West Lakes Catchment

Stormwater Management Plan

City of Charles Sturt

CCS045206
26 April 2022
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Building exceptional outcomes together

Document History and Status

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Glossary

AAD	Annual average damage
ACWS	Adelaide coastal waters study
ACWQIP	Adelaide coastal water quality improvement plan
AEP	Annual exceedance probability
ASR	Aquifer storage and recovery
ARI	Average recurrence interval
ARR	Australian Rainfall and Runoff
AUSMAP	Australian Microplastic Assessment Project
BCR	Benefit-cost ratio
BoM	Bureau of Meteorology
DEM	Digital elevation model
DIT	Department for Infrastructure and Transport
EY	Exceedances per year
GP/GPT	Gross pollutant / Gross pollutant trap
HGL	Hydraulic grade line
MAR	Managed aquifer recharge
ODMG	Optimised Decision Making Guidelines
PET	Potential evapotranspiration
RAGC	Royal Adelaide Golf Club
RAM	Rapid appraisal method
RCP	Representative concentration pathway
SES	State Emergency Service
SMA	Stormwater Management Authority
SMP	Stormwater management plan
SSWFE	Southern and South Western Flatlands (East)
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
WPW	Waterproofing the West
WSSA	Water Sensitive South Australia
WSUD	Water sensitive urban design

1 Introduction

This draft stormwater management plan (SMP) for the West Lakes catchment has been developed to provide the framework for a coordinated and multi-objective approach to the management of stormwater on a whole of catchment basis. The SMP is aimed at addressing existing problems and identifying opportunities that provide a range of benefits. It is intended that the plan be used as the basis for developing budgets for the works recommended herein. Consistent with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007), the SMP includes the following catchment-specific details:

- Objectives for managing stormwater in the catchment.
- Actions (both structural and non-structural) required to manage stormwater to achieve beneficial outcomes and meet the specified objectives.
- Justification for any proposed actions.
- Estimates of capital and recurrent costs and identification of priorities and timeframes for each of the actions.
- Obligations of the relevant parties in funding, implementing and communicating the plan.

The plan has been prepared in consultation with staff from the City of Charles Sturt (Council) and other key stakeholders.

2 Catchment characteristics

The study area for the West Lakes SMP consists of eight sub-catchments which discharge to West Lakes ('the Lake'). The study area, which is shown in Figure 2.1, has a total area of approximately 25.4 km^2 and extends along the coast from Semaphore Park in the north to Henley Beach in the south and towards Port Road to the east. The study area is located entirely within the City of Charles Sturt.

The study area is predominantly residential in nature, and most of the area is heavily developed. An extensive underground drainage network services the catchment, conveying stormwater runoff to multiple discharge points within the Lake, either directly or via an open channel.

2.1 Description of sub-catchments

The major sub-catchments within the study area are listed in Table 2.1. The catchment boundaries are shown in Figure 2.2.

Table 2.1 West Lakes SMP sub-catchments

Catchment	Area (km^2)	Outlet location
Henley Grange	6.0	Trimmer Parade (western end)
Meakin	4.4	Trimmer Parade (western end)
Trimmer Parade	4.6	Trimmer Parade (western end)
West Lakes Central	1.0	Various discharge points into West Lakes
West Lakes East	3.5	Adjacent to Sea Lake Court
West Lakes North East	0.8	Adjacent to Lochside Drive and adjacent to Eildon Court
West Lakes South	1.7	Various discharge points into West Lakes
West Lakes West	3.3	Various discharge points into West Lakes

The study area receives overflows from a number of external catchments including Port Road (which discharge into the Lake) and the Torrens East Catchment.

Overflows from the Port Road catchment, which is located to the east of the study area, are discharged into the Lake. The Port Road catchment is not covered by the SMP as it is addressed separately by the Port Road SMP (Connell Wagner, 2007). The Port Road catchment is included in the TUFLOW model so that the impact of these overflows on the study area can be modelled.

The Frogmore Road pump station, which is located in the Torrens East catchment to the southeast of the study area contributes flows to the West Lakes catchment and has therefore the pump station and contributing stormwater catchment has also been included within the modelling. Previous modelling of the broader Torrens East catchment (Tonkin, 2012) shows that aside from in the vicinity of the Frogmore Road pump station, the flows from the Torrens East catchment into the study area are negligible and hence the broader Torrens East catchment is not included in the TUFLOW model.

Flood mapping of the West Torrens catchment (to the south of the study area) was undertaken in parallel (by a third party) with the modelling for the West Lakes SMP. The flood mapping shows water ponding near the boundary of the West Lakes SMP study area in a 1% AEP event. Review of the DEM indicates that this area is a trapped low point and it is not expected that these flows would contribute flows to the West Lakes SMP study area. This catchment is therefore not included within the West Lakes TUFLOW model.

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WEST LAKES STORMWATER MANAGEMENT PLAN
STUDY AREA BOUNDARY

Figure 2.1

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WEST LAKES STORMWATER MANAGEMENT PLAN
MAJOR SUB-CATCHMENT BOUNDARIES

Figure 2.2

2.2 Topography

Situated on the western Adelaide Plains, the West Lakes SMP catchment gradually and uniformly slopes towards the coast.

A digital elevation model (DEM) of the study area was provided by Council. The DEM was extracted from the Adelaide Metro Councils' DEM which is owned by the Department of Infrastructure and Transport. The LiDAR based DEM was flown in April 2018 by Aerometrex using a RIEGL VQ-780i sensor, with a minimum of 8 points per square metre. The original DEM had a grid size of 1 m, however Aerometrex reprocessed the raw data to provide a 0.5 m grid size for the purpose of the SMP.

Review of the digital elevation model shows that the catchment generally falls in a north-westerly direction. Surface elevations of the catchment range from approximately 13 mAHD at its easternmost point in Beverley to approximately 1.5 mAHD at the northern boundary.

The invert of the Lake itself is unknown but based on the outlet structure into the Port River is estimated to have an invert of -3.0 mAHD. The invert of the Lake does not influence the results of the modelling as the Lake never empties. The water level in the lake is controlled by the tidal levels.

Some relatively localised formations in the topography are seen, particularly the dune system that runs along the coastline and the variations in topography introduced by the Royal Adelaide, Grange and West Lakes golf clubs.

The DEM used to define the topography for the study is shown in Figure 2.3.

2.3 Groundwater

The West Lakes SMP area is located within the Urban Torrens groundwater catchment. AWE (2002) reviewed the hydrogeology of the Urban Torrens catchment for the purpose of understanding the potential for aquifer storage and recovery (ASR) schemes within the area. A summary of the groundwater, in the context of implications on the management of stormwater, is provided in the following sections.

2.3.1 Geology

The study area is located within the Adelaide Plains sub-basin which is underlaid by the St Vincent Basin formation. The sediments consist of interbedded Quaternary sands and clays up to 80 m thick which in turn are underlain by shelly limestones and sands of Tertiary age, averaging 150 m in thickness. These sediments overlie basement rocks. The heavily developed nature of the urban catchments combined with the clayey nature of the soils limit direct recharge from rainfall to the shallow aquifers. Recharge to the shallow aquifer does occur from creeks and some reaches of the River Torrens through permeable alluvial sediments. The deeper Tertiary aquifers are recharged only by groundwater flow from the fractured rock aquifers along the faulted Hills Face zone. A summary of the generalised stratigraphy is provided in Table 2.2. Georges (2006) notes that the first Tertiary aquifer (T1) is recognised as the superior aquifer in terms of salinity and yield, and is also the shallowest of the four Tertiary aquifers. It is therefore considered that the T1 aquifer has the greatest potential for stormwater harvesting and reuse schemes.

Table 2.2 Adelaide Plains – generalised stratigraphy (Gerges, 2006)

Age	Lithology	Hydraulic Characteristics
Quaternary	Mainly fluvio-lacustrine clay with minor sands and gravel.	Sands and gravels form thin aquifers, usually high in salinity and low yielding.

Age	Lithology	Hydraulic Characteristics
Tertiary	Fossiliferous, glauconitic, partly carbonaceous sand, sandstone, limestone, chert, marl and shell remains. Thick clay layers and thin lignitic beds.	Sand, sandstone and limestone form aquifers with potential high yields. Clay, chert and marl form leaky confining beds. The late Tertiary sediments contain the better quality and quantity of water.
Precambrian	Slate, phyllite, quartzite and dolomite.	Where highly fractured (near faults) high supplies of low salinity.

2.3.2 Hydrogeology

AWE (2002) defined a number of hydrogeological zones based on the hydrogeological characteristics and the nature of groundwater use. The zones are illustrated in Figure 2.4. It can be seen that the West Lakes SMP study area is largely within Zone 2 and Zone 4.

Zone 2 coincides with the West Lakes irrigation area. In this area the groundwater is used for irrigation of golf courses and other recreational grounds. There is a resultant seasonal effect on the water table in this zone due to large quantities of seasonally extracted groundwater.

Zone 4 contains domestic bores that mostly access the shallow Quaternary aquifers for garden watering.

2.4 Soils

The distribution of soils across the catchment was derived from information contained in Bulletin 46 (Taylor, Thomson, & Shepherd, 1974) and is shown in Figure 2.5.

The catchment is predominantly underlain by red brown earths to the east and estuarine muds and sands to the west. Pockets of dune sands and alluvial soils are also found within the study area.

