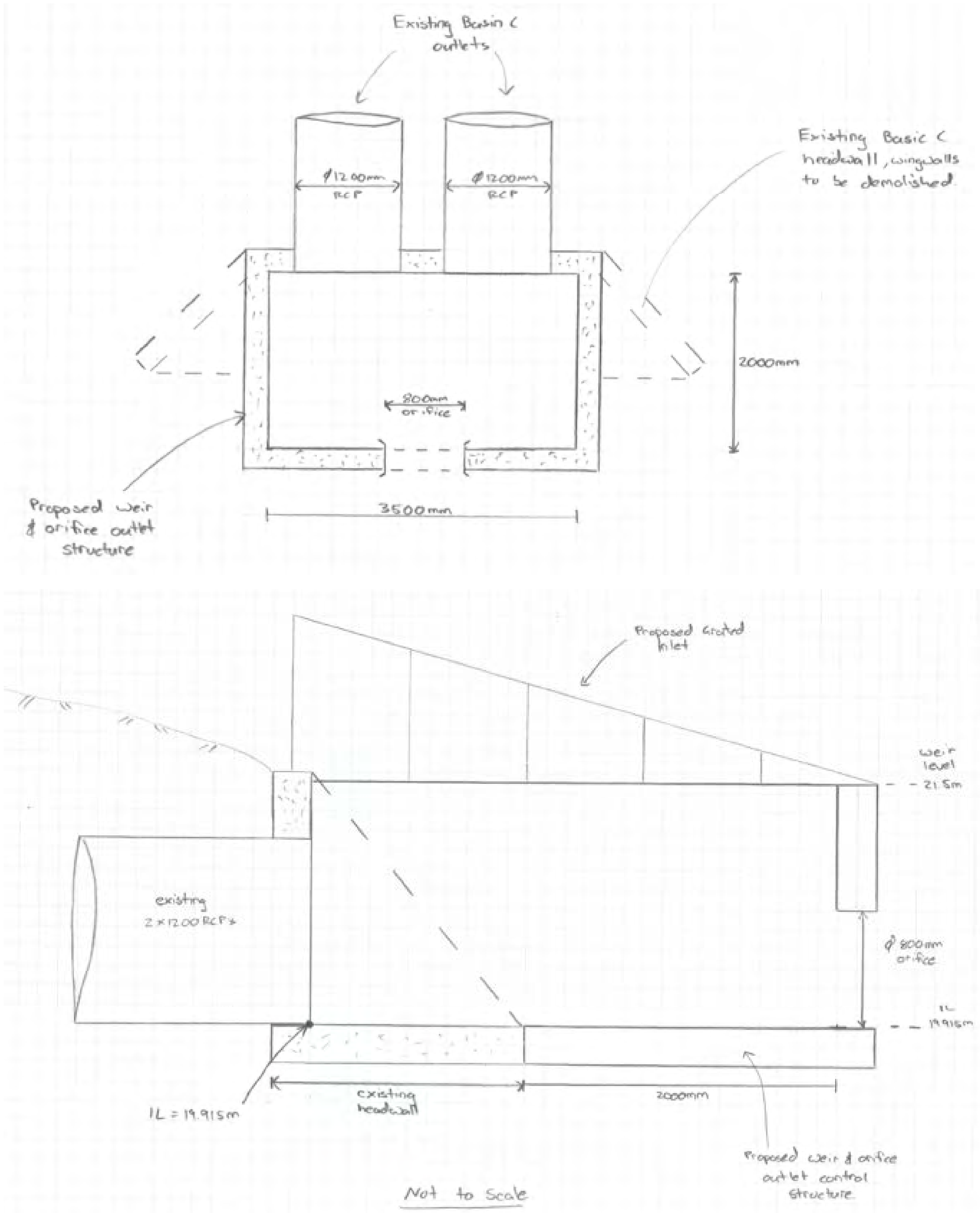

Figure 5-4: Plan and section of Basin C Outlet Control Structure

6 Conclusion

A piped stormwater drainage system would need to be established to manage stormwater runoff from the future development site and connected with the existing and proposed stormwater management network and basins. Any future stormwater drainage systems need to be integrated with the detention storage and water quality treatment controls. All treated stormwater is then ultimately discharged into the existing stormwater drainage system located downstream of the subject site.

