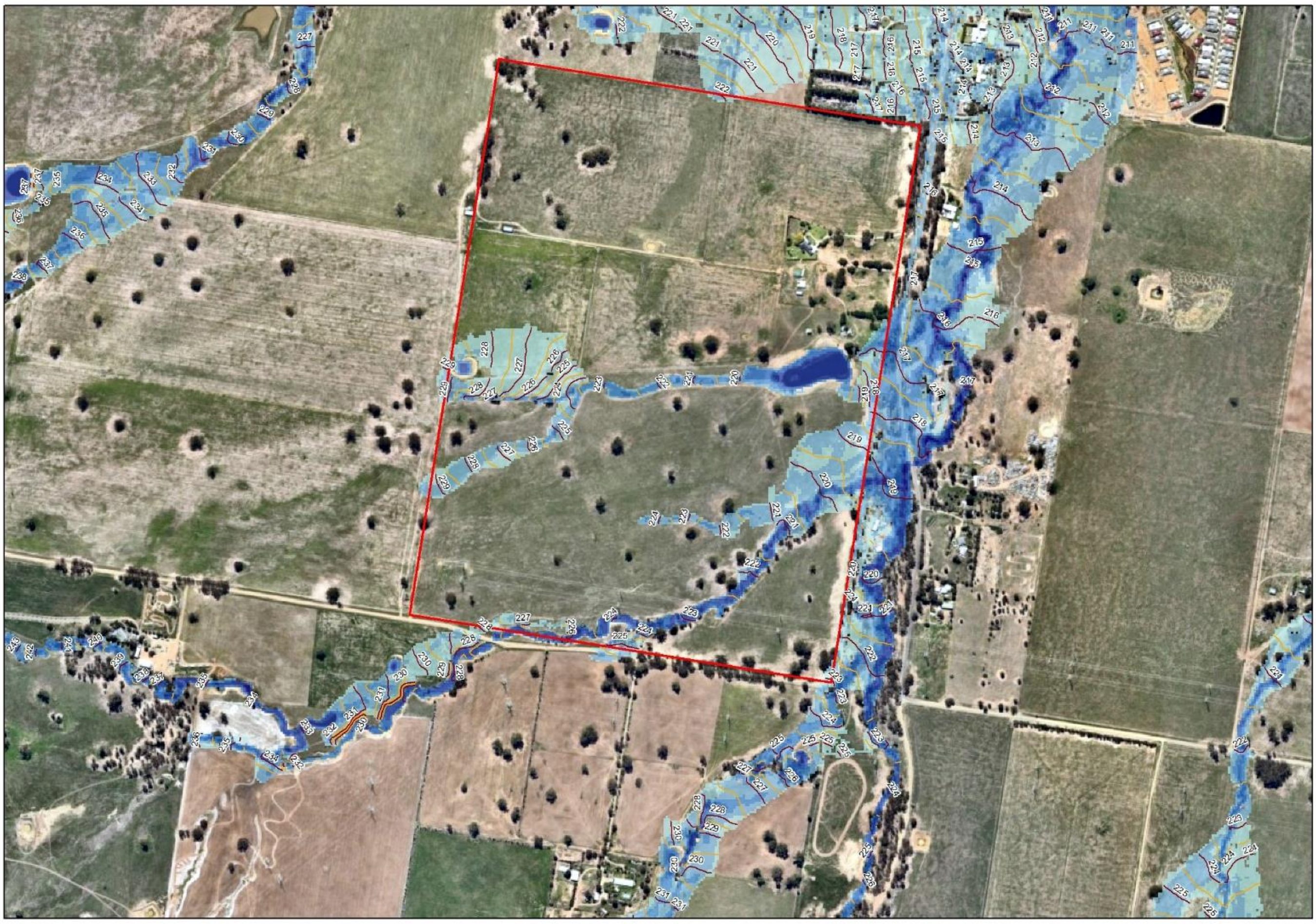
Appendix C – Precinct Stormwater Design Strategy

SUNNYSIDE VENTURES

SUNNYSIDE ESTATE WAGGA WAGGA – PRECINCT STORMWATER DRAINAGE STRATEGY

FINAL REPORT



JANUARY 2021

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SUNNYSIDE ESTATE WAGGA WAGGA – PRECINCT STORMWATER DRAINAGE STRATEGY

FINAL REPORT

JANUARY 2021

Project Sunnyside Estate Wagga Wagga – Precinct Stormwater Drainage Strategy	**Project Number** **120036**
Client Sunnyside Ventures	**Client's Representative** Yaaman Majeed
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Revision History

Revision	Description	Distribution	Authors	Reviewed by	Verified by	Date
0	Draft report	WMAwater	Mark Colegate, Yuan Li	Mark Colegate		JAN 21
1	Final Report	WMAwater	Mark Colegate, Yuan Li	Mark Colegate		JAN 21

SUNNYSIDE ESTATE WAGGA WAGGA – PRECINCT STORMWATER DRAINAGE STRATEGY

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LIST OF ACRONYMS

AEP	Annual Exceedance Probability
ARF	Areal Reduction Factor
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
BOM	Bureau of Meteorology
DEM	Digital Terrain Model
EY	Exceedances per Year
IFD	Intensity, Frequency and Duration (Rainfall)
m AHD	meters above Australian Height Datum
SSMP	Site Stormwater Management Plan
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)
WWCC	Wagga Wagga City Council
XPRAFTS	XP Runoff Analysis and Flow Training Simulator (hydrologic model)

ADOPTED TERMINOLOGY

Australian Rainfall and Runoff (ARR, ed Ball et al, 2016) recommends terminology that is not misleading to the public and stakeholders. Therefore, the use of terms such as “recurrence interval” and “return period” are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example, there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2016 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table below describes how they are subtly different.

For events more frequent than 50% AEP, expressing frequency in terms of Annual Exceedance Probability is not meaningful and misleading particularly in areas with strong seasonality. Therefore, the term Exceedances per Year (EY) is recommended. Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example, an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6-month Average Recurrence

Interval where there is no seasonality, or an event that is likely to occur twice in one year.

The Probable Maximum Flood is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore, an AEP is not assigned to the PMF.

This report has adopted the approach recommended by ARR and uses % AEP for all events rarer than the 50 % AEP and EY for all events more frequent than this.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

1. BACKGROUND

WMAwater was engaged by John Randall Consulting Pty Ltd on behalf of Sunnyside Ventures to prepare a high-level stormwater drainage service strategy for the greater precinct area surrounding Sunnyside Estate.

The land parcels known as 474 and 456 Plumpton Road (the Site) are being investigated for rezoning and development of a *circa* 500 lot residential sub-division (lot sizes approx. 1,000 / 1,200 m^2). The Site, with a total area of 110.17ha, is currently zoned Rural and used for agricultural activities.

A site stormwater management plan (SSMP) has been developed by WMAwater and submitted as part of the permit application to Wagga Wagga City Council (WWCC). WWCC has advised that the planning proposal will need to investigate, and has consideration to, infrastructure provision across a wider precinct, as indicated in Diagram 1, including the stormwater drainage aspect.

A coupled WBNM hydrologic and TUFLOW hydraulic flood model covering the Site was developed for the previous SSMP, by revising the regional model for *Wagga Wagga Major Overland Flow Floodplain Risk Management Study and Plan 2020 (MOFFRMS)* in accordance with the Site boundary. The model has a full coverage of the precinct area nominated by WWCC, as illustrated in Diagram 2.