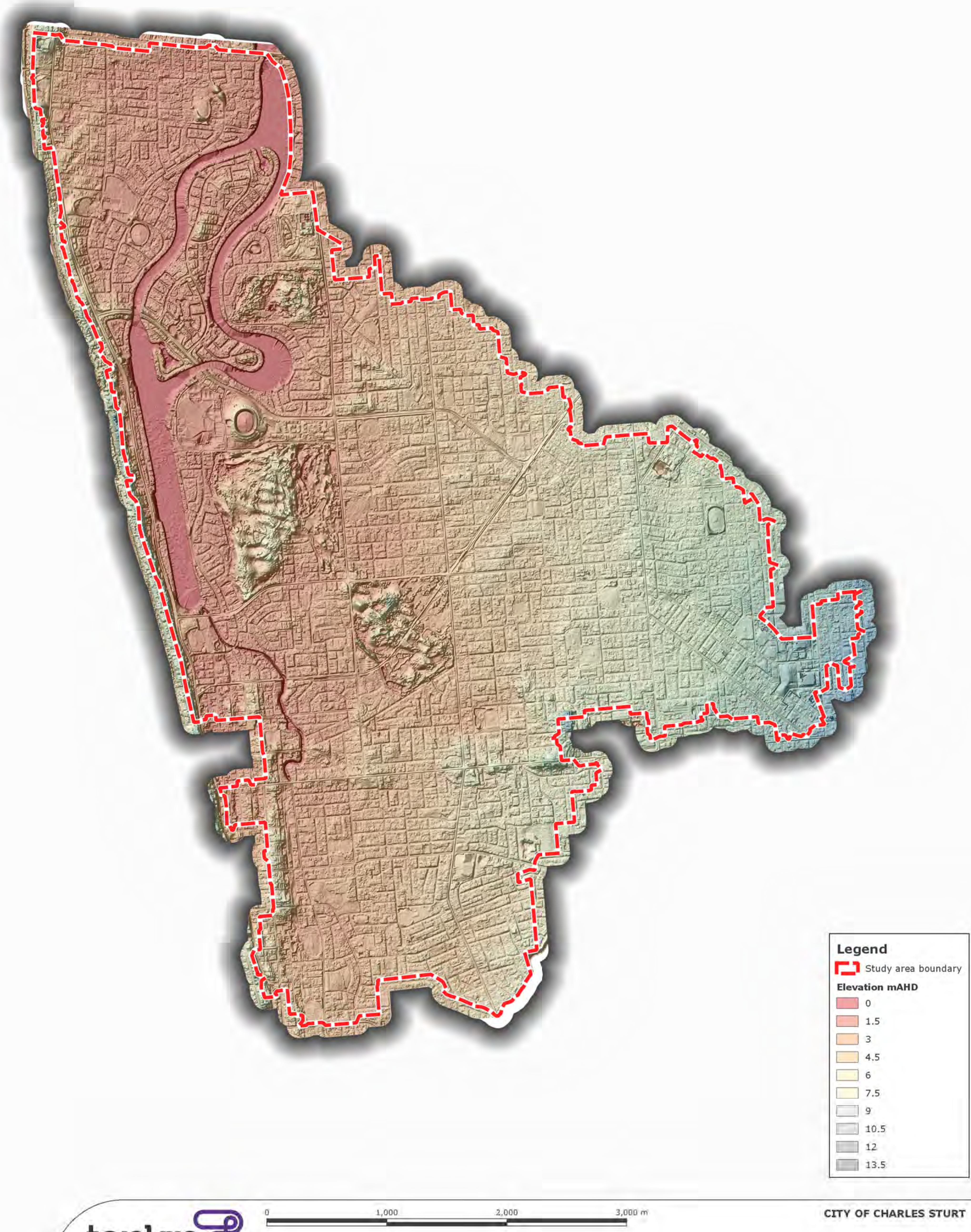
The red brown earths are characterised by brown sandy topsoil overlying red brown sandy clay of indeterminate thickness. This soil type generally experiences low shrinkage or swelling in response to changes in moisture content. The drainage capability of the soil is moderate to high.

Estuarine muds and sands are grey, dark grey or mottled silt and sand deposits with some organics. They generally do not shrink or swell with changes in moisture content, and drainage through them is relatively rapid.

The alluvial soils within the catchment are those deposited along the River Torrens and are generally silty and sandy clays. Internal drainage tends to be rapid and generally they do not undergo shrinking or swelling with changes in moisture content.

The dune sands are remnants from past dune systems along the Adelaide coast. They vary in colour, and are predominantly sand but can contain layers with higher clay content. Generally, they are well drained and stable.

It is considered that all of the soil profiles in the catchment are suitable for stormwater infiltration given the right conditions. This is a result of their low potential for swelling and shrinkage, and their good drainage characteristics.



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Digital terrain model from Aerometrix, 2019

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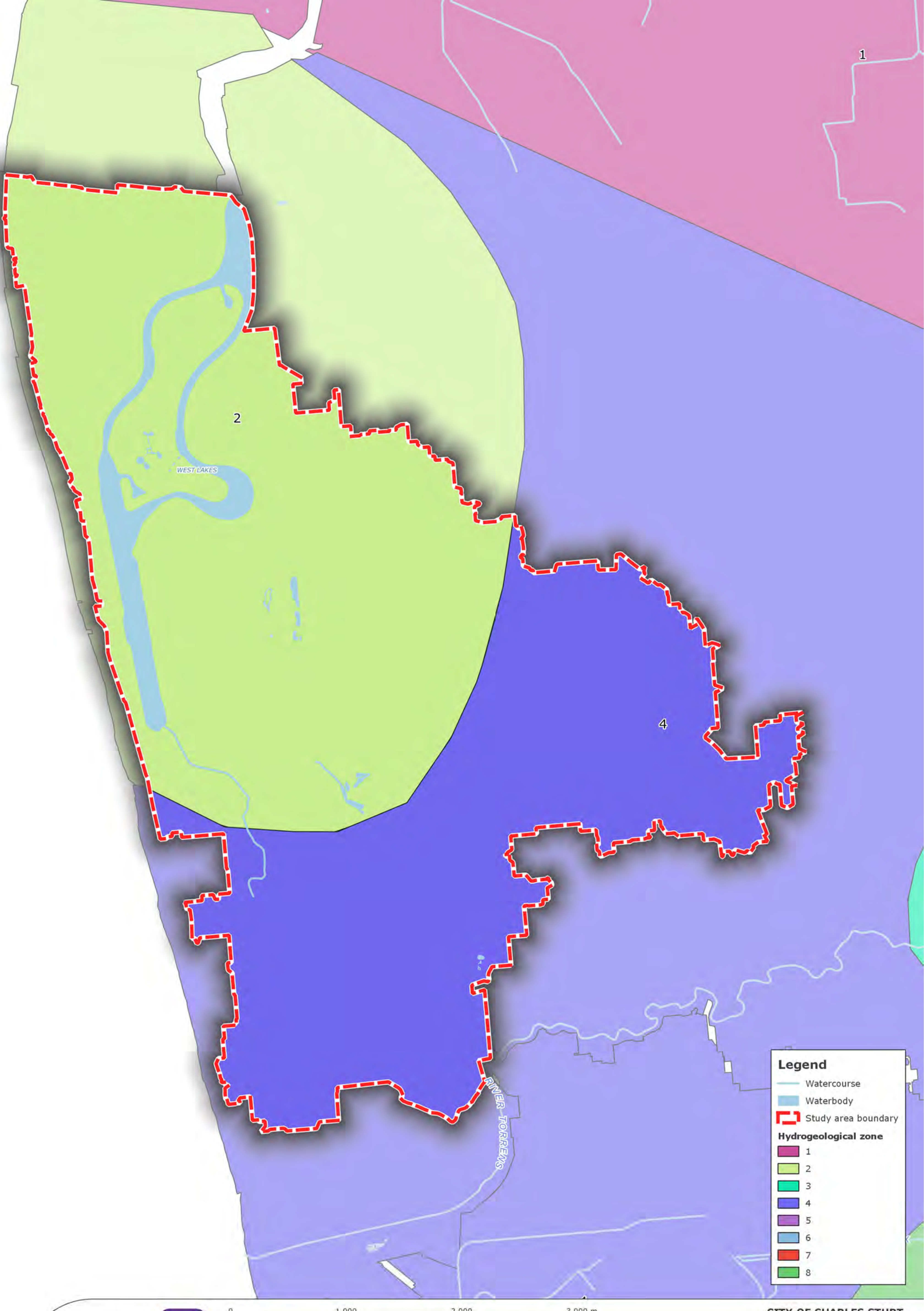
WEST LAKES STORMWATER MANAGEMENT PLAN
STUDY AREA TOPOGRAPHY

Figure 2.3



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Watercourses from Data SA, 2018
Hydrogeological zones from AWE, 2002

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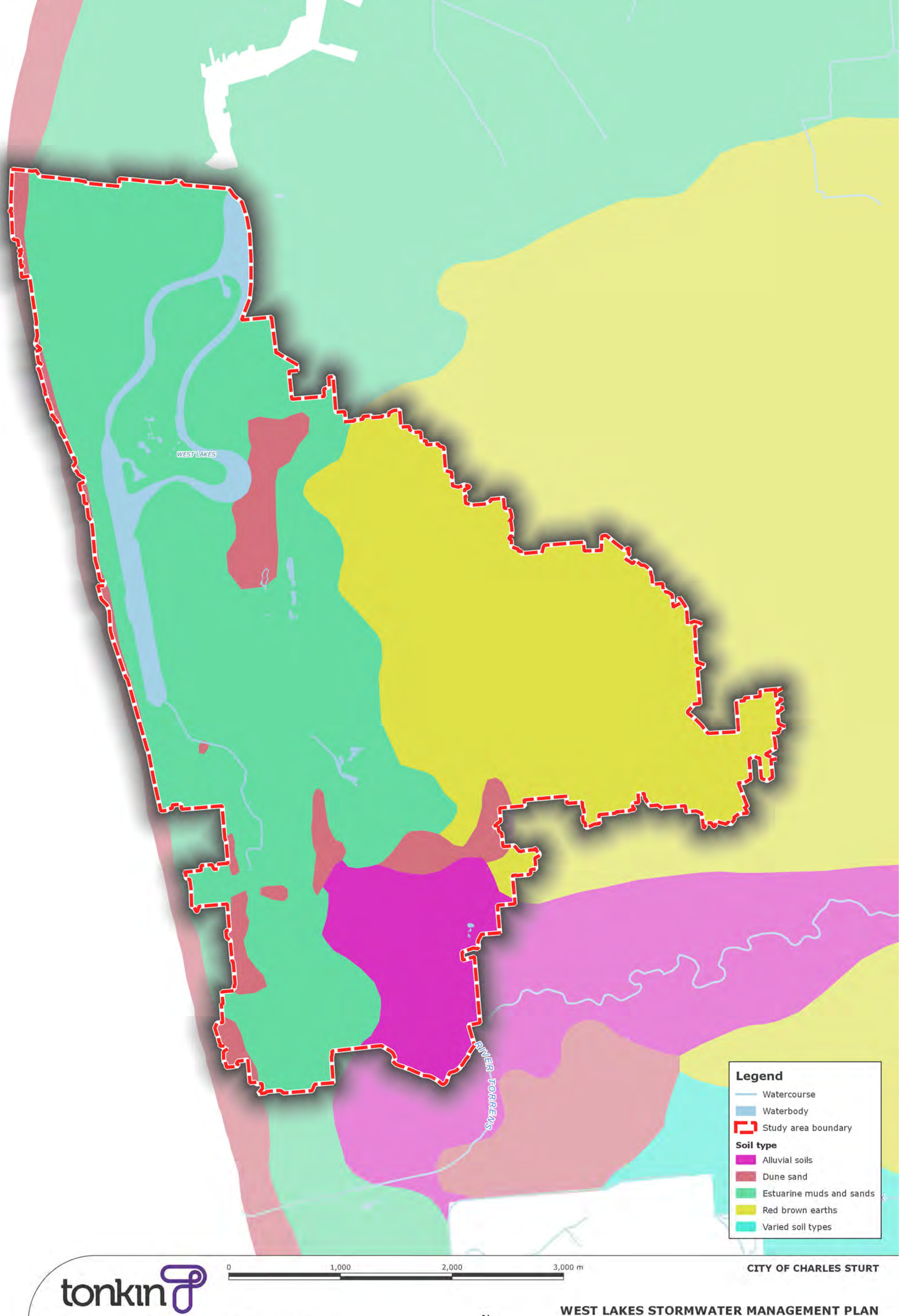
WEST LAKES STORMWATER MANAGEMENT PLAN
HYDROGEOLOGICAL ZONES

Figure 2.4



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Data Acknowledgement:
Watercourses from Data SA, 2018
Soils from Dept. of Mines, 1974

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WEST LAKES STORMWATER MANAGEMENT PLAN
SOILS

Figure 2.5

2.5 Land use and zoning

Current land use in the West Lakes catchment is primarily residential, with small pockets of industrial, commercial and retail use. There are also three golf courses within the study area which cover approximately 8% of the catchment. Maps of existing land use and land development zones are provided in Figure 2.6 and Figure 2.7 respectively. Table 2.3 provides a summary of land use (by area) within the catchment.