Using an updated and augmented version of the DRAINS model previously developed for the detailed design for Stages 1-6 and Basins A and B, it has been established that for the revised development layout the current network and basin designs within Catchments A and B are sufficient to accommodate any additional flows generated as a result of the increase in the site's overall imperviousness. As noted previously, the peak outflow rates achieved from this modelling are actually lower than those previously reported. This can be attributed to a more accurate representation of design conditions through further development of the model and conservative assumptions having previously been made for the upstream catchment areas regarding flow concentration and conveyance times.

The assessment for Catchment C however is currently less detailed (as detailed design of the piped drainage network has not yet commenced), therefore utilizing a 'lumped' drainage model as only an interim basin and no piped drainage networks have been provided for this catchment. The exercise undertaken here was to confirm that the area reserved for Basin C is sufficiently large to accommodate the basin required to service this catchment. A basin with capacity of approximately 6,000m^3 is possible in the reserve provided, with an outlet level of 19.915m and a top water level of 22m (given the above outlet controls). This is sufficiently large as only 5,020m^3 is required for the 100-year ARI event achieving a peak discharge rate of 5.6m^3/s. Given that that estimated peak discharge from the undeveloped catchment is 7.9m^3/s and the design is required to achieve parity with undeveloped catchment conditions, there is an opportunity for future optimisation of the basin and outlet design during the detailed design phase, i.e. increase the capacity of the orifice/weir controls to reduce the basin size.

Similarly to the above, the water quality controls previously provided for Catchments A and B are sufficient to satisfy LMCC's mean annual pollutant load reduction targets of 80%, 45% and 45% for TSS, TP and TN respectively. However, it should be noted that the additional water quality controls such as rainwater tanks (on a per lot basis), bioretention media and a proprietary stormwater treatment system (such as HumeGuard GPTs) are still required within Catchment/Basin C such that these targets are achieved for the site as a whole.

7 References

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8 Glossary

100-year event	An event that occurs on average once every 100 years. Also known as a 1% AEP event. See annual exceedance probability (AEP) and average recurrence interval (ARI).
2-year event	An event that occurs on average once every 2 years. Also known as a 50% AEP event. See annual exceedance probability (AEP) and average recurrence interval (ARI).
Afflux	The change in water level from existing conditions resulting from a change in the watercourse or floodplain – e.g. construction of a new bridge.
Annual Exceedance Probability (AEP)	Measured as a percentage and a term used to describe the size of an event. AEP is the long term probability between events of a certain magnitude. For example, a 1% AEP event is one that has a 1% probability of occurring in any given year. The AEP is closely related to the ARI.
Australian Height Datum	A common national plane of level approximately equivalent to the height above sea level. All water levels presented in this report have been provided in metres AHD.
Australian Rainfall and Runoff (AR&R)	Engineers Australia publication pertaining to rainfall and flooding investigations in Australia.
Average daily flowrate	The value (which can also be expressed in m^3/s) determined from measured or modelled daily flows (typically expressed in ML/day). It represents the average flow rate over 24 hours and is different to peak or instantaneous daily flow.
Average Recurrence Interval (ARI)	Measured in years and a term used to describe event size. It is a means of describing how likely an event is to occur in a given year. For example, a 100-year ARI event is one that occurs or is exceeded on average once every 100 years.
Calibration	The adjustment of model configuration and key parameters to best fit an observed data set.
Concentration	The amount or mass of a substance present in a given volume or mass of sample usually expressed as milligram per litre (water sample) or micrograms per kilogram (sediment sample).
Conceptual model	A simplified and idealised representation of the physical hydrologic setting and the understanding of the essential flow and water quality processes of the system.