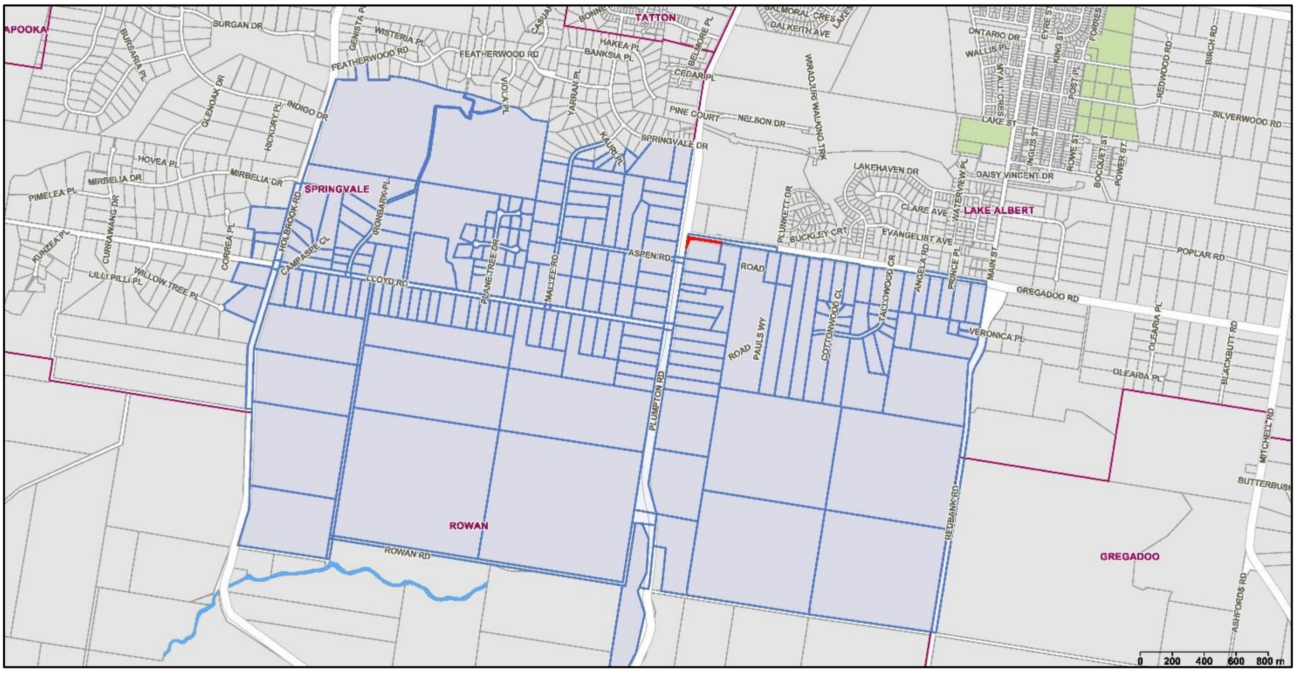

Diagram 1: Nominal Investigation Precinct Area (WWCC)

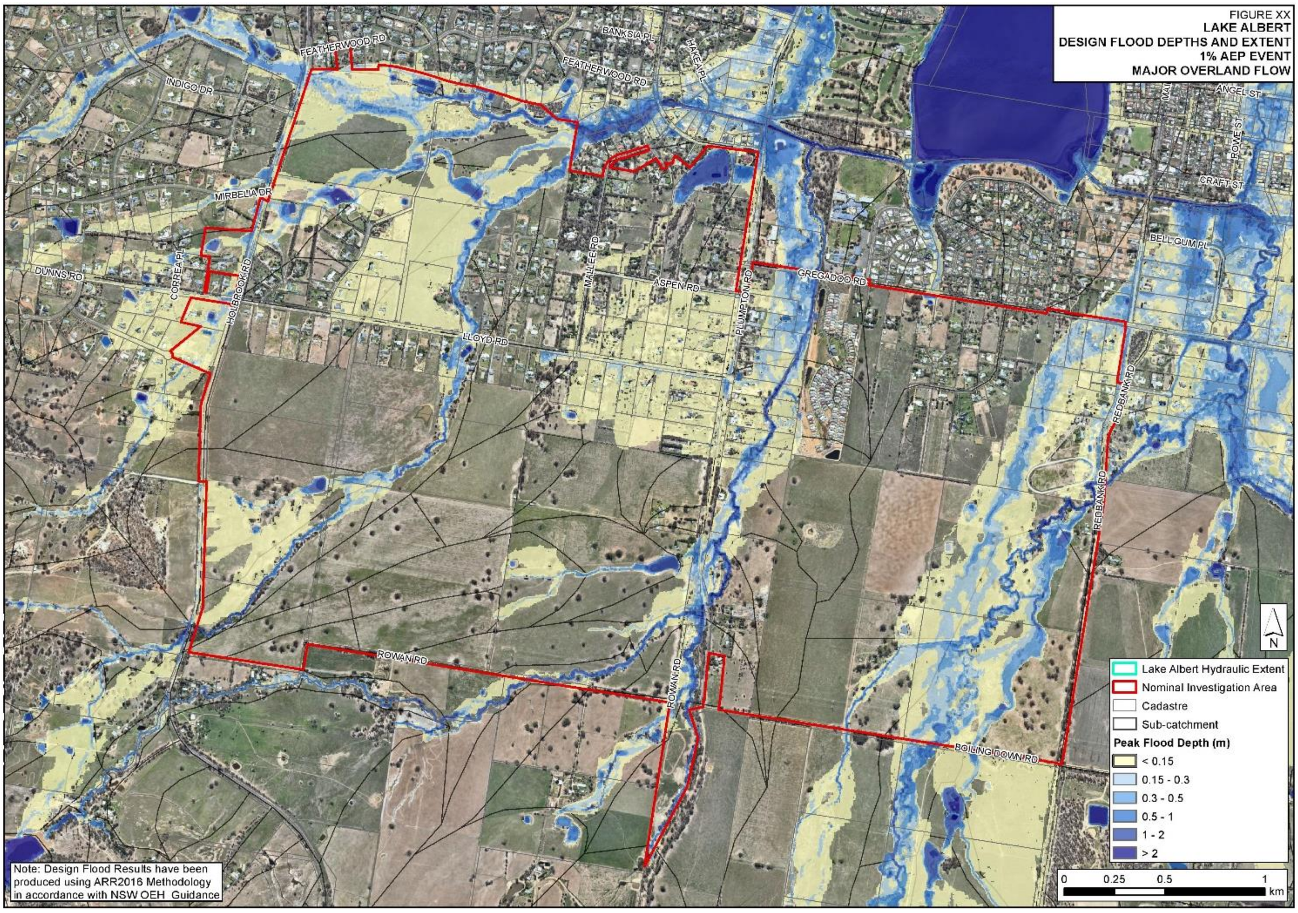

Diagram 2: Sub-catchments (hydrology) and Flood Extent (hydraulics) in the Nominal Investigation Precinct Area during 1% AEP Event

1.1. Study Precinct

The Precinct area (Diagram 1) was delineated using existing land use and state of development for this study. The Study Precinct is depicted in Diagram 3 and indicates the Existing Development Area and the Future Development Area to be considered. The Existing Development Area consist of the following Planning Zones –

- R5 (Large lot residential)
- RU6 (Transition), and
- RE1 (Public Recreation)
- RU1 (Primary production)

The Future development Area currently consist wholly of zone RU1 (Primary production), The zoning can be seen in Diagram 4.