Table 2.3 Land use classification

Land use category	Proportion of total catchment area
Residential	49%
Open space or recreation	15%
Education	2%
Other land uses	14%
Land not in cadastre (including road reserves and the Lake itself)	20%

2.6 Receiving waters

All of the catchments within the study area discharge into West Lakes, which is a man-made lake that was constructed on a tidal swamp as part of the development of the area by Delfin (now Lend Lease communities). The Lake is flushed by seawater and the water quality in the Lake is largely driven by tidal fluctuations which promote circulation and flushing of the Lake. In January 2018, a fish die-off was linked to low levels of oxygen near the Lake inlet, combined with warm temperatures. The underlying cause of the water quality issues was attributed to limited tidal movements.

While stormwater from urban areas is a known source of pollutants including nutrients, heavy metals, pesticides and hydrocarbons, all of which may negatively impact water quality, it is understood that historically stormwater discharges have not significantly impacted on water quality in the Lake.

2.6.1 Lake operations

Flow into the Lake is driven by tide levels in Gulf St Vincent and is controlled by tidal gates which allow water into the southern end of the Lake (near the Trimmer Parade inflow point) at high tide via an intake duct and 3.5 m diameter conduit. This water then flows in a general northerly direction through the Lake.

At its northern extent, the Lake discharges to the Port River through a set of three tide gates. Flows to the Port River are driven by the water level difference between the River and the Lake, with the flap gates preventing any tidal backflow into the flood storage.

The Department for Infrastructure and Transport (DIT) is responsible for water level management in the Lake, including management of inlet and outlet gates. The current operating principles of the Lake are as follows (DIT, 2021):

- Normal Lake level is controlled by the inlet gates at Trimmer Parade.
- The inlet gates are opened automatically to allow seawater to flow into the Lake whenever the Lake is below its pre-set target height and the sea level is above the Lake level at the time.
- The inlet gates close when the Lake reaches its target height or if the sea level falls below the Lake level before the target height is reached.

- When the level in the Port River falls below the Lake level the flap gates at the outlet (at Bower Road) are pushed open and water flows out of the Lake.
- Water will continue to flow out of the Lake until the level in the Port River rises again, causing the flap gates to close.
- If the Lake level falls below the pre-set low level, then the gates will close to prevent further outflows to the Port River. The gates will automatically open once the Port River rises above the Lake level.

The hydraulic design of the Lake aims for the Lake to be flushed twice daily, with complete turnover of water due to tidal flushing every 7-14 days (Read, 1971). This is intended to manage the water quality within the Lake.

2.6.2 Marine habitats

West Lakes is a man-made Lake. National benthic mapping (accessed via NatureMaps, 2021) defines the benthic habitat in West Lakes as "bare sand". No flora or fauna species are identified and the biodiversity values are considered to be limited (AMLR NRM Board, 2008).

Council have implemented a project to improve the fish habitat in the Lake with the installation of 12 artificial reefs. The reefs are expected to promote the health of the Lake and improve the fish habitat in the Lake.

It is considered that the greatest direct impacts of stormwater discharges on the Lake itself are likely to be on the recreational users of the Lake as opposed to the marine habitats. The discharges will also contribute to the total loads of suspended solids and nutrients entering the Port River, and subsequently the Gulf.

2.6.3 Microplastics

Microplastic pollution in aquatic environments is a growing concern world-wide due to its potential impacts on aquatic organisms and ecosystems. Microplastics are defined as plastics that are smaller than 5 mm and originate from many sources.

The Australian Microplastic Assessment Project (AUSMAP) undertakes microplastic surveys at coastal sites around South Australia to help map the extent of microplastic accumulation in our waterways and beaches, and to help improve awareness of microplastics.

The 2019 AUSMAP sampling included three locations around West Lakes, all of which had microplastic loads in excess of 5,000 particles/m^2. In contrast the other sites in the state, including Murray Bridge and metropolitan beaches, had concentrations of less than 11 particles/m^2. A recording of 9,517 particles/m^2 recorded at Towpath Reserve on the shores of West Lakes in 2019 is the highest recorded concentration within Australia.

Over 80% of the recorded microplastics in West Lakes are 'white foam', and the AUSMAP report (2019) concludes that it is difficult to identify the source of such plastics. Sources may include infrastructure associated with the rowing course and materials used in the construction of private pontoons on the Lake. Other sources of microplastics may include certain land uses within the catchments.

It is recommended that more extensive sampling be undertaken to build up a better picture of spatial and temporal variations in microplastics in West Lakes. It is also recommended that targeted sampling occur at stormwater inlets to understand the local catchment contribution.

Once there is more certainty regarding the source of the microplastics, it is recommended that engagement with key stakeholders be undertaken to work towards education and awareness of the issue.

2.6.4 Stormwater quality within the catchment

A water quality gauge is located within the study area at the Kirkcaldy wetland within the watercourse at Nash Street, Grange. A summary of the recorded water quality at this location is provided in Table 2.4 (Water Data Services, 2019). This data has been used to verify the results of the MUSIC model developed as part of the SMP.

Table 2.4 Kirkcaldy wetland water quality summary

Parameter	2013	2014	2015	2016	2017	2018
Annual flow (ML)	971.37	831.95	306.16	1571.96	753.03	620.46
Total phosphorus load (t)	0.16	0.15	0.05	0.33	0.14	0.10
Total nitrogen load (t)	1.78	0.97	0.35	2.71	1.18	1.00
Suspended solids load (t)	63.40	48.64	11.24	136.82	35.93	38.23

2.6.5 Known stormwater risks

Stormwater discharges from the study area flow into West Lakes, which is diluted with sea water and then discharges into the Port River as a result of tidal flushing of the Lake.

Stormwater has been directly linked to negative impacts on the environments of the Adelaide Coastal Waters which, by definition, includes the Port River. The Adelaide Coastal Waters Study (Fox et al, 2001) was undertaken in response to the noticeable decline in coastal water quality and the rapid loss of seagrass meadows. The ACWS concluded that nutrient and suspended solid loads associated with wastewater treatment, industrial and stormwater discharges into Adelaide coastal waters are causing the loss of seagrass. Stormwater discharges were identified as the key contributor of "suspended solid pollution", with the study recommending a 50% reduction in suspended solids.

Habitats in the immediate vicinity of stormwater outfalls are most at risk from direct stormwater impacts. Further away from the outfalls, dilution reduces the concentration of pollutants, thereby reducing the direct impacts on marine habitats. Flows through West Lakes (predominantly tidal flushing) are estimated to be in the order of 600 ML/day (Pfennig, 2008). By comparison, the MUSIC modelling estimates that the annual average volumes of stormwater discharging into the Lake are 3,500 ML/a (based on the existing level of development and historic climate).

Given the lack of natural habitat in West Lakes, and the strong dilution of stormwater with seawater prior to discharge into the Port River, it is considered that the primary risks associated with stormwater discharges into the Lake are:

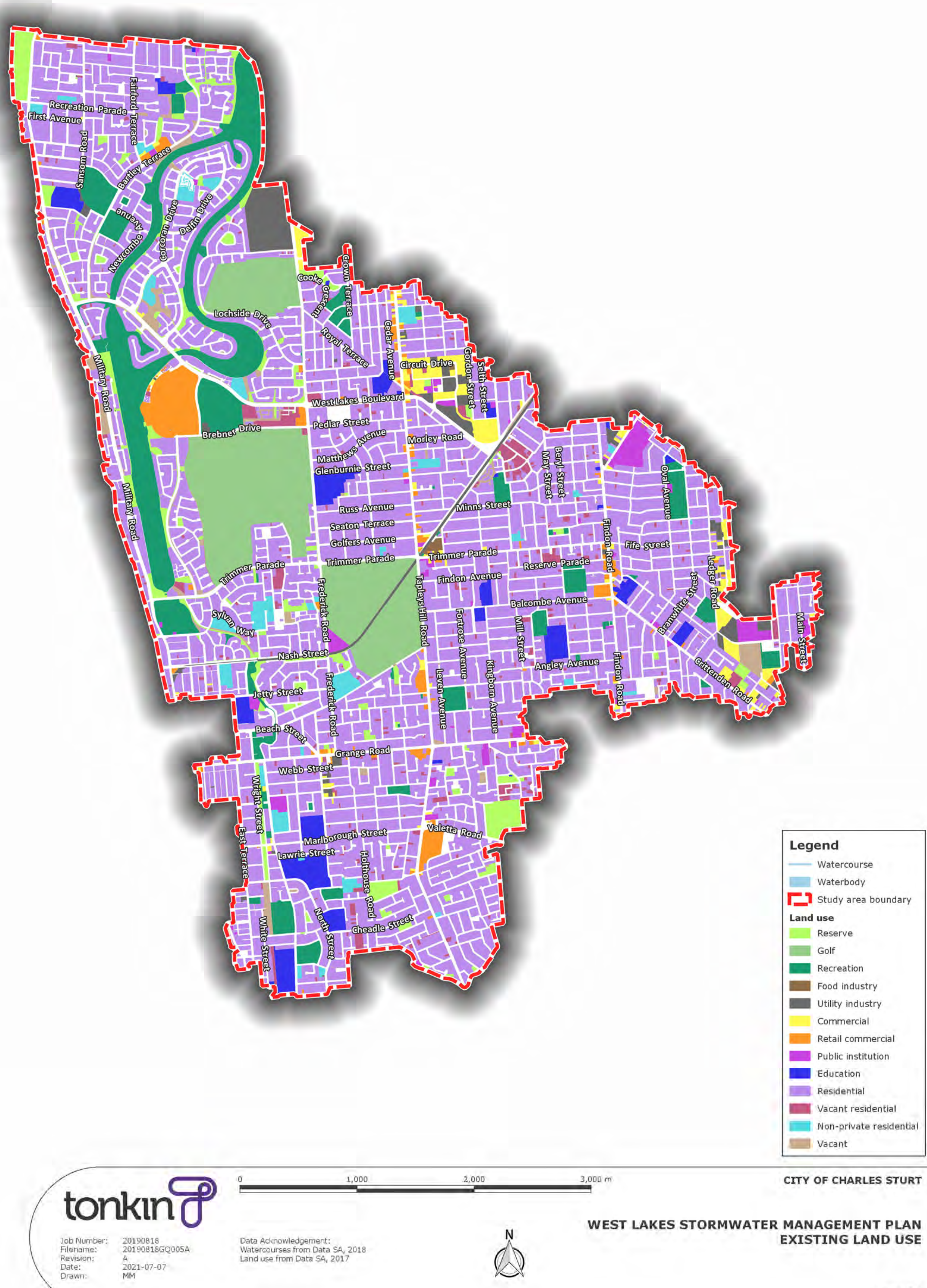
- Impacts on recreational users, particularly following a rainfall event.
- Accumulation of heavy metals and microplastics in marine species in the Lake (which may be consumed by humans).
- Contribution of suspended solid and nutrient loads to the Port River and coastal environments.