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Design flood event	A hypothetical flood representing a specific likelihood of occurrence (for example the 100yr ARI or 1% AEP flood).
Detention storage	The dedicated area set aside for the temporary storage of stormwater during large rainfall events.
Development	Existing or proposed works that may or may not impact upon flooding. Typical works are filling of land, and the construction of roads, floodways and buildings.
Digital Elevation Model	A digital representation of ground surface topography or terrain.
Discharge	The rate of flow of water measured in terms of volume per unit time, for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving for example, metres per second (m/s).
DRAINS	Stormwater Drainage System design and analysis program widely used in Australia.
Drinking water	A common name utilised for potable water.
Flood	Relatively high river or creek flows, which overtop the natural or artificial banks, and inundate floodplains and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Hydraulic conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium.
Hydraulic head	A specific measurement of water pressure above a datum. It is usually measured as a water surface elevation, expressed in units of length. The hydraulic head can be used to determine a hydraulic gradient between two or more points.
Flood source	The source of the floodwaters. In this assessment, urban stormwater from the local catchment is the primary source of floodwaters.
Floodway	A flow path (sometimes artificial) that carries significant volumes of floodwaters during a flood.
Freeboard	A factor of safety usually expressed as a height above the adopted flood level thus determining the flood planning level. Freeboard tends to compensate for factors such as wave action, localised hydraulic effects and uncertainties in the design flood levels.
Hydraulic	The term given to the study of water flow in creeks, rivers, estuaries and coastal systems. Deals with practical applications (such as the transmission of energy or the effects of flow) of liquid (such as water) in motion.

Hydrograph	A graph showing how a river or creek's discharge changes with time.
Hydrologic	The term given to the study of the rainfall-runoff process in catchments.
Hyetograph	A graph showing the depth of rainfall over time.
Intensity Frequency Duration (IFD) Curve	A statistical representation of rainfall showing the relationship between rainfall intensity, storm duration and frequency (probability) of occurrence.
MUSIC	Model for Urban Stormwater Improvement Conceptualisation predicts the performance of stormwater quality management systems. It is intended to help organisations plan and design (at a conceptual level) appropriate urban stormwater management systems for their catchments.
Overland flows	Surface runoff flows that migrates to the receiving environment when an area is over irrigated beyond its hydraulic capacity limits.
Pluviometer	A rainfall gauge capable of continuously measuring rainfall intensity.
Probable maximum flood (PMF)	An extreme flood deemed to be the maximum flood likely to occur.
Riparian	The interface between land and waterway. Literally means "along the river margins".
Runoff	The amount of rainfall from a catchment that ends up as flowing water in the river or creek.
Stage	See flood level.
Stage hydrograph	A graph of water level over time.
TN	Total Nitrogen, the sum of all forms of nitrogen in surface waters comprising a dissolved component (nitrate, nitrite), ammonia and ammonium, and an organic component (organic nitrogen).
Topography	The shape of the surface features of the land.
TP	Total Phosphorus, the sum of all forms of phosphorus in surface waters comprising soluble and particulate fractions of organic and inorganic phosphorus.
TSS	Total Suspended Solids, the total quantity measurement of solid material per unit volume of water. Units commonly expressed as mg/L.
Water quality	Term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.

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Appendix A: Proposed Development Layout

NOTES:

1. LOT NUMBERS SUBJECT TO CHANGE TO SUIT FUTURE STAGING OR FUTURE REVIEWS.
2. LOT LAYOUT SUBJECT TO:-
   - FURTHER REVIEW
   - COUNCIL APPROVAL
3. ROAD WIDTHS SUBJECT TO RURAL FIRE SERVICE (RFS) APPROVAL
4. AREAS & DIMENSIONS SUBJECT TO:-
   - FUTURE REVIEWS
   - DEVELOPMENT CONSENT
   - FINAL SURVEY

REV.	DATE	DESCRIPTION	APP.	INITIAL
F	04/07/22	MINOR LOT ADJUSTMENT	R.F.	S.S.
E	10/06/22	LOTS ALONG EAST BOUNDARY ROAD	R.F.	S.S.
C	04/04/22	ADJUST LOTS TO SUIT E2	R.F.	S.S.
C	25/03/22	MINOR LOT ADJUSTMENTS	R.F.	S.S.
B	22/03/22	PRELIMINARY ISSUE	R.F.	S.S.
A	09/03/22	DRAFT ISSUE	R.F.	S.S.