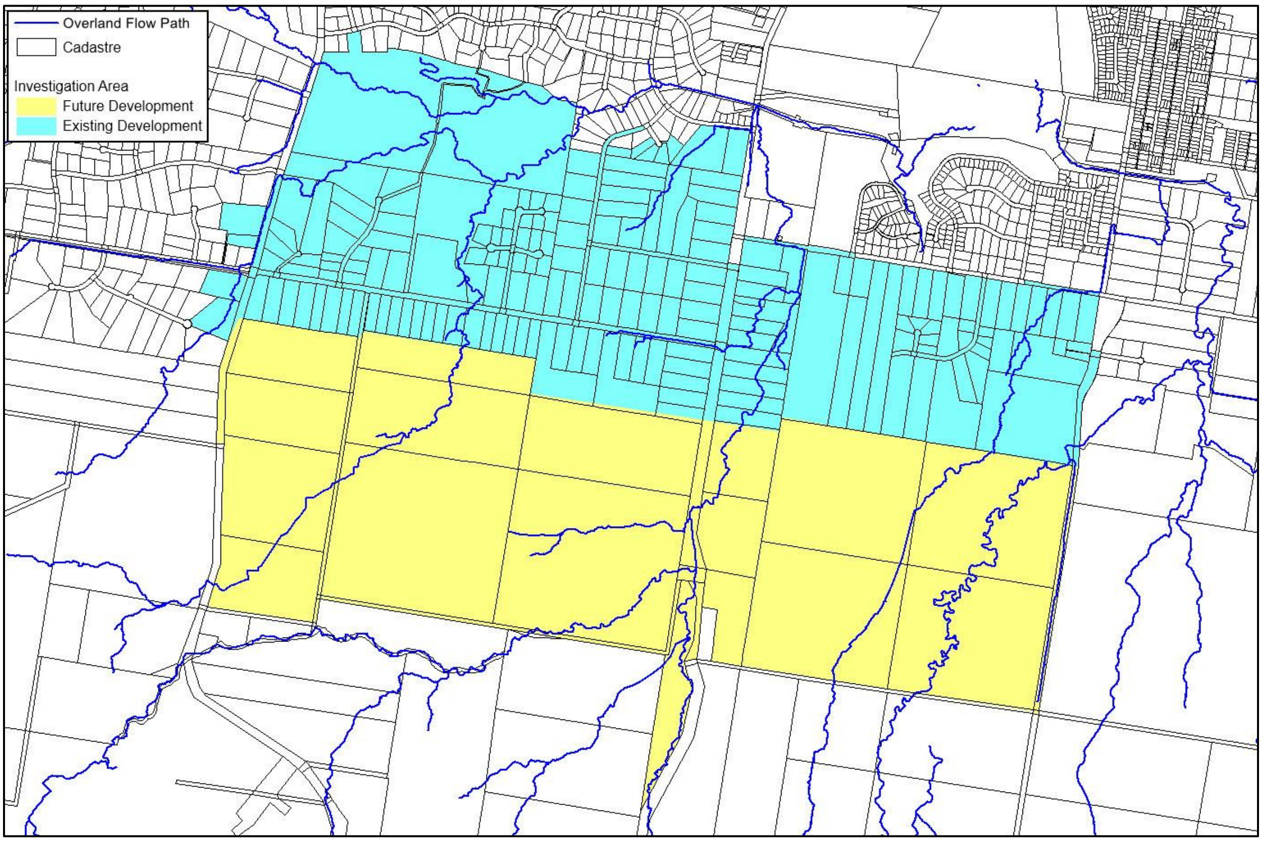

Diagram 3: Study Precinct Delineation

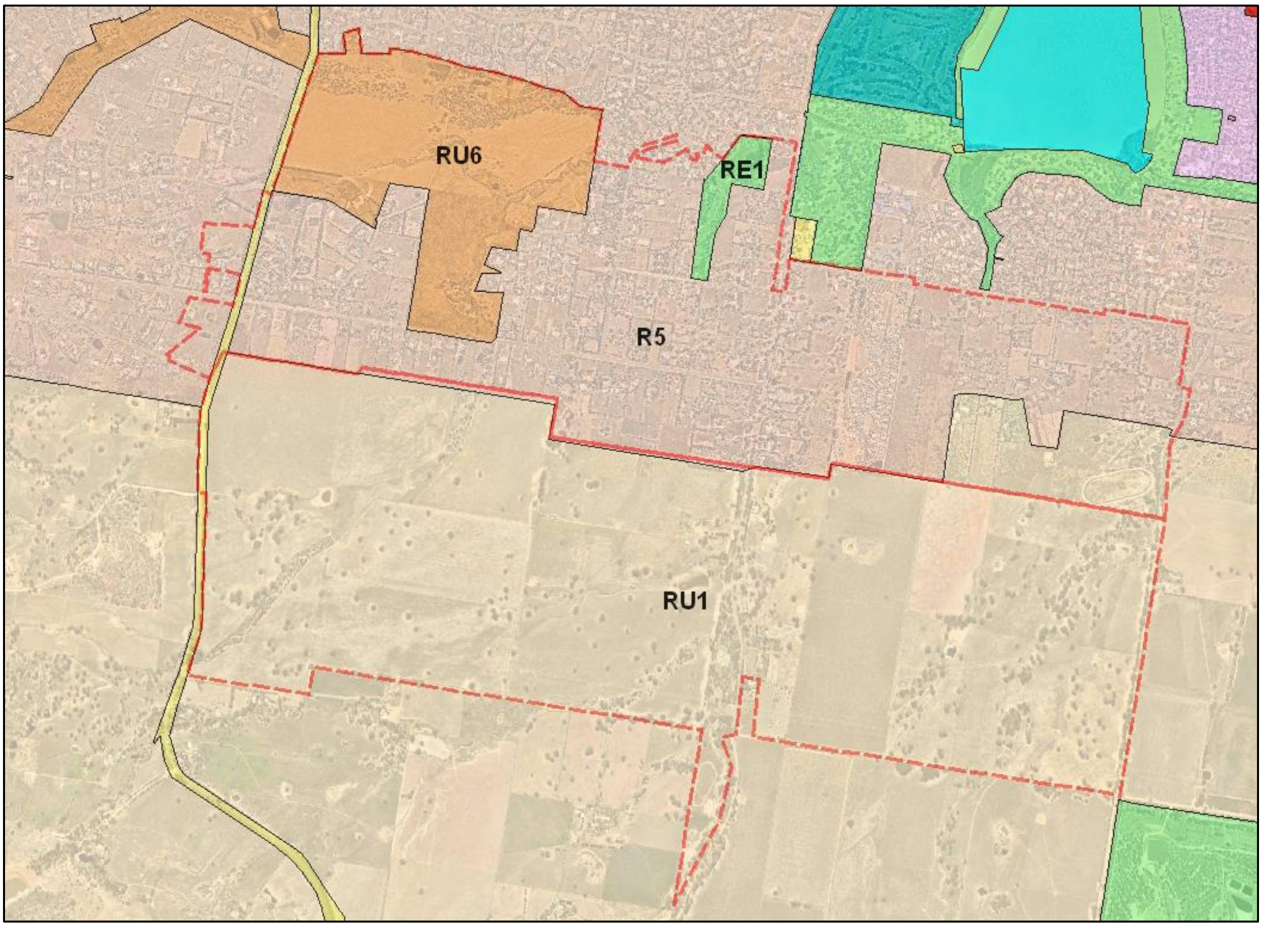

Diagram 4: Land Use Zones within Study Precinct

1.2. Previous Studies

There have been a number of flood studies and stormwater management plans in this area, including the following recent studies:

- Sunnyside Estate Wagga Wagga – Site Stormwater Management Plan (SSMP), WMAwater, 2020 (Reference 1)
- Wagga Wagga Major Overland Flow Floodplain Risk Management Study (MOFFRMS) – Public Exhibition Version, WMAwater, 2020 (Reference 2)
- Wagga Wagga Revised Murrumbidgee River Floodplain Risk Management Study and Plan, WMAwater, 2018 (Reference 3)
- Wagga Wagga Detailed Flood Model Revisions, WMAwater, 2014 (Reference 4)
- Wagga Wagga LGA Murrumbidgee River Flood Modelling, WMAwater, 2012 (Reference 5)
- Wagga Wagga Major Overland Flow Flood Study (MOFFS), 2011 (Reference 6)

The Sunnyside Estate SSMP was an initial stormwater management plan conducted by WMAwater for the proposed development in the Site at 474 and 456 Plumpton Road, Rowan. A regional hydrological model (WBNM) was developed for the SSMP based on the refinement of the MOFFRMS hydrological model, in accordance with the methodology detailed in the latest best practice guideline, ARR 2019 (Reference 7). The hydrological model for this study was established based on the refinement of the Sunnyside Estate SSMP WBNM model.

1.3. Stormwater Drainage Strategy

The proposed rezoning and future development of the RU1 zone (southern sector) will create an urban growth area for Wagga Wagga. The future development has the potential to put increased pressure on the existing stormwater treatment train within the established urban area (northern sector) of the precinct.