On the basis of the above, it is considered that the targets for improved water quality should consider a reduction in average annual loads of nutrients, as opposed to concentration-based water quality targets

2.6.6 Desirable end state values for West Lakes

While the nature of West Lakes means that the biodiversity values within the lake itself of are considered to be limited (AMLR NRM Board, 2008), the lake discharges into the Port River, which forms part of the Adelaide Coastal Waters.

Given the potential stormwater impacts on the Coastal Waters, the desirable end state values for the West Lakes SMP study area are improved water quality through a reduction in suspended solids and nutrients.



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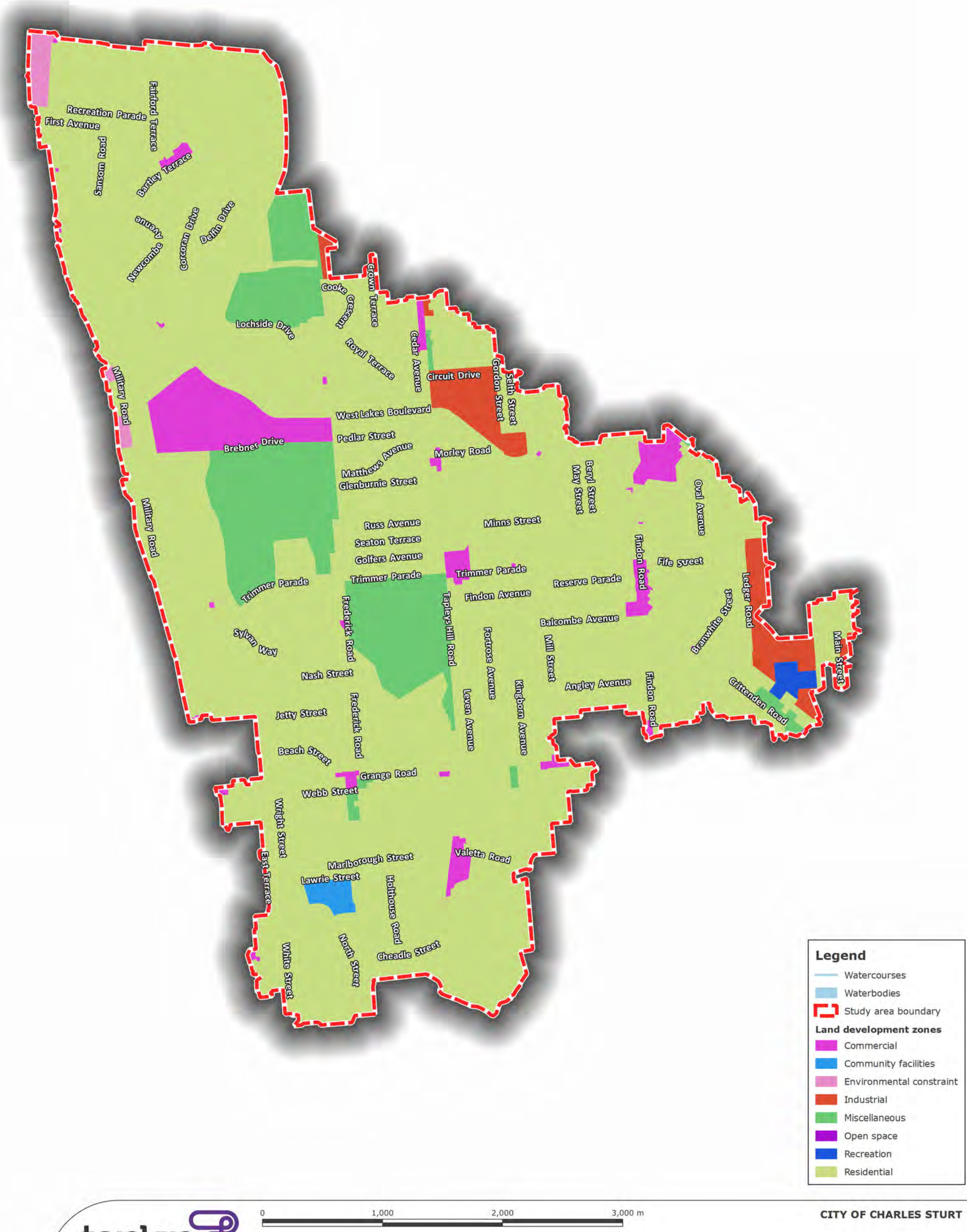
WEST LAKES STORMWATER MANAGEMENT PLAN
EXISTING LAND USE

Figure 2.6



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Roads and railways from Data SA, 2019

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WEST LAKES STORMWATER MANAGEMENT PLAN
LAND DEVELOPMENT ZONES

Figure 2.7

2.7 Existing stormwater infrastructure

As a heavily developed urban area, extensive underground stormwater infrastructure exists in the West Lakes catchment with over 210 km of pipes and culverts. A summary of the existing stormwater infrastructure within the study area is provided in Table 2.5. The existing stormwater network is also shown in Figure 2.8.

In addition to the stormwater drains, Council is also responsible for the recycled water pipeline associated with the Waterproofing the West stormwater harvesting scheme. Additional information about this scheme is provided in Section 2.8.

Table 2.5 Summary of existing stormwater infrastructure

Asset type	Description	Quantity
Gravity pipes	≤300 mm	9,161 m
	375 - 750 mm	139,614 m
	825-1200 mm	31,007 m
	>1200 mm	17,674 m
	Total	197,456 m
Box culverts	Span < 1.2 m	6,272 m
	Span ≥ 1.2 m	10,217 m
	Total	16,488 m
Recycled water pipeline	Within the West Lakes SMP area	18,326 m
	Total (City of Charles Sturt)	28,003 m
Rising main	Stormwater rising main	3,048 m
Nodes	Side-entry pits	3,992
	Grated inlet pits	441
	Junction box/man hole	1,349
Gross pollutant traps/debris collectors	Number (total)	24

There is a Council owned wetland (which is part of the WPW scheme) within Cooke Reserve. There are also privately owned wetlands within the Grange Golf Club and the Royal Adelaide Golf Club (RAGC).

Additionally, soakage pits have been installed at various locations within the catchment (both within reserves and the road reserve) to promote infiltration of runoff. These locations include Frank Mitchell reserve, Willcocks Reserve, Fraser Street, Surrey Street and Duncan Street. \

2.7.1 Pump stations

The Golfers Avenue pump station is located within the study area. There is also a pump station which diverts flows from Meakin Terrace into the Royal Adelaide Golf Club wetland.

Additionally, the Frogmore Road pump station, while located in the Torrens East catchment (i.e. outside of the SMP study area) is included within the model. The Frogmore Pump Station comprises three pumps with a combined capacity of 1.2 m^3/s. The pumps direct flows from the upstream catchment to the River Torrens. Flows exceeding the capacity of the pump station enter the West Lakes catchment via a pipe in Kidman Avenue.

2.7.2 Grange Lakes

The Grange Lakes corridor predominantly comprises an open channel than runs between Grange Road and the southern end of West Lakes. The upstream end of the channel takes the form of a natural waterway (Grange Creek), transitioning to a concrete lined open channel in the vicinity of the railway line, approximately 900 m upstream of West Lakes. The Grange Lakes system receives stormwater inflows from the Henley/Fulham Gardens catchment, Meakin Terrace catchment, Grange catchment and the Trimmer Parade catchment, conveying the flows in a northerly direction towards West Lakes. There is also the ability to divert water from the River Torrens into the upstream end of the Grange Lakes system.

The Grange Lakes corridor provides a range of functions including stormwater conveyance, water quality improvement, habitat provision and pathways for recreational purposes.

It is considered that there may be opportunities within the Grange Lakes corridor to improve the level of drainage service provided whilst also realising opportunities to provide improved water quality, increased biodiversity, improved aesthetics, increased recreational opportunities, and stormwater harvesting and re-use.

2.7.3 Condition of existing infrastructure

The condition of Council's stormwater infrastructure is reported in the Water Assets Management Plan (AMP), which was last updated in 2020. In the AMP, Council notes that regular condition audits are undertaken for stormwater infrastructure.

Council owns and operates its own CCTV service, and to date has undertaken condition assessments for approximately 70% of its stormwater network. The balance of the network has not yet been assessed to due to a combination of factors including small pipe sizes (the camera cannot fit in drains that are 225 mm or smaller), access issues and the fact that the asset is less than 20 years old.

Based on the data that Council has, it can be concluded that the overall network is generally in good condition, with 62% of assets being classified as being in 'good' or 'very good' condition and 32% of assets having an 'unknown' condition.

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Stormwater infrastructure from City of Charles Sturt, 2019

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WEST LAKES STORMWATER MANAGEMENT PLAN
EXISTING STORMWATER INFRASTRUCTURE

Figure 2.8

2.8 Existing water reuse schemes

Council owns and operates the 'Water Proofing the West' scheme which is a region wide scheme that harvests, treats, and stores stormwater in the aquifer prior to distributing water for the purposes of irrigation and other non-potable uses. The scheme, which encompasses a number of sites, includes wetlands and biofilters for treatment, bores for injection and extraction and a distribution network in excess of 50 km long which distributes the water to customers across the Council area.

The scheme has a design harvest capacity of 2,400 ML/year and can harvest a combination of stormwater and water pumped from the River Torrens. While the scheme is not entirely within the SMP study area, two of the wetland sites are (Cooke Reserve and the West Lakes Golf Course) and it is considered that the scheme presents a source of non-potable water within the study area. The extent of the associated non-potable water reticulation network within the study area is shown in Figure 8.1.