50 25 0 50 100 150 200 250

SCALE IN METRES ON ORIGINAL DRAWING AT REDUCTION RATIO 1:2500

DIAL 1100 BEFORE YOU DIG

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ABN 35 078 017 508

PRELIMINARY
ISSUED FOR DISCUSSION

SCALE: 1:2500
DESIGNED: T.O.
SURVEY: –
DATUM.: AHD
CONTOUR : –

PROJECT:
CONCEPT SUBDIVISON
22057 (DA NORTH)
WEEMALA

TITLE:
OVERALL PLAN

HDB Job No: 22057
DRAWING NO: 22057(PS)N
CLIENT : GREEN CAPITAL
Sheet: 2
REV: F

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Appendix B: DRAINS Models (to be provided)

- Catchments A & B: Boolaroo V32 02-08-22 SWMP V2 & Phase 2
- Catchment C: Boolaroo V32 02-08-22 SWMP V2 Cat C

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Appendix C: Stormwater Quantity and Quality Modelling (MUSIC)

MUSIC Model Configuration

Model description

Stormwater quality modelling was undertaken to estimate the hydrology and load of common stormwater pollutants (i.e. TSS, TP and TN) generated by the site. MUSIC modelling was undertaken to estimate continuous hydrology and runoff water quality for the site. MUSIC includes algorithms to evaluate the hydrology and concentrations/loads from urban catchments and estimate the performance of stormwater management measures at capturing these pollutants. MUSIC was designed to continuously simulate urban stormwater systems over a range of temporal and spatial scales utilising historically representative rainfall data.

MUSIC is considered within the industry to be an appropriate conceptual design tool for the analysis of runoff water quality in the urban environment. The hydrologic algorithm in MUSIC simplifies the rainfall-runoff processes and requires the input of the following variables to perform the hydrological assessment:

- Rainfall data (time steps varying from 6 minutes to 1 day)
- Areal potential evapotranspiration (PET) rates
- Catchment parameters (area, % impervious and pervious areas)
- Impervious and pervious area parameters (rainfall threshold, soil and groundwater parameters)
- Storm event and base flow stormwater (event mean) pollutant concentrations.

MUSIC can be applied for comparison of alternative scenarios that adopt the same base inputs. Although the magnitude of the estimates may not be equivalent to actual site conditions (due to limitations in available data for a particular site), the relative differences between scenarios are expected to be appropriate for decision making.

The MUSIC modelling approach applied to estimate stormwater runoff and pollutant loads for the local catchment is described in the following sections.

Delineation of surface types and area

Surface types and areas were mapped in a GIS-based on 2020 Nearmap aerial image of the development site and design drawings of the proposed residential development layout provided by HDB.

Rainfall and PET

The MUSIC meteorological template includes the rainfall and areal potential evapotranspiration data. It forms the basis for the hydrologic calculations within MUSIC. To simulate the performance of stormwater quality treatment measures, MUSIC requires the input of data from a representative continuously recording rainfall station (pluviograph).

The sub-daily rainfall and average monthly areal potential evapotranspiration (PET) rates were obtained from the MUSIC-Link data Version 6.3 for Lake Macquarie City Council for the northern region (LMCC North catchments 1999-2008 6 min.mlb).

Model time step
A 6-minute time step was adopted to simulate water quality and characterise pollutant loads across the site.

Site parameters

Source nodes, linked to varying surface types, were utilised for the development of the MUSIC Model; namely: Urban-Roof, Urban-Sealed Road, Urban-Mixed. The area and percentage imperviousness of the sources nodes used to represent the major surfaces across the site were estimated from the subdivision layout for Lot 1006 provided by HDB.

Rainfall-runoff parameters

Modelling of the rainfall-runoff process in MUSIC requires the definition of one impervious surface parameter and eight pervious surface parameters. The rainfall-runoff parameters were defined using MUSIC-Link data Version 6.31 for Lake Macquarie City Council for the northern region. The impervious surface parameter (rainfall threshold) was adjusted for major surfaces as follows:

- Building roofs – 1 mm (accounts for small depression store on the roof area and first flush device)
- Sealed road – 1.5 mm
- Landscaped and open space – 1 mm

Runoff quality parameters

The MUSIC stormwater constituent pollutant concentrations were adopted from those provided by MUSIC Link data detailed above.

Treatment nodes

Treatment nodes were configured to represent the type and size of treatment measures outlined by the conceptual stormwater management plan and WSUD strategy identified for the developed site. The treatment measures were represented within the MUSIC model using the parametrisation outlined in **Table C-1**.