Without consideration, this can lead to the over-loading of the existing system resulting in flooding and drainage issues. Mitigation may be required, in the form of costly augmentation of existing drainage infrastructure, to accommodate the increased runoff associated with urban growth.

Alternatively, stormwater drainage strategies can be developed to outline regional infrastructure assets (future local Council assets) required to service urban growth. A stormwater drainage strategy can include conceptual designs for works such as:

- Pipelines
- **Overland flow paths**
- **Retarding basins**
- Wetlands
- Floodways
- Other drainage and water quality treatment measures

For this study, the pressure of increased stormwater runoff volumes was deemed to be the critical factor when considering the capacity of downstream drainage systems. Therefore, the following study will assess flow conveyance (overland flow paths) and peak flow mitigation (retarding basins) requirements to manage the impact of the future development on the downstream drainage system.

The study objectives are defined below.

2. OBJECTIVES

The objective of the Precinct Stormwater Drainage Strategy is to identify how a future urban growth area can be serviced, from a drainage perspective, to facilitate drainage and effectively mitigate adverse on established urban drainage networks because of increased stormwater volumetric discharges. Specifically, stormwater management measures (e.g., detention basins) are required to ensure:

- the stormwater discharges from the developed precinct, in conjunction with upstream inflows, are managed to the pre-development level during regional flood events; and
- the stormwater discharges from the developed precinct are managed to the pre-development level during local flood events.

3. HYDROLOGICAL MODEL

The Lake Albert flood model, a subset of the entire model from the MOFFRMS (Reference 2), was used as a base model for this study and minor refinements were carried out to characterise existing flood conditions for the Site.

An initial master plan for the developable area within the Precinct was prepared by SIVA Projects, which was then incorporated in our GIS system, as shown in Diagram 5, and used as a base for assessment.

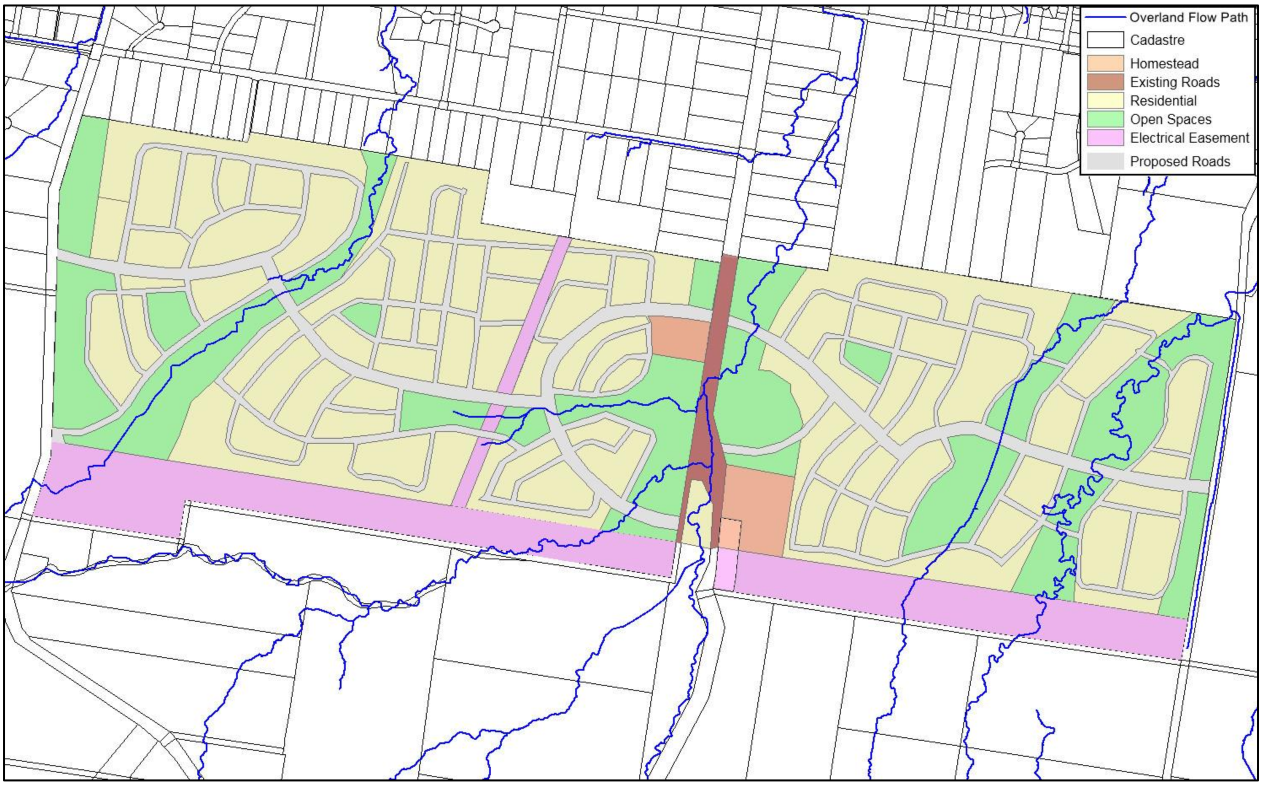

Diagram 5: Development Master Plan

The Sunnyside Estate SSMP WBNM model (Reference 1), was used as a base model for this study and minor refinements were carried out with the consideration of the proposed development.

For a full description of the Sunnyside Estate SSMP WBNM model, refer to Sunnyside Estate SSMP (Reference 1) and MOFFRMS (Reference 2).

The refinements of the WBNM model made for this study are summarised below:

- Sub-catchments around the developable area of the Precinct were further delineated according to the area boundary, as illustrated in Diagram 6
- Areas of refined sub-catchments were recalculated
- The ARFs and IFDs were averaged for the contributing catchment, specifically:
    - for regional flood events, the contributing catchment was defined as sub-catchments in and upstream of developable precinct
    - for local flood events, the contributing catchment was defined as the sub-catchments only in the developable precinct.

- The fractions (%) of Effective Impervious Area (EIA), Indirectly Connected Area (ICA), and Rural Pervious Area (RPA) of refined sub-catchments were updated as follow:
  - for pre-development conditions, the RPA was retained as 100% as per the Sunnyside Estate SSMP and MOFFRMS
  - for post-development conditions, the fractions for each refined sub-catchment were calculated based on the land use types on the master development plan (Diagram 6) and values set for each land use type as summarized in Table 1.