In addition to the Council-owned stormwater harvesting scheme, there are two privately-owned stormwater harvesting and reuse schemes owned and operated by golf clubs within the SMP study area. The Grange and Royal Adelaide Golf Clubs both operate schemes which harvest water from Council's stormwater network with treatment via wetlands prior to injection into the aquifer. The water is then extracted during the warmer months and used for irrigation of the golf courses. The Grange Golf Club scheme has a design harvest capacity of 200 ML/a, while the Royal Adelaide Golf Club has a capacity of 324 ML/a. Review of historical data suggest that the typical volumes harvested by the schemes are 50 and 175 ML/a respectively. Further details regarding these schemes, and the reasons why the yields are less than the design harvest capacities are provided in Tonkin (2019).

2.9 Development potential

URPS was engaged by Tonkin to undertake an assessment of the current and potential future levels of development within the study area. The full report is contained within Appendix A. The assessment (URPS, 2019) was made with regard to the planning context provided in the newly released Planning and Design Code and 30 Year Plan for Greater Adelaide.

Three residential zone development scenarios were assessed using the following criteria:

1. Low density development: only sites greater than 900 m^2 are developed.
2. Medium density development: only sites greater than 600 m^2 are developed.
3. High density development: sites greater than 400 m^2 are developed.

The potential increase in the number of allotments by 2070 (Council's nominated timeframe for the assessment) for each of these scenarios is summarised in Table 2.6.

Table 2.6 Potential number of residential allotments (2070)

Sub-catchment	Current residential allotments	2070 high density scenario	2070 medium density scenario	2070 low density scenario
Henley Grange	4,927	12,533	8,152	5,310
Meakin	3,792	9,276	6,126	4,046
Trimmer Parade	4,040	10,057	6,544	4,309
West Lakes Central	843	2,263	1,414	882
West Lakes East	3,017	6,253	4,238	3,122
West Lakes North East	246	677	435	256

Sub-catchment	Current residential allotments	2070 high density scenario	2070 medium density scenario	2070 low density scenario
West Lakes South	261	785	504	290
West Lakes West	2,606	6,127	4,041	2,730
Total	19,732	47,971	31,454	20,945

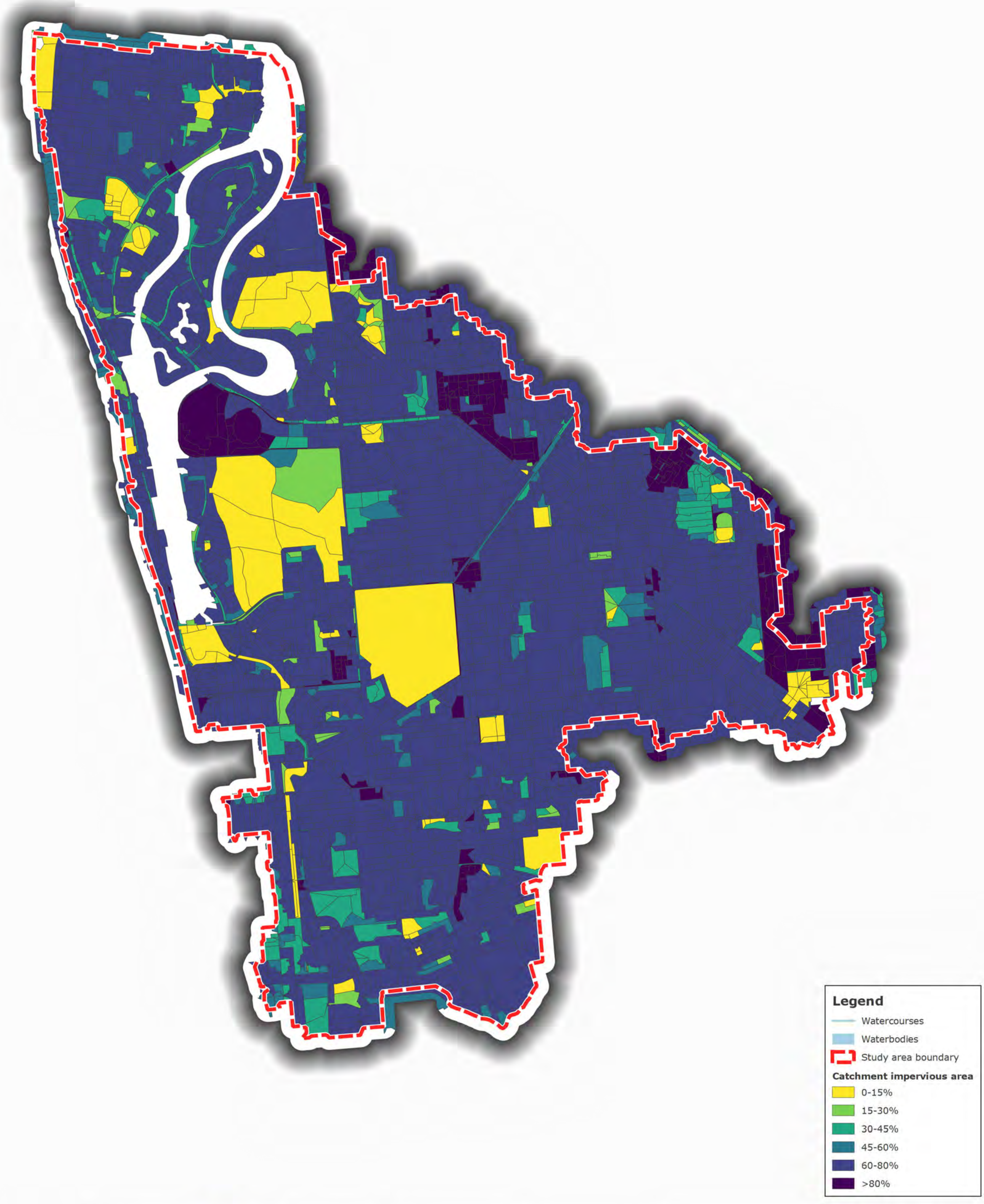
While the URPS study considered the potential increase in the number of allotments based on a range of development scenarios, the focus of the study was on understanding the impacts of development on the proportion of the catchment which is impervious, and hence the impacts on stormwater generation potential.

URPS (2019) noted that even if land is not subdivided to create additional dwellings, the impervious area could increase through activities such as dwelling additions, new verandas or other outbuildings and by an increase in paved/hard surfaces.

The study determined that the area of permeable cover within residential properties could be expected to significantly reduce considering future likely development conditions. It concluded that the impervious area within the catchment would likely be independent of which scenario (high, medium or low density) was adopted.

The modelling undertaken as part of the SMP development therefore assumes that by 2070 all residential land has 80% site imperviousness. The assumption of 80% imperviousness is consistent with the provisions for 'soft landscaping' in the Planning and Design Code.

Based on conversations with Council, the development scenario for 2070 also assumes full development of the SA Water owned land on Frederick Road. The assumed catchment impervious area associated with the 2070 development scenario is shown in Figure 2.9.



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Watercourses from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
CATCHMENT IMPERVIOUS AREA
2070 DEVELOPMENT SCENARIO

Figure 2.9

2.10 Climate

The West Lakes study area receives an average of 441 mm of rainfall per year. The mean monthly rainfall for West Lakes (based on rainfall observations at the Adelaide (Seaton) weather station (023034)) is shown in Figure 2.10. Based on historic data, there are on average 70 rain days (>1 mm) per year. Figure 2.10 also shows the mean monthly potential evapotranspiration (PET) for each month, with 10 months of the year experiencing a rainfall deficit. The mean annual PET is 1747 mm per year.

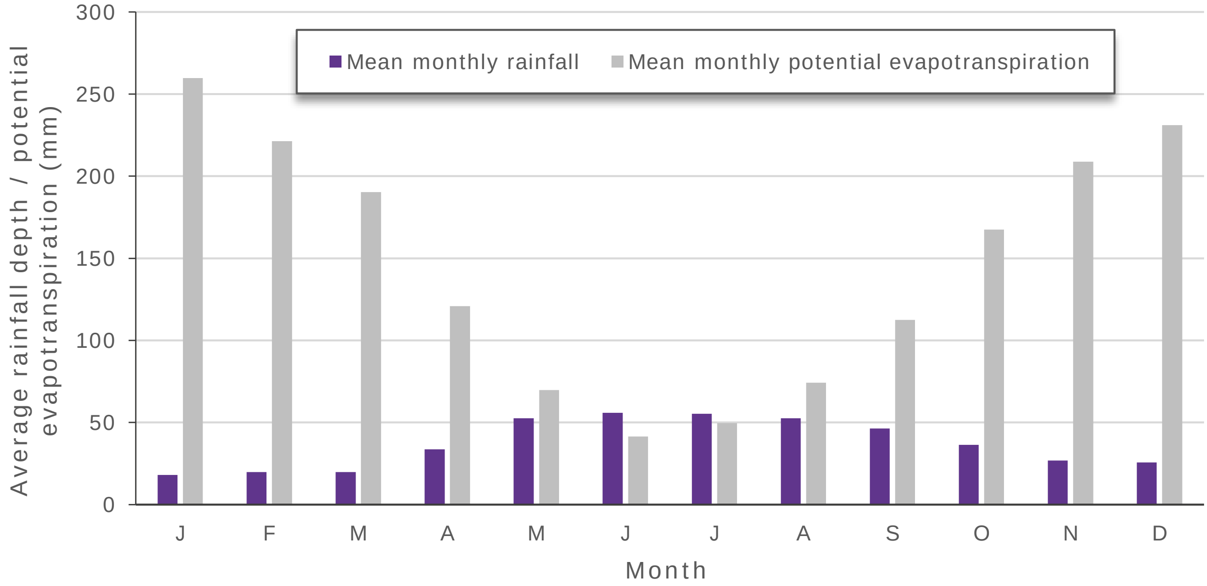

Figure 2.10 Mean monthly rainfall and PET for West Lakes (site number: 023024)

2.10.1 Climate change

The latest available science indicates that the climate is changing. CSIRO (2019) prefaces the latest regional climate change summaries with the following statement:

"Australia's changing climate represents a significant challenge to individuals, communities, governments, businesses, industry and the environment. Australia has already experienced increases in average temperatures over the past 60 years, with more frequent hot weather, fewer cold days, shifting rainfall patterns, and rising sea levels."

Despite global efforts to mitigate greenhouse gas emissions, the momentum of the climate system means that the observed climatic changes will continue with increasing magnitude, for many decades to come.