Table C-1: Treatment node parameters

Stormwater Treatment Measure	Potential Configuration
Constructed wetland – Basin A	Surface area = 11,661 m^2 Permanent Water Level = 26.4 m Extended detention depth = 0.75 m Extended detention level = 27.15 m Permanent pool volume = 6,864 m^3 Exfiltration rate = 0 mm/hr Evaporative loss as % of PET = 125% Equivalent outlet pipe diameter = 160 mm
Bioretention basin – Basin B	Surface area = 1,203 m^2 Extended detention depth = 0.20m Extended detention level = 8.3m Total biofilter area = 1,127 m^2 Biofilter depth = 0.50 m (0.4 m Filter, 0.1 m Transition) Saturated hydraulic conductivity = 200 mm/hr TN content of filter media = 800 mg/kg Orthophosphate content of filter media = 55 mg/kg Exfiltration rate = 0mm/hr
Bioretention basin – Basin C	Surface area = 1,000 m^2 Extended detention depth = 0.30 m Total biofilter area = 700 m^2 Biofilter depth = 0.50 m Saturated hydraulic conductivity = 200 mm/hr TN content of filter media = 800 mg/kg Orthophosphate content of filter media = 55 mg/kg Exfiltration rate = 0mm/hr
Gross Pollutant Trap (HumeGuard or similar)	Number of GPTs = 3 High flow by-pass = 0.035 m^3/s Flow reduction = 0% TSS concentration reduction = 50% TP concentration reduction 40% TN concentration reduction = 26%
Rainwater tanks/basement storage	Number of tanks = 549 (one per residential lot) Individual tank properties: *Volume below overflow pipe = 3 kL* *Depth above overflow = 0.2 m* *Surface area = 1.5 m^2* *Initial volume = 1.5 kL* *Overflow pipe diameter = 100 mm* *Max drawdown height = 2 m* Re-use demand for each tank: Constant daily demand Outdoor water use (distribution PET-Rain)

The arrangement of source nodes and treatment nodes for the subject site is shown in **Figure C-1**.

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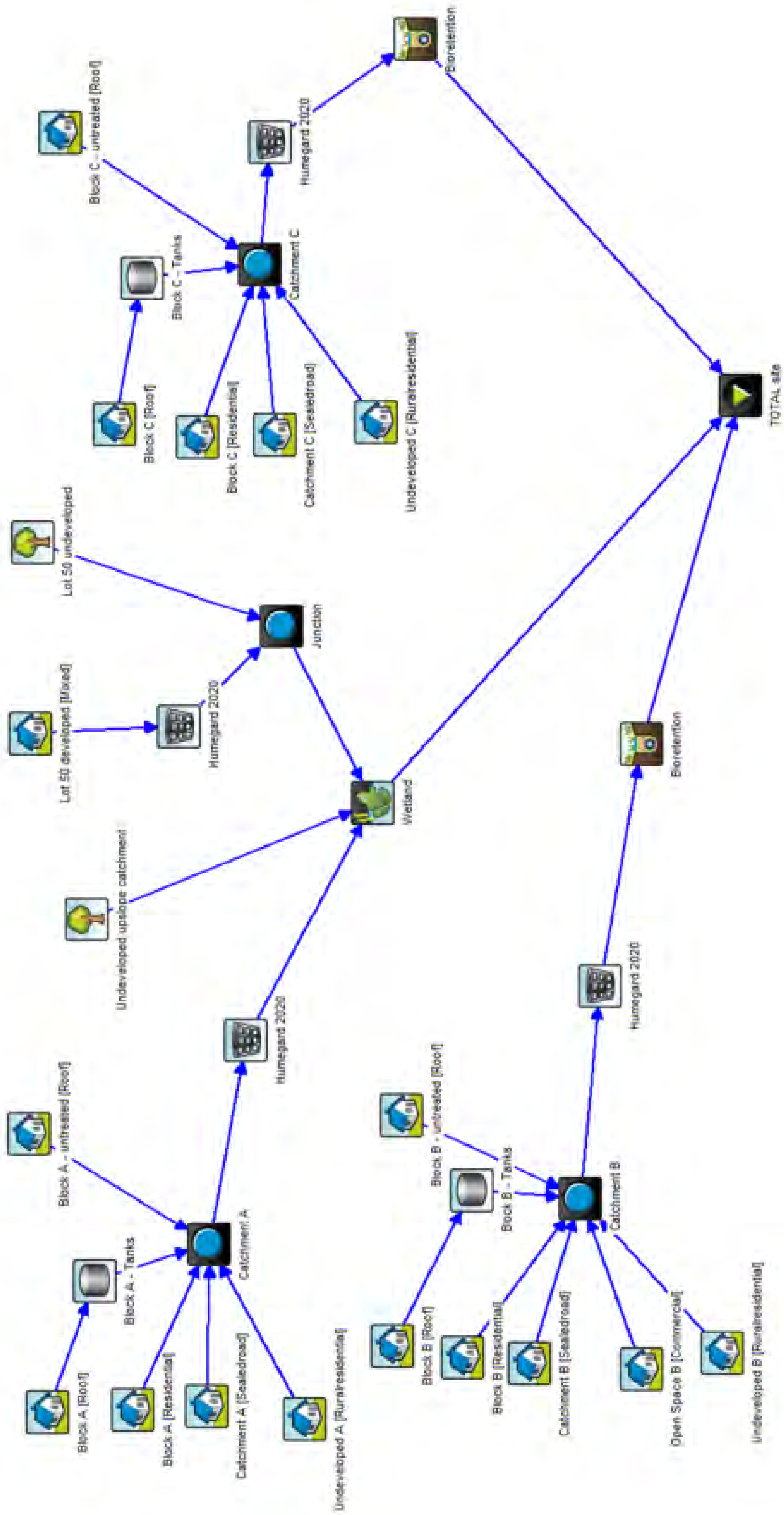