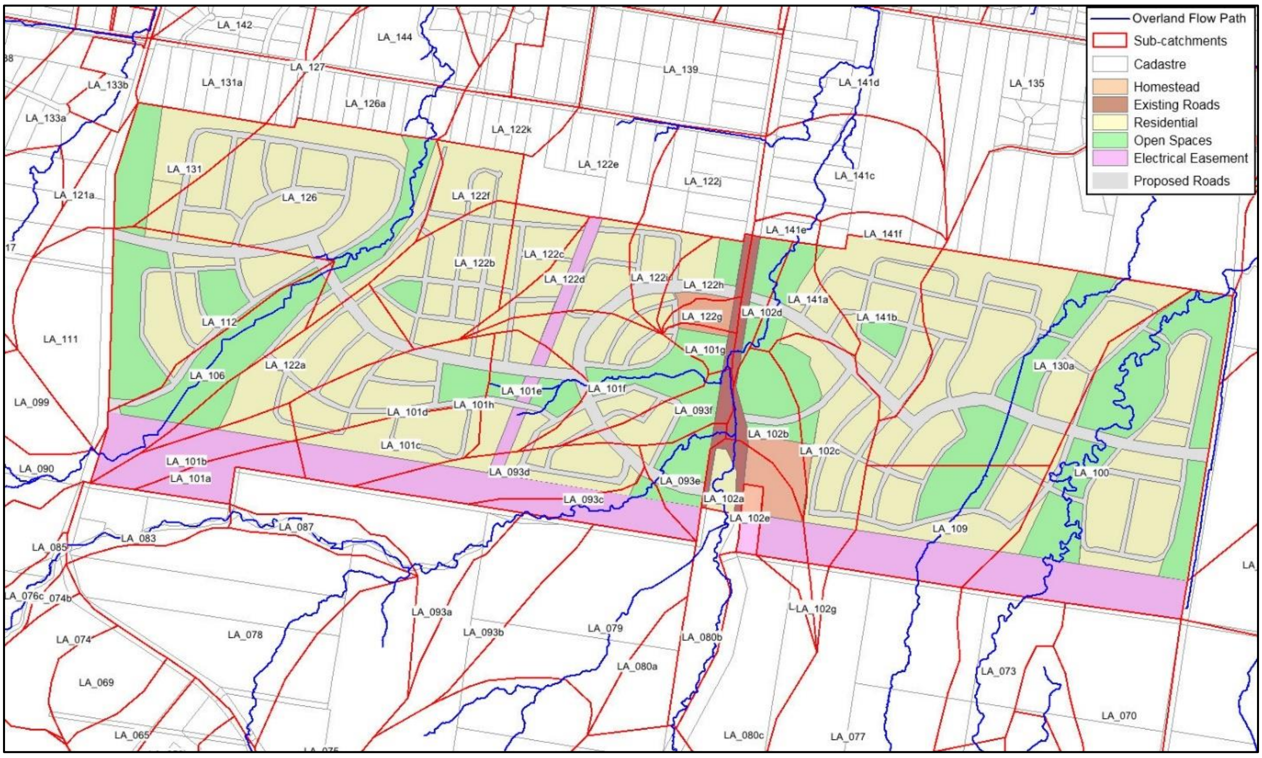

Diagram 6: Updated Sub-catchments in accordance with the Development Plan for WBNM Model

Table 1: Fractions of Effective Impervious Area (EIA), Indirectly Connected Area (ICA), and Rural Pervious Area (RPA) for Post-development Conditions

Land Use	EIA (%)	ICA (%)	RPA (%)
Residential	35	50	15
Roads	65	35	0
Open Spaces	0	0	100
Electrical Easement	0	0	100
Homestead	0	5	95

The fractions for Roads were adopted as per the Sunnyside Estate SSMP. The fractions for Residential (large lots with size≥ 1000 m^2) were set based on the review of the existing lots in the region with lot size of approximately 1000 m^2. This was based on a conservative assumption that all Residential area in the Master Plan would be built at its potentially highest density, i.e., lot size of approximately 1000 m^2. Examples of existing lots reviewed are illustrated in Diagram 7.

Hydrological modelling was carried out for 1% AEP, ten (10) temporal patterns, and a range of storm durations (30 min to 12 hr) using the updated WBNM model. The simulated peak flow rates and flow volumes of pre- and post-development conditions were used for high-level quantification of required stormwater detention storages detailed in Section 4.

Diagram 7: Sampled Existing Lots (highlighted) in the Region with Lot Size of approximately 1000 m^2

4. STORMWATER DRAINAGE STRATEGY

To achieve the stormwater objectives (Section 2), high-level assessment of detention storage requirements was conducted for regional and local flood events. Several preliminary detention basin sizing methods were compared for the assessment.

4.1. Preliminary Detention Basin Sizing Methods

Six preliminary detention basin sizing methods were used for this study, including four methods suggested in the Queensland Urban Drainage Manual (QUDM) (Reference 8) and two methods proposed in USDA TR-55 (Reference 9).

The four QUDM methods are referred as Culp (Equation 1), Boyd (Equation 2), Carroll (Equation 3), and Basha (Equation 4) based on the authors of each method.

$$\frac{V_s}{V_i} = \frac{r(1+2r)}{3} \tag{1}$$

$$\frac{V_s}{V_i} = r \tag{2}$$

$$\frac{V_s}{V_i} = \frac{r(3+5r)}{8} \tag{3}$$

$$\frac{V_s}{V_i} = \frac{r(2+r)}{3} \tag{4}$$

where V_s is the storage volume, V_i is the inflow volume, and r is reduction ratio calculated by:

$$r = \frac{Q_i - Q_o}{Q_i} \tag{5}$$

where Q_i and Q_o are the peak inflow and outflow rates of the detention basin.

The two TR-55 methods are referred as Type I / IA and Type II / III based on different relationships between peak flows and storage/runoff volumes (Reference 9).

The six methods were initially cross-validated against the three basins designed in Sunnyside Estate SSMP (Reference 1) using XP-RAFTS, and the estimated basin sizes area summarized in Table 2. It is shown that the basin sizes modelled by XP-RAFTS are generally between the two highest estimates using Boyd and Basha methods. It is also noted that TR-55 methods have more significant underestimation compared to the QUDM methods. This may be because the inflow volumes were estimated by the preliminary methods in TR-55, while they were extracted from hydrological model (WBNM) for QUDM methods which were more accurate representation of the ARR 2016 events.

Table 2: Cross-validation of Preliminary Basin Sizing Methods against XP-RAFTS using the Three Basins designed in Sunnyside Estate SSMP.

Basin	QUDM (m^3)				TR-55 (m^3)		XP-RAFTS (m^3)
	Culp	Boyd	Carroll	Basha	Type I/IA	Type II/III	
S1	6385.4	8456.8	6514.8	7421.1	3988.2	5537.1	7929.2
S2	6391.0	8448.0	6519.5	7419.5	3991.1	5532.9	7942.5
S3	4493.6	6299.4	4606.5	5396.5	2893.5	4247.3	5744.9

4.2. Regional Detention Requirements

There are four main waterways through the developable precinct and the outlet discharge locations of the four waterways from the precinct are noted in Diagram 8 (Locations A, B, C, and D).

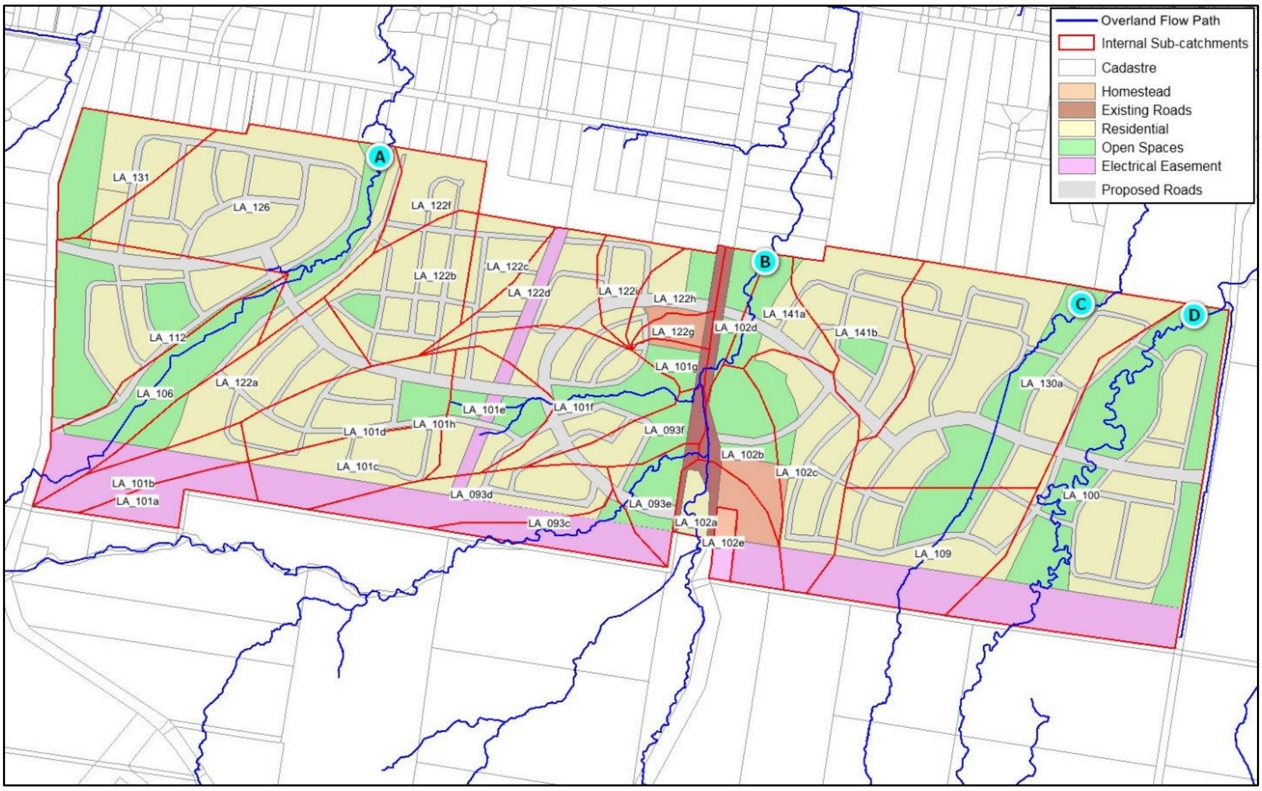

Diagram 8: Discharge Locations for Regional Flooding

The peak flow rates at the four locations under pre-development and post-development conditions were extracted from the WBNM model and summarized in Table 3. The peak flows at B and D were reduced after development, while the flows at A and C were slightly increased after development.