Projections for West Lakes

Climate Change in Australia (CSIRO and Bureau of Meteorology, 2016) provides climate change projections for selected Australian Cities, including Adelaide. The key climate change projections relevant to the design of stormwater systems for the Adelaide metropolitan area are as follows:

- A continuation of the trend of decreasing winter rainfall is projected with high confidence. Spring rainfall decreases are also projected with high confidence.
- An increase evapotranspiration is projected with high confidence.
- Increased intensity of extreme rainfall events is projected, with high confidence.

- Mean sea level will continue to rise and the height of extreme sea-level events will also increase (very high confidence).

With respect to the management of stormwater within the West Lakes catchment, the key risks associated with the projected changes in climate are as follows:

- A reduced level of service (greater frequency of flooding) due to the higher intensity rainfall events resulting in higher peak flows.
- Higher downstream water levels as a result of rising sea levels.
- Rising groundwater levels as a result of rising sea levels.
- Impacts on the function of existing water harvest and reuse schemes due to changes in rainfall patterns and increasing evapotranspiration.

The projected changes in maximum rainfall intensities (ARR, 2016) for West Lakes are summarised in Table 2.7. Representative concentration pathway (RCP) 4.5 represents a low emissions future and RCP 8.5 represents a high emissions scenario.

Table 2.7 Summary of climate change projections for West Lakes (ARR, 2016)

Year	RCP 4.5		RCP 8.5	
	Temperature	Rainfall intensity	Temperature	Rainfall intensity
2030	0.76ºC	3.8%	0.78ºC	3.9%
2050	1.18ºC	5.9%	1.50ºC	7.6%
2070	1.53ºC	7.7%	2.34ºC	12.1%
2090	1.67ºC	8.5%	3.40ºC	18.1%

The 2070 median projected sea level rise for the RCP 8.5 scenario for the City of Charles Sturt is 0.4 m (CoastAdapt, 2019). Work previously undertaken by Tonkin (Tonkin,2015) recommended that a mean sea level rise of 0.5 m be adopted for 2070. This is consistent with the Coast Protection Board Policy Document.

AdaptWest

The AdaptWest Climate Change Action Plan (URPS, 2016) was developed collaboratively by the City of Charles Sturt, Port Adelaide-Enfield and West Torrens. Its aims were to identify the regional specific implications of climate change and provide realistic strategies for communities within the region to adapt. The AdaptWest Plan adopts RCP4.5 projections for 2070.

Risk-based approach to climate adaptation

Recognition of the risks associated with climate change is required for better planning for new infrastructure and mitigating the potential damage to existing infrastructure (ARR, 2016). Despite advances in climate science there are still significant uncertainties associated with the projections of future climate, not least of which is patterns of global development and greenhouse gas emissions. A risk-based approach to climate change adaptation is therefore recommended.

Factors to be considered when developing an adaptation approach include:

- The design life of the asset – the impacts of climate change will be greater for assets with a long design life.
- The consequences of failure – if failure is catastrophic then design should be based on the worst-case climate change projection for the end of the asset life. If not catastrophic, design may be based on

climate change projections for the middle of the design life of the asset with acceptance of increased risk of failure towards the end of the asset life.

- Impacts of the projections on system performance – a sensitivity analysis should be undertaken to provide an understanding of what the projected changes mean for system performance.
- Cost of the adaptation measures – no cost or low-cost options should be sought, particularly where the consequence of failure is not severe.

Recommendations for West Lakes SMP

Projections of future climate are inherently uncertain. For the purpose of capturing the potential impacts of climate change on stormwater management within the West Lakes catchment the following has been adopted:

- Consider a 2070 scenario, which is consistent with the approach adopted in the consideration of future development potential and is likely to roughly correspond with the middle of the design life of most stormwater assets (assumed design life of concrete assets is 70-100 years).
- Assume a 10% increase in rainfall intensity. This represents the rough mid-point between the recommendations of the Adapt West project and a RCP 8.5 2070 scenario. Given the highly uncertain nature of climate change, this is considered suitable to inform a risk-based approach to stormwater planning.
- Assume a 0.5 m rise in sea level. While higher than the value provided by Coast Adapt, it is considered prudent to adopt a more conservative approach (the precautionary principle) which is consistent with previous planning documents and studies (e.g. the Coast Protection Board and Tonkin 2015).

2.11 Previous studies and investigations

A number of previous studies of relevance to the SMP have been undertaken within the catchment. These previous studies have provided a basis for the development of the models that will be used to identify issues and opportunities as part of the SMP. A brief description of the key previous studies and their relevance to this SMP is provided below.

2.11.1 Western Adelaide region climate change adaptation plan

The objective of the Western Adelaide region climate change adaption plan (Tonkin Consulting, 2018) was to quantify the impacts of climate change on sea water and stormwater flooding in potentially sensitive costal catchments, including West Lakes. After quantifying these impacts, mitigation options were considered.

West Lakes was modelled as part of this study to assess the impact of sea level rise, increased rainfall intensity and increasing initial lake water levels associated with climate change. The study concluded that the Lake could be potentially susceptible to climate change impacts on stormwater/seawater interactions. Particularly, under an assumed sea level rise of 1 m, it was found that the Lake would rarely flush due to its dependency on tidal interactions; modelling indicated that 1 m of sea level rise caused an increase in flood depth for the 100-year average recurrence interval (ARI) event of 840 mm.

To mitigate the potential impacts associated with rising sea levels, an increase in the size of the Bower Road outlet was recommended when mean sea level increased by 300 mm. This level corresponds to a peak water level increase in the Lake of around 260 mm.

The study also identified the possibility for pumping for the purposes of water quality management, when the sea level rises to a point that there is insufficient flushing of the lake. The pumps could also be used for drawing down the lake prior to a predicted heavy rainfall event. The study identified that this option would not need to be considered until post 2050.

The amalgamated TUFLOW models developed as part of the climate change adaptation plan will be used as the basis for the floodplain mapping of the West Lakes SMP study area.

2.11.2 West Lakes TUFLOW floodplain modelling

The objective of this investigation (Tonkin Consulting, 2009) was to generate a series of flood maps identifying potential areas of flooding within a portion of the West Lakes catchment for a range of rainfall events (note that the contributing catchment area for the study is less than that for the West Lakes SMP). The modelling considered long-term development, but did not include an allowance for climate change.

Comparison of the results of this modelling, which covers about half of the West Lakes SMP study area, with the results of the modelling undertaken as part of the SMP development shows close general agreement for the long-term development scenario.

Development of the SMP has built upon this previous floodplain modelling.

2.11.3 Henley Fulham catchment initial urban stormwater master plan

As part of this stormwater master plan (Tonkin Consulting, 2005), strategies for managing the high-risk flooding of the Henley Fulham catchment were developed. Strategies included upgrades of some key underground drainage systems in the catchment and provision of detention basins at key points. Suggested upgrades to the underground drainage system included:

- Northern lateral drain (Murray Street)
- Central lateral drain (Marlborough Street)
- Main outfall along Cudmore Terrace north of North Street
- A number of laterals feeding into the Henley-Fulham drain.

Locations suggested for further investigation of detention basins included:

- Fulham Gardens Primary School Oval
- County Street Reserve
- St Michaels College Oval
- Jeanes Street Reserve
- Fulham North Primary School Oval.

Regarding improvement of stormwater quality, the installation of gross pollutant traps (GPT) was recommended. However, it was noted that the grade of pipes in the Henley-Fulham catchment was generally low and, therefore, the hydraulic losses introduced could be significant. As such, the location of any proposed GPTs needs to be investigated to ensure that significant reduction in capacity of the upstream drainage system does not occur.

Since the initial USMP was issued, minor drainage upgrades have occurred within the catchment to address localised flooding areas, including on Marlborough Street. None of the detention basins have been constructed.

2.11.4 Trimmer Parade catchment initial urban stormwater master plan

Previous work by Tonkin (2003a) found that the hydraulic capacity of the Trimmer Parade catchment's stormwater systems was generally inadequate, with the systems as they existed at the time generally having less than a 2-year ARI capacity. Upgrade of the existing drainage systems to increase capacity was not recommended due to high estimated costs. Instead, provision of detention basins and other management strategies (such as on-site retention or detention and monitoring and management of development with consideration of how that development affected the stormwater system) were recommended.

It was noted that the northern end of Frank Mitchell reserve appeared to offer the greatest potential for establishment of a stormwater detention basin. Since this report was prepared, a number of other detention storages have been incorporated into the catchment.

As part of the Renewal SA residential development on Trimmer Parade, located between Cameron Avenue and Field Court, additional underground detention storage tanks have been incorporated within the road drainage system, providing 205 m^3 of storage (Greenhill, 2018).

A new underground drain along the full length of Duncan Street has also since been constructed, with a large detention system in the north eastern corner of Don Klaebe Reserve used to detain flows (Tonkin Consulting, 2014).

A review of the stormwater design models for the Woodville West development (provided by Council) also show a number of basins within the development, including within Frank Mitchell reserve. These basins are captured in the modelling being undertaken for the SMP development.

2.11.5 Meakin Terrace catchment initial urban stormwater master plan

Tonkin Consulting (2003b) previously completed work developing an urban stormwater master plan for the Meakin Terrace catchment. While the construction of underground drainage alone was not suggested at the time due to cost and the potential effects downstream, construction of a new outfall channel was recommended based on the flows from the existing level of development. The suitability of detention basins was also considered, but existing areas of reserves were not suitably located to intercept runoff from large upstream catchments. It was suggested that with further investigation, small detention basins on purchased land could be targeted at areas where more intense redevelopment was likely and where they would have the greatest effect.

Since this study detention has been implemented in a number of locations with the catchment including Willcocks Reserve, Dumfries Reserve and Fraser Street.

2.12 Model development and information gaps

As part of the Stage 1 data investigations, the TUFLOW models previously developed and used for the studies summarised above were revised. Specifically, the following changes were made:

- Drainage elements that have been constructed since the previous models were developed have been incorporated into the model. Approximately 900 drains were added/amended. The new detention basins and underground storages have also been incorporated into the model.
- Council's TUFLOW model of the Port Road drainage upgrade project was added to the model. The Port Road model was assumed to have all recent upgrades included, however, it was found this was incorrect. Lateral systems in Ledger Road, Main Street, Charles Road, William Street did not reflect Council's GIS data. These lateral systems were updated using Council's GIS.
- The Frogmore Pumping station and overflow weir was updated based on Tonkin design drawings. The pump station now has a peak outflow of 1200 L/s and operates according to the design operating rules.
- The Golfers Avenue pump station was added to the model using Council records. Inverts in the Trimmer Parade trunk drain were updated downstream of the pump station using Council GIS data. This will improve the estimate of flooding in the Golfers Avenue sub-catchment. The Trimmer Parade outfall dimensions were also updated from Council GIS. Previously, this parallel pipe system was represented using a single equivalent diameter pipe. The new configuration enables more accurate drain inverts to be used.
- Four large open air GPTs were added to the model to better reproduce hydraulic conditions at the outlet of drains into the Lake. Council provided scans of original design drawings for this exercise. The Trimmer Parade GPT was added using survey as design drawings were not available.
- The schematisation of Grange Lakes was updated to include more representative inverts and channel dimensions. The area south of the Grange railway line was represented in 2D. The area north of Grange railway line was added as a 1D channel to ensure that the correct conveyance of this open drain was captured in the model.