Figure C-1: MUSIC Model Schematisation

Appendix D: MUSIC-Link Report

MUSIC-*link* Report

Project Details		Company Details	
Project:	Lot 1006 Boolaroo (Weemala)	**Company:**	Royal HaskoningDHV
Report Export Date:	11/08/2022	**Contact:**	Harrison Oakley
Catchment Name:	LMCC_MUSIC_Link_v6.3_Weemala_007_SWMPv2	**Address:**	
Catchment Area:	119.152ha	**Phone:**	02 4926 9524
Impervious Area*:	26.94%	**Email:**	harrison.oakley@rhdhv.com
Rainfall Station:			
Modelling Time-step:	6 Minutes		
Modelling Period:	1/01/1999 - 31/12/2008 11:54:00 PM		
Mean Annual Rainfall:	902mm		
Evapotranspiration:	1408mm		
MUSIC Version:	6.3.0		
MUSIC-link data Version:	6.33		
Study Area:	North Region		
Scenario:	North Region		

* takes into account area from all source nodes that link to the chosen reporting node, excluding Import Data Nodes

Treatment Train Effectiveness		Treatment Nodes		Source Nodes	
Node: TOTAL site	**Reduction**	**Node Type**	**Number**	**Node Type**	**Number**
Flow	10.3%	Rain Water Tank Node	3	Urban Source Node	17
TSS	81.9%	Wetland Node	1	Forest Source Node	2
TP	59.4%	Bio Retention Node	2		
TN	49.5%	GPT Node	4		
GP	99.9%				