It is noted that the waterways discharging at B and D (Stringybark Creek and Crooked Creek, respectively) have a much bigger upstream contributing catchment than the contributing area from the developable precinct. Therefore, the peak flows at B and D were still driven by the upper undeveloped catchments. The development in the precinct resulted in a quicker discharge and thus reduced the peak of the regional flood. This is evident when the hydrographs for pre-development and post-development conditions are compared. Diagram 9 shows the hydrographs at Location B under pre- and post-development conditions. The peak flow rate is slightly lower under post-development conditions, but the development also resulted in an increase of flow rate before the peak flow.

The peak flow rates indicate that stormwater runoff detention is only required at Locations A and C from a regional flow perspective. Preliminary detention storage volume was estimated using the QUDM methods and summarized in Table 3.

Table 3: Peak Flow Rates and Estimated Detention Storage Requirement for Regional Flooding

	Peak Flow (m^3/s)		**Detention Storage (m^3)**			
Location	Post-development	Pre-development	Culp	Boyd	Carroll	Basha
A	16.65	16.60	127.3	379.8	143.1	253.6
B	56.88	57.31	-	-	-	-
C	13.01	12.43	892.5	2458.2	990.4	1675.4
D	54.90	55.08	-	-	-	-

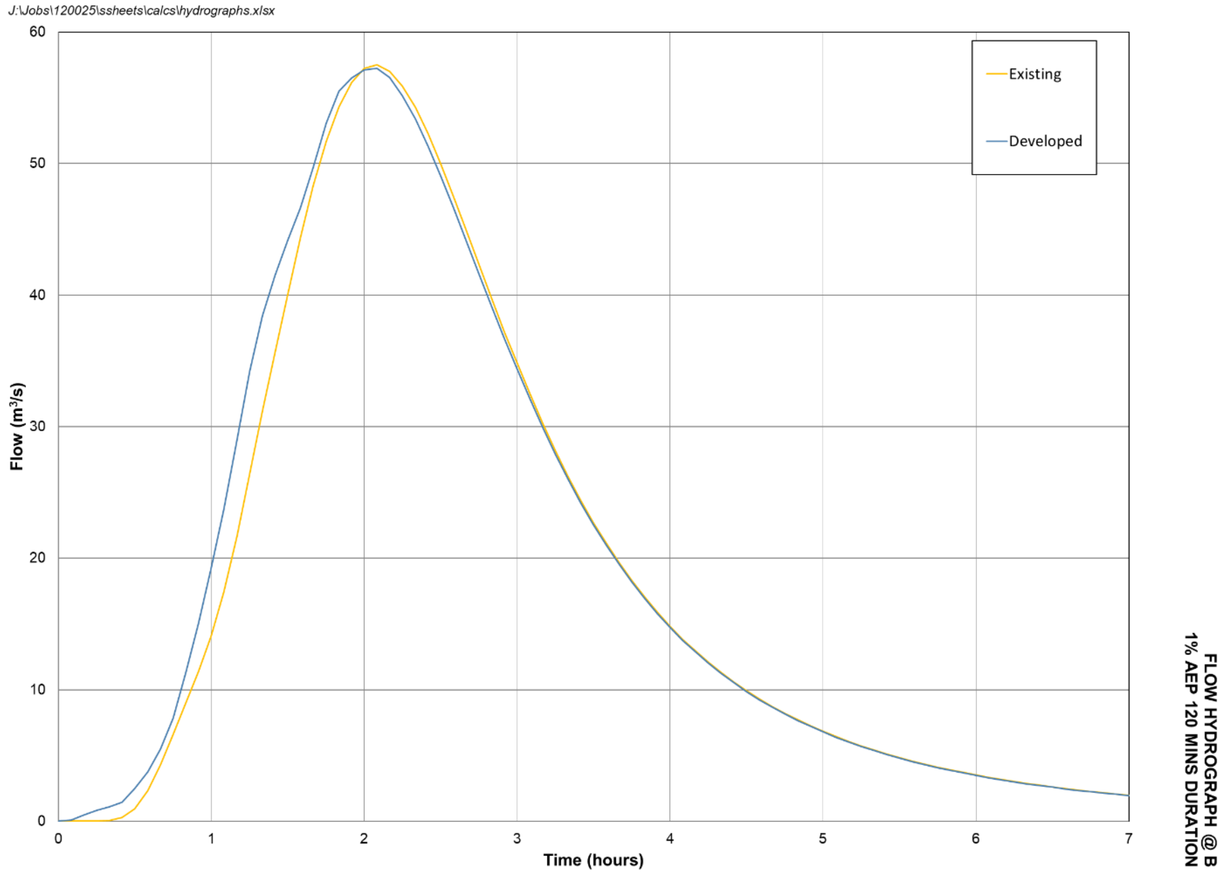

Diagram 9: Flow Hydrographs at Location B under Pre- and post-development Conditions

4.3. Local Detention Requirements

To ensure that the proposed development will not cause detrimental impacts on receiving systems during local flood events, the peak discharge rates from the developed precinct (i.e., flows from local sub-catchments *a priori* to discharging into the main waterways) should be maintained to the pre-development levels. To achieve the objective, offline detention basins were proposed at eight (8) locations as illustrated in Diagram 10.

The peak flow rates from developed precinct were extracted from the WBNM model at the 8 locations under pre-development and post-development conditions and summarized in Table 4. As expected, the development resulted in increased peak flow rates at all 8 locations. Preliminary offline detention storages were estimated using the QUDM methods and summarized in Table 4.

As the preliminary basin sizing process is high-level, and there is considerable variation among the 4 methods, the Boyd method which yielded highest detention storage volumes for all 8 basins was adopted to provide enough confidence that the stormwater discharge from the proposed development can be managed.

According to the assessment in Section 4.2, detention is required at Locations 1 and 7 in Diagram 10 (i.e., A and C in Diagram 9) for regional flood events. However, the required detention volumes for regional flood mitigation (Table 3) are much lower than the required detention volumes for local flood mitigation (Table 4). Therefore, estimated detention storage by Boyd method in Table 4 are sufficient for managing stormwater during both local and regional flood events.

A preliminary functionality check was conducted for each proposed detention basin in Diagram 10. The existing topography indicates that there is enough grade at the proposed locations to accommodate a basin with a depth of at least 1-metre. The concept Master Plan nominates reserved open space (green) at key locations to accommodate these facilities. Location 3 has the smallest reserve area; however, it still has a 16,900 m^2 footprint which is enough to accommodate the required 6454.5 m^3 basin (1-metre-deep) as suggested in Table 4.

Possible locations for the basin facilities have been identified in the 'mud map' plan of the concept layout, in Diagram 11.