- A new LiDAR derived DEM was integrated. Care was taken to ensure that the underground drainage network was properly linked to the new DEM. On average the new DEM was 100 mm lower than the old DEM, but in places was up to ±500 mm. Therefore, the connection of all inlets to the new DEM was carefully managed to ensure correct connectivity between the 1D and 2D domains. Additionally, all underground drains were checked to ensure they still had appropriate cover compared to the new DEM.
- Multiple soakage basins were added to the model to better replicate infiltration during small events.
- All model elements have been converted to GDA2020 to match the projection of the new LiDAR DEM.

2.12.1 Data gaps and areas for additional improvement

Surface flows from the Torrens East catchment flow into the West Lakes SMP study area when the capacity of the underground network is exceeded. The Torrens East catchment has not previously been included in the West Lakes modelling and it is considered that the impact of the overflows on flood depths in the West Lakes catchment will be localised. Incorporation of the Torrens East catchment into the existing West Lakes TUFLOW model could be considered if Council want to verify the impacts of surface flows from the Torrens East catchment on the West Lakes study areas, however it is considered that this work is beyond the scope of the current SMP.

While the TUFLOW model includes details of outlet structures, based on plans provided by Council, the model does not include representation of the trash nets in the catchment. Based on results of preliminary hydraulic modelling it is not considered that this assumption will significantly impact the modelled water levels during major flow events. They may have localised impacts during smaller flow events.

3 SMP objectives

This section provides details of the objectives underpinning the development of the framework for the whole of catchment approach to the management of stormwater within the West Lakes SMP area.

3.1 Guidelines and policies

Objectives guiding the development of this SMP have been established with reference to a range of guidelines and policy documents relevant to the management of stormwater. Of specific relevance are the following:

- Stormwater Management Authority (SMA) Guidelines
- State WSUD Guidelines
- Planning and Design Code
- Council's Biodiversity Action Plan
- Australian Coastal Water Quality Improvement Plan
- Green Adelaide Draft Regional Landscape Plan

The sections of these plans of specific relevance to this SMP are discussed in the following sections.

3.1.1 SMA guidelines

The key issues to be addressed in the development of any plan for the management of stormwater runoff from an urban catchment include:

- flooding
- water quality
- water use
- environmental protection and enhancement
- asset management.

Catchment specific objectives are set based upon the problems and opportunities identified within the study area. The Stormwater Management Planning Guidelines (SMA, 2007) state that, as a minimum, objectives are to set measurable goals for:

- An acceptable level of protection of the community and both private and public assets from flooding.
- Management of the quality of runoff and effect on the receiving waters, both terrestrial and marine.
- Extent of beneficial use of stormwater runoff.
- Desirable end-state values for watercourses and riparian ecosystems.
- Desirable planning outcomes associated with new development, open space, recreation and amenity.
- Sustainable management of stormwater infrastructure, including maintenance.

3.1.2 State WSUD guidelines

The Department for Environment and Water's (DEW, formerly DEWNR) Water Sensitive Urban Design (WSUD) Guideline (2013) sets out the South Australian Government's position on WSUD in a local context, provides State-wide WSUD 'targets' for new developments and details the role that Government will play in collaboration with other stakeholders to maximise the use of WSUD approaches.

The aim of WSUD in South Australia is that urban landscapes are planned, designed and managed to be 'water sensitive' and in doing so contribute to the liveability of South Australia's urban environments and the wellbeing of South Australians, both for current and future generations.

The stated objectives of the SA WSUD Guidelines include:

- Encouraging best practice in the use and management of water to minimise reliance on imported water.
- Promoting safe, sustainable use of rainwater, recycled stormwater and wastewater.
- Mimicking a more natural runoff regime.
- Maintaining and enhancing water quality.
- Managing rainfall runoff so that it does not increase the potential for flooding.

A summary of the key performance principles, intents and targets that have been set, and which are considered relevant to the development of this SMP, is provided in Table 3.1

Table 3.1 State-wide WSUD performance principles and performance targets (from DEWNR 2013)

Performance principle	Performance principle intent	State-wide performance target
Runoff quality Positively manage the quality of urban runoff through implementing water-sensitive urban design.	To help protect and, where required, enhance, the quality of runoff entering receiving water environments, in order to support environmental and other water management objectives.	Minimum reductions in total pollutant load, compared with that in untreated stormwater runoff, from the developed part of the site: • Total suspended solids by 80% • Total phosphorus by 60% • Total nitrogen by 45% • Litter/gross pollutants by 90%
Runoff quantity Post-development hydrology should, as far as practical and appropriate, minimise the hydrological impacts of urban built environments on watercourses and their ecosystems.	• Help protect waterways and, where relevant, promote their restoration by seeking to limit flow from development to pre-development levels. • Help to manage flood risk, by limiting the rate of runoff to downstream areas to appropriate levels.	For flood management: For development and other relevant infrastructure that will drain runoff to an existing publicly managed drainage system or to a drainage system such as a creek or watercourse on privately-owned land: • the capacity of the existing drainage system is not exceeded • there is no increase in the 5 year ARI peak flow and no increase in flood risk for the 100 year ARI peak flow, compared to existing conditions.
Integrated design That the planning, design, and management of WSUD measures seeks to support other relevant State, regional and local objectives.	Implement WSUD in a way that promotes establishment of 'green infrastructure' and achievement of multiple outcomes, for example: public amenity, habitat protection and improvement, reduced energy use and greenhouse emissions, and other outcomes that	Evidence that relevant stakeholders are engaged at appropriate stages of planning, designing, constructing, and managing WSUD measures so as to maximise the potential for WSUD to contribute to 'green infrastructure' and other relevant State, regional, and local objectives.

Performance principle	Performance principle intent	State-wide performance target
	contribute to the wellbeing of South Australians.	

3.1.3 Planning and Design Code

The South Australian Planning and Design Code includes several provisions to manage stormwater within new developments (of all scales). The code includes provisions associated with the management of hazards associated with flooding and the management of stormwater. The sections of the code that are of relevance to this SMP are summarised below.

Hazards (Flooding) Overlay

The desired outcome of the assessment provisions associated with the Hazards (Flooding) Overlay section of the code is that impacts on people, property, infrastructure and the environment from high flood risk are minimised by:

- retaining areas free from development
- minimising intensification where development has occurred
- appropriate siting and design of development.

Stormwater management requirements

The Planning and Design Code also contains requirements for water sensitive design. The requirements vary depending on the type of development but they typically include measures to manage runoff quality and the volume and magnitude of flows.

For residential developments, the code requires that the '*development is designed to capture and reuse stormwater to maximise conservation of water resources; manage peak stormwater runoff flows and volume; and manage runoff quality.'*

3.1.4 Biodiversity Action Plan

Council's Biodiversity Action Plan (2017) seeks to implement strategies to enhance biodiversity, create diverse and connected open space, promote education and implement strategic drivers. Water quality is identified as one of four key biodiversity action areas for which specific and measurable actions have been developed. These actions include the following:

- Identify significant contributing factors to decreased water quality and develop priority action plans to address these factors.
- Implement WSUD and raingardens/filters in public parks and gardens.
- Engage community and landowners in education programs regarding water quality on private land.

3.1.5 Australian Coastal Water Quality Improvement Plan

The Australian Coastal Water Quality Improvement Plan (ACWQIP), developed by the SA EPA, provides a long-term strategy to achieve and sustain water quality improvement for Adelaide's coastal waters and create conditions to see the return of seagrass along the Adelaide coastline.

The EPA has developed strategies to assist with achieving their target of reducing nitrogen loads by approximately 75% from 2003 levels to halt seagrass loss and create conditions that support seagrass restoration. The strategies that apply to stormwater management include reducing nutrient, sediment and organic matter discharges through the uptake and implementation of WSUD and promoting integrated reuse of wastewater and stormwater (EPA SA, 2013). The ACWQIP targets include:

- The total load of nitrogen discharged to Adelaide's marine environment should be reduced to around 600 tonnes/year (representing a 75% reduction from the 2003 value of 2,400 tonnes). The ACWQIP target for the stormwater contribution is 50 tonnes/year by 2028.
- Steps should be taken to progressively reduce the load of particulate matter discharged to the marine environment. A 50% load reduction (from 2003 levels) would be sufficient to maintain adequate light levels above seagrass beds for most of the time. The reduced sediment load will also contribute to improved water quality and aesthetics.
- The ACWQIP target for the stormwater contribution of suspended solids is 730 tonnes/year by 2028 for discharges into the Barker Inlet. One means of reaching this target is to reduce the volume of stormwater discharging to the Barker Inlet.
- To assist in the improvement of the optical qualities of Adelaide's coastal waters, steps should be taken to reduce the amount of coloured dissolved organic matter in waters discharged by rivers, creeks and stormwater drains.

3.1.6 Green Adelaide

The West Lakes catchment is located within the boundary of the Green Adelaide Board. The Board has recently released the draft regional landscape plan which identifies a number of key focus areas and outcomes across seven priority areas (Green Adelaide, 2021). The goals of the plan that are of relevance to the SMP are listed below:

- Partner and invest in the conservation and restoration of coastal and marine environments.
- Protect, enhance and restore water resources.
- Facilitate and incentivise best practice biodiversity sensitive urban design and WSUD in new developments, major transport corridors, public open spaces and local streetscapes.
- Identify priority locations for improved urban greening.

3.2 Stormwater management goals

With consideration of the guidelines and policies discussed in the preceding sections, the following objectives specific to the management of stormwater within the West Lakes catchment have been developed.

3.2.1 Objective 1: Provide an acceptable level of flood protection.

The SMA states that the priorities for stormwater management should focus on measures that reduce the risks associated with flooding and protect property and human lives. ARR (2019) provides guidance on the design standards for urban stormwater drainage. The design standard is embodied in the major-minor principle, which aims to ensure that development is protected from inundation in a 1% AEP event.

The objectives associated with the provision of an acceptable level of flood protection, outlined below, have been developed with regard to the highly developed state of the catchment and the limitations that this poses on achieving the recommended standard of protection in all areas.

Goal F1: Reduce the risk of flooding to private property through improving the levels of service provided by the drainage infrastructure.