Comments

Passing Parameters

Node Type	Node Name	Parameter	Min	Max	Actual
Bio	Bioretention	Hi-flow bypass rate (cum/sec)	None	None	1.5
Bio	Bioretention	Hi-flow bypass rate (cum/sec)	None	None	1.5
Bio	Bioretention	PET Scaling Factor	2.1	2.1	2.1
Bio	Bioretention	PET Scaling Factor	2.1	2.1	2.1
Forest	Lot 50 undeveloped	Area Impervious (ha)	None	None	0
Forest	Lot 50 undeveloped	Area Pervious (ha)	None	None	12.411
Forest	Lot 50 undeveloped	Total Area (ha)	None	None	12.411
Forest	Undeveloped upslope catchment	Area Impervious (ha)	None	None	0
Forest	Undeveloped upslope catchment	Area Pervious (ha)	None	None	37.047
Forest	Undeveloped upslope catchment	Total Area (ha)	None	None	37.047
GPT	Humegard 2020	Hi-flow bypass rate (cum/sec)	None	None	100
GPT	Humegard 2020	Hi-flow bypass rate (cum/sec)	None	None	100
GPT	Humegard 2020	Hi-flow bypass rate (cum/sec)	None	None	100
GPT	Humegard 2020	Hi-flow bypass rate (cum/sec)	None	None	100
Rain	Block A - Tanks	% Reuse Demand Met	80	None	82.4212
Rain	Block B - Tanks	% Reuse Demand Met	80	None	81.8638
Rain	Block C - Tanks	% Reuse Demand Met	80	None	85.1857
Receiving	TOTAL site	% Load Reduction	None	None	10.3
Receiving	TOTAL site	GP % Load Reduction	70	None	99.9
Receiving	TOTAL site	TN % Load Reduction	45	None	49.5
Receiving	TOTAL site	TP % Load Reduction	45	None	59.4
Receiving	TOTAL site	TSS % Load Reduction	80	None	81.9
Urban	Block A	Area Impervious (ha)	None	None	2.789
Urban	Block A	Area Impervious (ha)	None	None	0.341
Urban	Block A	Area Pervious (ha)	None	None	0
Urban	Block A	Area Pervious (ha)	None	None	6.291
Urban	Block A	Total Area (ha)	None	None	2.789
Urban	Block A	Total Area (ha)	None	None	6.633
Urban	Block A - untreated	Area Impervious (ha)	None	None	1.859
Urban	Block A - untreated	Area Pervious (ha)	None	None	0
Urban	Block A - untreated	Total Area (ha)	None	None	1.859
Urban	Block B	Area Impervious (ha)	None	None	3.252
Urban	Block B	Area Impervious (ha)	None	None	0.402
Urban	Block B	Area Pervious (ha)	None	None	0
Urban	Block B	Area Pervious (ha)	None	None	7.408
Urban	Block B	Total Area (ha)	None	None	3.252
Urban	Block B	Total Area (ha)	None	None	7.811
Urban	Block B - untreated	Area Impervious (ha)	None	None	2.168
Urban	Block B - untreated	Area Pervious (ha)	None	None	0
Urban	Block B - untreated	Total Area (ha)	None	None	2.168

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Node Type	Node Name	Parameter	Min	Max	Actual
Urban	Block C	Area Impervious (ha)	None	None	2.753
Urban	Block C	Area Impervious (ha)	None	None	0.313
Urban	Block C	Area Pervious (ha)	None	None	0
Urban	Block C	Area Pervious (ha)	None	None	6.244
Urban	Block C	Total Area (ha)	None	None	2.753
Urban	Block C	Total Area (ha)	None	None	6.558
Urban	Block C - untreated	Area Impervious (ha)	None	None	1.835
Urban	Block C - untreated	Area Pervious (ha)	None	None	0
Urban	Block C - untreated	Total Area (ha)	None	None	1.835
Urban	Catchment A	Area Impervious (ha)	None	None	2.977
Urban	Catchment A	Area Pervious (ha)	None	None	0
Urban	Catchment A	Total Area (ha)	None	None	2.977
Urban	Catchment B	Area Impervious (ha)	None	None	3.586
Urban	Catchment B	Area Pervious (ha)	None	None	0
Urban	Catchment B	Total Area (ha)	None	None	3.586
Urban	Catchment C	Area Impervious (ha)	None	None	2.954
Urban	Catchment C	Area Pervious (ha)	None	None	0
Urban	Catchment C	Total Area (ha)	None	None	2.954
Urban	Lot 50 developed	Area Impervious (ha)	None	None	4.955
Urban	Lot 50 developed	Area Pervious (ha)	None	None	4.905
Urban	Lot 50 developed	Total Area (ha)	None	None	9.861
Urban	Open Space B	Area Impervious (ha)	None	None	1.917
Urban	Open Space B	Area Pervious (ha)	None	None	0.220
Urban	Open Space B	Total Area (ha)	None	None	2.138
Urban	Undeveloped A	Area Impervious (ha)	None	None	0
Urban	Undeveloped A	Area Pervious (ha)	None	None	7.463
Urban	Undeveloped A	Total Area (ha)	None	None	7.463
Urban	Undeveloped B	Area Impervious (ha)	None	None	0
Urban	Undeveloped B	Area Pervious (ha)	None	None	1.296
Urban	Undeveloped B	Total Area (ha)	None	None	1.296
Urban	Undeveloped C	Area Impervious (ha)	None	None	0
Urban	Undeveloped C	Area Pervious (ha)	None	None	3.761
Urban	Undeveloped C	Total Area (ha)	None	None	3.761
Wetland	Wetland	% Reuse Demand Met	None	None	0

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