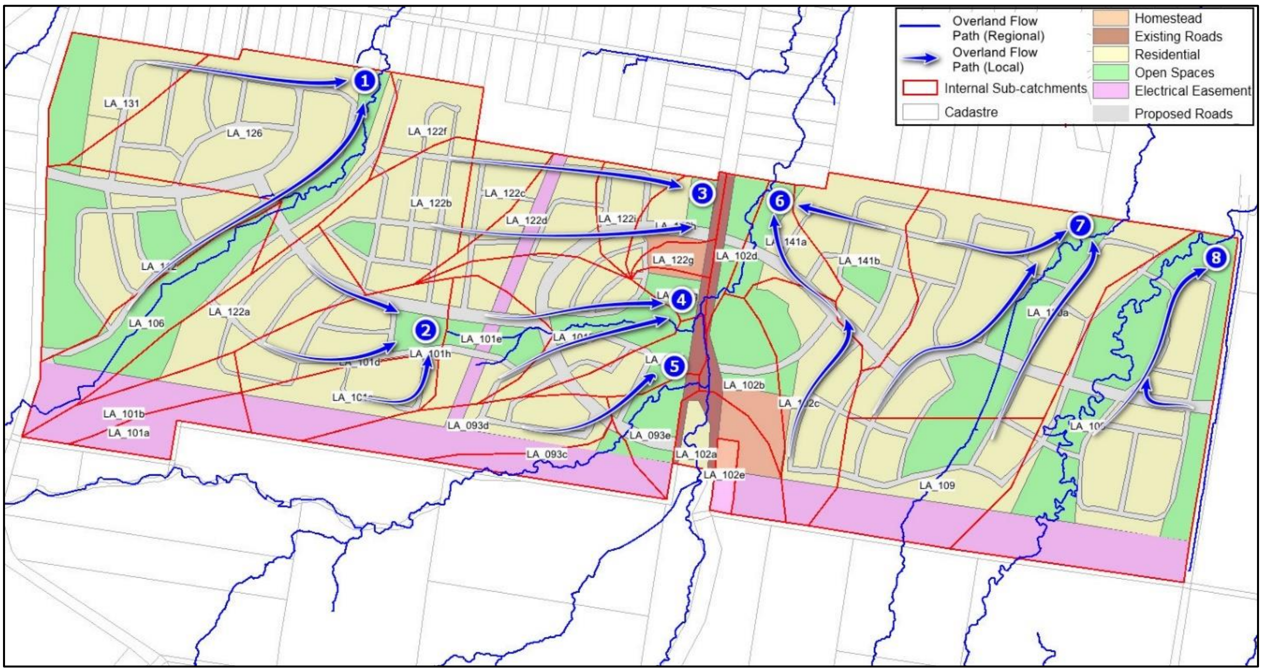

Diagram 10: Locality Map of Offline Detention Basins for Local Flooding

Table 4: Peak Flow Rates and Estimated Detention Storage Requirement for Local Flooding

	Peak Flow (m^3/s)		**Detention Storage (m^3)**			
Location	Post-development	Pre-development	Culp	**Boyd**	Carroll	Basha
1	11.08	8.40	5206.3	**10526.6**	5538.8	7866.4
2	8.34	6.44	2888.4	**5956.3**	3080.2	4422.3
3	6.03	4.68	3114.4	**6454.5**	3323.2	4784.4
4	5.74	4.32	2367.4	**4743.4**	2515.9	3555.4
5	3.94	3.41	710.6	**1676.8**	771.0	1193.7
6	9.00	7.01	3102.9	**6453.3**	3312.3	4778.1
7	9.42	6.38	6001.5	**10944.1**	6310.4	8472.8
8	7.77	5.77	3390.3	**6722.4**	3598.6	5056.3

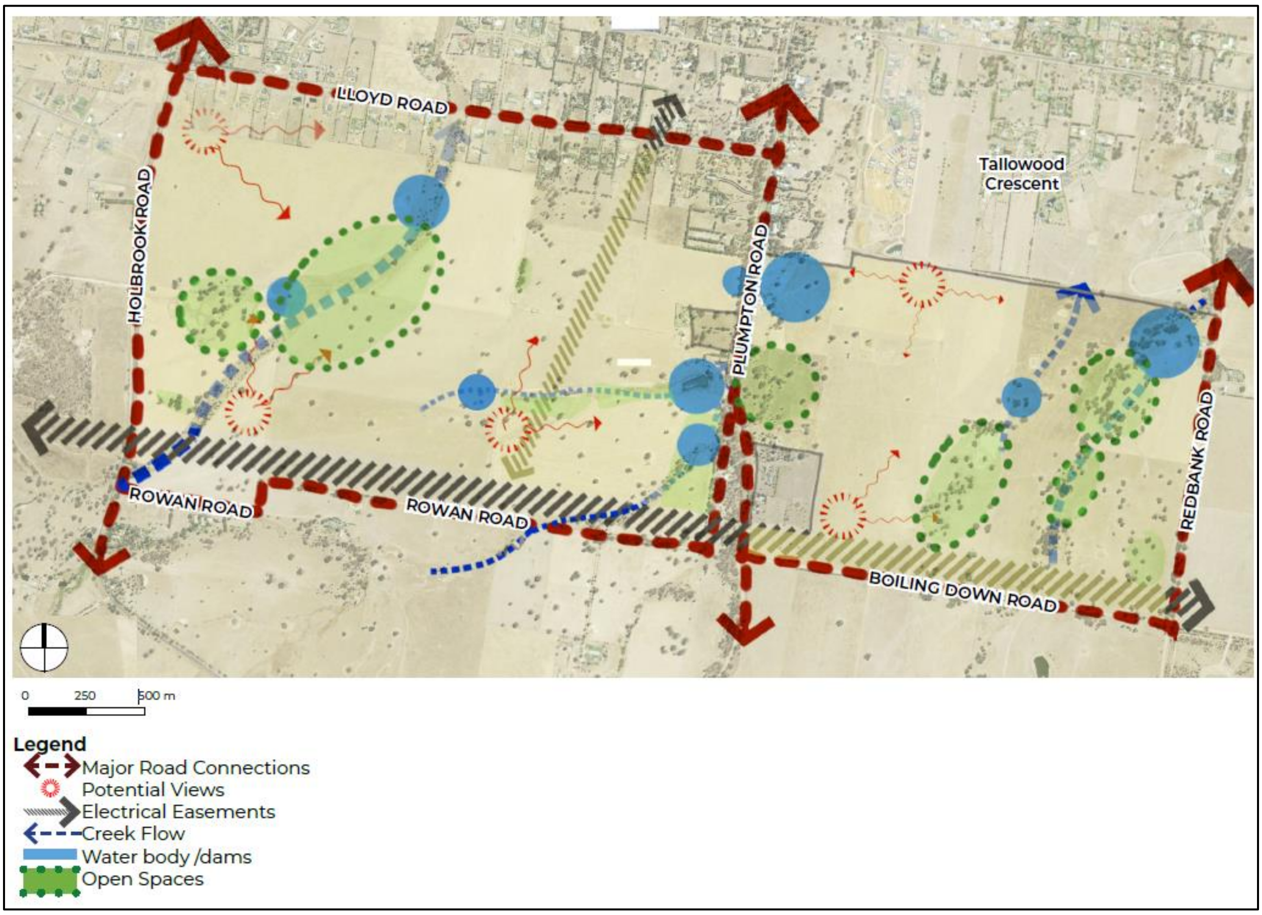

Diagram 11: Growth Area 'Mud Map' Identifying Possible Detention Basins Distribution and Overland Flow Paths

5. CONCLUSIONS

A high-level precinct wide stormwater drainage strategy (concept) has been developed using ARR 2019 current industry best practice for the possible future urban growth area in Rowan NSW 2650.

Stormwater detention requirements were investigated for regional and local flood management. The analysis indicates that offline detention basins can provide required detention to achieve “no-worsening” stormwater objectives for local and regional flood events. Eight (8) offline detention basins were proposed. The locality plan is shown in Diagram 10. The storage volumes were quantified using preliminary basin sizing methods and summarized in Table 4. The detention storage volumes estimated by Boyd method (the highest estimates among the investigated methods) are suggested to provide enough confidence that the stormwater discharge from the proposed development can be managed.

A preliminary functionality check was conducted for in terms of reserve footprints and topographic grades. It indicates that the proposed detention basins can be accommodated at suggested locations in the Master Plan.

It should be noted that the basin volumes were estimated through preliminary methods which have significant uncertainties associated. Detailed modelling should be considered for functional design and development of a detailed stormwater drainage strategy and/or drainage service scheme.

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Appendix A

APPENDIX A. GLOSSARY

Taken from the Floodplain Development Manual (April 2005 edition)

acid sulphate soils	Are sediments which contain sulfidic mineral pyrite which may become extremely acid following disturbance or drainage as sulphur compounds react when exposed to oxygen to form sulfuric acid. More detailed explanation and definition can be found in the NSW Government Acid Sulphate Soil Manual published by Acid Sulphate Soil Management Advisory Committee.
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood discharge of 500 m^3/s has an AEP of 5%, it means that there is a 5% chance (that is one-in-20 chance) of a 500 m^3/s or larger event occurring in any one year (see ARI).
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrence of a flood as big as, or larger than, the selected event. For example, floods with a discharge as great as, or greater than, the 20-year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
caravan and moveable home parks	Caravans and moveable dwellings are being increasingly used for long-term and permanent accommodation purposes. Standards relating to their siting, design, construction and management can be found in the Regulations under the LG Act.
catchment	The land area draining through the mainstream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
consent authority	The Council, government agency or person having the function to determine a development application for land use under the EP&A Act. The consent authority is most often the Council, however legislation or an EPI may specify a Minister or public authority (other than a Council), or the Director General of DIPNR, as having the function to determine an application.
development	Is defined in Part 4 of the Environmental Planning and Assessment Act (EP&A Act). **infill development:** refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. **new development:** refers to development of a completely different nature to that associated with the former land use. For example, the urban subdivision of an area previously used for rural purposes. New developments involve rezoning and typically require major extensions of existing urban services, such as roads, water supply, sewerage and electric power. **redevelopment:** refers to rebuilding in an area. For example, as urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large

scale. Redevelopment generally does not require either rezoning or major extensions to urban services.

disaster plan (DISPLAN)	A step-by-step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations, with the object of ensuring the coordinated response by all agencies having responsibilities and functions in emergencies.
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).
ecologically sustainable development (ESD)	Using, conserving and enhancing natural resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained or increased. A more detailed definition is included in the Local Government Act 1993. The use of sustainability and sustainable in this manual relate to ESD.
effective warning time	The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
emergency management	A range of measures to manage risks to communities and the environment. In the flood context it may include measures to prevent, prepare for, respond to and recover from flooding.
flash flooding	Flooding which is sudden and unexpected. It is often caused by sudden local or nearby heavy rainfall. Often defined as flooding which peaks within six hours of the causative rain.
flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
flood awareness	Flood awareness is an appreciation of the likely effects of flooding and a knowledge of the relevant flood warning, response and evacuation procedures.
flood education	Flood education seeks to provide information to raise awareness of the flood problem to enable individuals to understand how to manage themselves and their property in response to flood warnings and in a flood event. It invokes a state of flood readiness.
flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
flood liable land	Is synonymous with flood prone land (i.e., land susceptible to flooding by the probable maximum flood (PMF) event). Note that the term flood liable land covers the whole of the floodplain, not just that part below the flood planning level (see flood planning area).
flood mitigation standard	The average recurrence interval of the flood, selected as part of the floodplain risk management process that forms the basis for physical works to modify the impacts of flooding.

floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land.
floodplain risk management options	The measures that might be feasible for the management of a particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually includes both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defined objectives.
flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at State, Division and local levels. Local flood plans are prepared under the leadership of the State Emergency Service.
flood planning area	The area of land below the flood planning level and thus subject to flood related development controls. The concept of flood planning area generally supersedes the Aflood liable land@ concept in the 1986 Manual.
Flood Planning Levels (FPLs)	FPL=s are the combinations of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the Astandard flood event@ in the 1986 manual.
flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings or structures subject to flooding, to reduce or eliminate flood damages.
flood prone land	Is land susceptible to flooding by the Probable Maximum Flood (PMF) event. Flood prone land is synonymous with flood liable land.
flood readiness	Flood readiness is an ability to react within the effective warning time.
flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. **existing flood risk:** the risk a community is exposed to because of its location on the floodplain. **future flood risk:** the risk a community may be exposed to because of new development on the floodplain. **continuing flood risk:** the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation. Hence,

it is necessary to investigate a range of flood sizes before defining flood storage areas.

floodway areas Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flows, or a significant increase in flood levels.

freeboard Freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.

habitable room **in a residential situation:** a living or working area, such as a lounge room, dining room, rumpus room, kitchen, bedroom or workroom.

in an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.

hazard A source of potential harm or a situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community. Definitions of high and low hazard categories are provided in the Manual.

hydraulics Term given to the study of water flow in waterways; in particular, the evaluation of flow parameters such as water level and velocity.

hydrograph A graph which shows how the discharge or stage/flood level at any location varies with time during a flood.

hydrology Term given to the study of the rainfall and runoff process; in particular, the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

local overland flooding Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.

local drainage Are smaller scale problems in urban areas. They are outside the definition of major drainage in this glossary.

mainstream flooding Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.

major drainage Councils have discretion in determining whether urban drainage problems are associated with major or local drainage. For the purpose of this manual major drainage involves:

- the floodplains of original watercourses (which may now be piped, channelised or diverted), or sloping areas where overland flows develop along alternative paths once system capacity is exceeded; and/or

- water depths generally in excess of 0.3 m (in the major system design storm as defined in the current version of Australian Rainfall and Runoff). These conditions may result in danger to personal safety and property damage to both premises and vehicles; and/or

- major overland flow paths through developed areas outside of defined drainage reserves; and/or
- the potential to affect a number of buildings along the major flow path.

mathematical/computer models The mathematical representation of the physical processes involved in runoff generation and stream flow. These models are often run on computers due to the complexity of the mathematical relationships between runoff, stream flow and the distribution of flows across the floodplain.

merit approach The merit approach weighs social, economic, ecological and cultural impacts of land use options for different flood prone areas together with flood damage, hazard and behaviour implications, and environmental protection and well-being of the State's rivers and floodplains.

The merit approach operates at two levels. At the strategic level it allows for the consideration of social, economic, ecological, cultural and flooding issues to determine strategies for the management of future flood risk which are formulated into Council plans, policy and EPIs. At a site-specific level, it involves consideration of the best way of conditioning development allowable under the floodplain risk management plan, local floodplain risk management policy and EPIs.

minor, moderate and major flooding Both the State Emergency Service and the Bureau of Meteorology use the following definitions in flood warnings to give a general indication of the types of problems expected with a flood:

minor flooding: causes inconvenience such as closing of minor roads and the submergence of low-level bridges. The lower limit of this class of flooding on the reference gauge is the initial flood level at which landholders and townspeople begin to be flooded.

moderate flooding: low-lying areas are inundated requiring removal of stock and/or evacuation of some houses. Main traffic routes may be covered.

major flooding: appreciable urban areas are flooded and/or extensive rural areas are flooded. Properties, villages and towns can be isolated.

modification measures Measures that modify either the flood, the property or the response to flooding. Examples are indicated in Table 2.1 with further discussion in the Manual.

peak discharge The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF) The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation, and where applicable, snow melt, coupled with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study.

Probable Maximum Precipitation (PMP) The PMP is the greatest depth of precipitation for a given duration meteorologically possible over a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends (World Meteorological Organisation, 1986). It is the primary input to PMF estimation.

probability	A statistical measure of the expected chance of flooding (see AEP).
risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
stage	Equivalent to Awater level@. Both are measured with reference to a specified datum.
stage hydrograph	A graph that shows how the water level at a particular location changes with time during a flood. It must be referenced to a particular datum.
survey plan	A plan prepared by a registered surveyor.
water surface profile	A graph showing the flood stage at any given location along a watercourse at a particular time.
wind fetch	The horizontal distance in the direction of wind over which wind waves are generated.