Within existing developed areas:

a. Where practical and economically viable, protect existing habitable buildings from over-floor flooding in a 1% AEP event. A lower standard of protection may be adopted where physical and economic constraints limit the ability to achieve a 1% AEP standard.

b. Where practical, provide a minor drainage system capacity of 20% AEP. A lower standard may be adopted where physical and economic constraints limit the ability to achieve 20% AEP standard and where an overflow route exists.

Within areas of new development:

c. Protect new development from inundation for all events up to and including the 1% AEP event.

d. Provide a minor drainage system capacity of 20% AEP. Where no overflow route is possible, a higher design standard should be adopted.

Goal F2: No private property is subject to high or extreme hazard in a 1% AEP flood event.

Goal F3: Create an informed and more flood resilient community.

3.2.2 Objective 2: Improve water quality to achieve desirable end-state values in receiving waters

To ensure that this stormwater management plan aligns with other strategies and guidelines, stormwater quality targets from other documents have been reviewed. These include the recommendations made in:

- Adelaide Coastal Waters Study (ACWS) (EPA SA, 2007) and Adelaide Coastal Water Quality Improvement Plan (ACWQIP) (EPA SA, 2013).
- Australian Runoff Quality: A Guide to Water Sensitive Urban Design (Engineers Australia, 2006).
- Water Sensitive Urban Design – Creating more liveable and water sensitive cities in South Australia (DEWNR, 2013).

With infill development likely to occur within the catchment, it is imperative that pollutant loadings and concentrations are not increased to a level that would be harmful to the receiving environments. The catchment specific objectives shown below have been set to ensure that the desirable end-state water quality goals are met.

Goal WQ1: Improve the quality of stormwater runoff discharging into West Lakes; aim to achieve the following pollution reduction targets, compared to the 'untreated' case (consistent with the DEWNR (2013) guidelines):

- Total suspended solids: 80%
- Total phosphorus: 60%
- Total nitrogen: 45%
- Gross pollutants: 90%

Goal WQ2: Reduce the concentrations of microplastics in West Lakes to a 'moderate' level (less than 250 mp/m^2).

3.2.3 Objective 3: Maximise the economic use of stormwater runoff for beneficial purposes.

Council currently manages the Waterproofing the West recycled water scheme, which facilitates extensive reuse of harvested stormwater for irrigation within the study area (and beyond).

Consistent with the stated objectives of the State Government's WSUD Guidelines this SMP includes goals to increase the volumes of water that are reused both through expansion of existing schemes, and through development of small-scale schemes. The goals related to the reuse of stormwater are as follows.

Goal RU1: Increase the volumes of stormwater that are harvested and reused within the catchment.

Goal RU2: Increase the delivery of small-scale projects (Council owned and private) which promote the beneficial reuse of runoff.

3.2.4 Objective 4: Achieve desirable planning outcomes associated with new development, open space, recreation, and amenity.

The new Planning and Design Code includes a number of controls relating to the management of stormwater and the management of risk associated with flooding. It is recommended that the outcomes from this SMP, specifically the flood mapping, be used to inform the application of the provisions of the Planning and Design Code for the assessment of development within the SMP study area.

Further, opportunities to leverage off stormwater upgrades to deliver benefits associated with open space, recreation and amenity should be considered. The goals related to planning outcomes, recreation and amenity values are as follows.

Goal RA1: Incorporate flood map outputs from this SMP into the Planning and Design Code.

Goal RA2: Council guidelines for stormwater management should include a requirement to consider opportunities to provide non-flood risk related benefits when developing capital works projects.

Goal RA3: Environmental enhancement of drainage reserves and waterbodies within the study area to promote improved biodiversity and better environmental outcomes.

3.2.5 Objective 5: Sustainable management of stormwater infrastructure

Council owns and operates an extensive network of stormwater infrastructure, with a high capital value. The infrastructure is in varying ages and conditions. Degraded infrastructure will reduce the ability of the drainage system to act as per its original design intent. Without careful planning, structural failure of existing infrastructure may necessitate immediate and expensive rectification. Careful asset management will allow for future planning to determine the timeline for replacement of assets. Goals related to the sustainable management of Council’s stormwater assets are as follows.

Goal AM1: Ensure that Council has asset management plans for all stormwater infrastructure, and these plans consider long-term sustainable management (including consideration of the impacts of climate change).

Goal AM2: Ensure operation and maintenance plans are in place for all WSUD assets. Failure to follow proper operation and maintenance regimes will result in significantly reduced performance of the assets.

4 Identification of flooding

One of the primary objectives of the SMP is the identification of issues associated with flooding within the catchment. To achieve this objective, detailed hydrologic and hydraulic modelling of the study area and surrounding catchments has been undertaken. A single long-term (2070) scenario was modelled which included projections of development, a 10% increase in rainfall and 0.5 m sea level rise.

The primary purpose of the modelling was to define the extent and magnitude of flooding during events of differing annual exceedance probabilities (AEP) and to identify areas of significant inundation relevant to the preparation of the SMP. The risk to public safety ('flood hazard') was also categorised for the 1% AEP event. Flood hazard uses the depth and velocity of floodwater to categorise the risk of harm to individuals from floodwater. For example, shallow but swift moving floodwater might be categorised as hazardous to individuals because of the potential for that individual to lose their footing and be pulled downstream by the floodwater.

Details of the hydrologic and hydraulic modelling are provided in Appendix B.

4.1 Assessment of stormwater drainage system standard

The results of the hydraulic modelling were used to estimate the level of service ('drainage standard') provided by the existing drainage network within the study area. The pipe standard was defined by assessment of the freeboard at each pit. The capacity of a drain was deemed to have been exceeded during a particular storm event if the modelling results indicated that the freeboard at the upstream pit was less than 150 mm during that event. Capacity limitations may be associated with inlet capacity or the capacity of the pipe network itself.

Figure 4.1 shows the colour-coded results of the capacity assessment. Drainage systems highlighted in red have a standard of less than 63% AEP (1 EY) and potentially require upgrading to reach the desired standard of protection. Many of the upstream (eastern) drains were identified as having a very low standard.

4.2 Key flood prone areas

This section describes the nature and cause of the most prominent flooding issues identified by the flood modelling. For each location the predominant flood behaviour is described, and the main causal mechanisms are defined where possible. An overview showing the relative location of each of the key flood prone areas discussed is provided in Figure 4.2. For each area, a figure showing the modelled inundation for the 20% AEP and 1% AEP events is provided. A full set of flood inundation maps can be found in Appendix C.

The general design standard for underground stormwater networks is conveyance of all flows for events up to the 20% AEP event. The modelling of the West Lakes catchment indicates that in some areas, the underground network has insufficient capacity for the frequent events (up to and including the 20% AEP event). This results in stormwater ponding and/or flowing within the road reserve, with ingress of floodwaters into private property in some locations.

Results of the 1% AEP event show widespread areas of inundation across the catchment, both within the road reserve and private property. Given the assumed level of development and increases in rainfall intensity associated with climate change, this level of inundation would be expected, and it is unlikely to be practicable to upgrade the stormwater systems to provide flood protection to all private property.

The identification of key flood prone areas, which underpins the development of flood mitigation options in this SMP, has therefore been based on identification of areas of significant flooding of private property that occurs in events more frequent than the 1% AEP event. Consistent with the objectives of this SMP, the proposed flood mitigation solutions at these locations aimed to provide protection to private properties in a 1% AEP event.

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
PIPE DRAINAGE STANDARD
2070 DEVELOPMENT WITH CLIMATE CHANGE

Figure 4.1

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
KEY FLOOD PRONE AREAS

Figure 4.2

4.2.1 Meakin Terrace / Leven Avenue

The most widespread area of modelled inundation within the West Lakes catchment is located within the area surrounding Meakin Terrace, to the south of the Grange railway line and the Royal Adelaide Golf Club (RAGC), as shown in Figure 4.3. Information provided by Council indicates that a number of properties within this area reported flooding as a result of the heavy rainfall events that occurred in 2016.

The area shown in Figure 4.3 is served by two primary underground drainage networks. Most of the eastern area drains towards an 1800 mm x 900 mm RCBC within Meakin Terrace. A pump station is used to divert a portion of the runoff within this drain into the RAGC water reuse scheme. A 1050 mm pipe conveys the remaining runoff to the Grange Lakes, along an alignment following the railway line. The western area (to the west of Frederick Road) is directed towards a 525 mm trunk main within Jetty Street, before also discharging to the Grange Lakes.

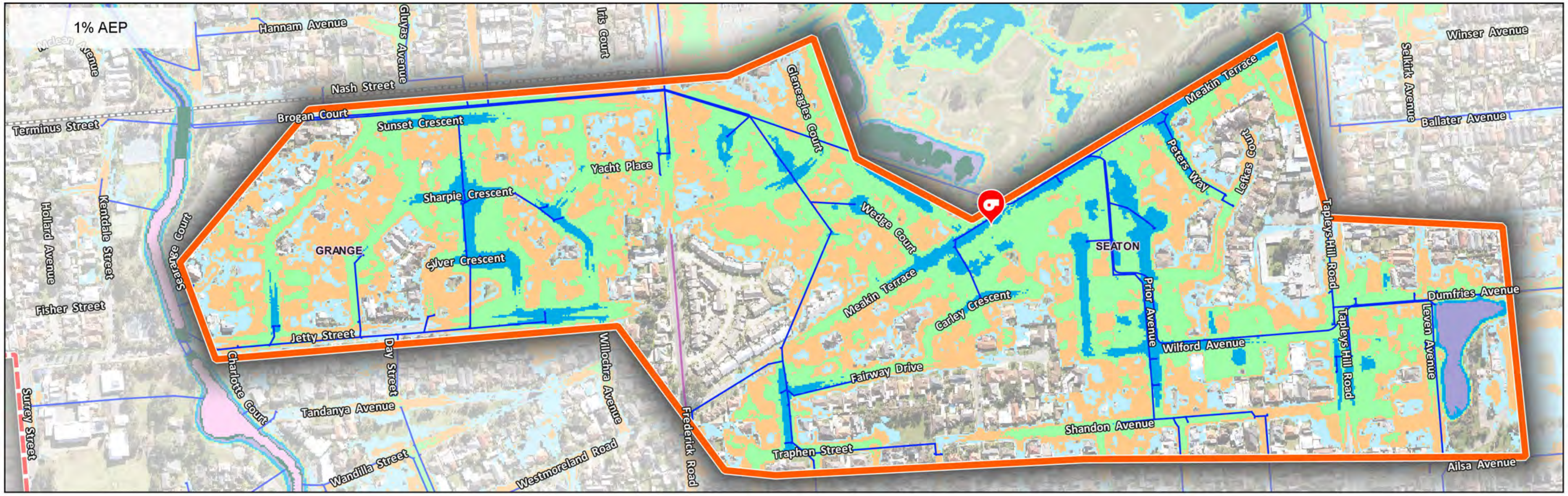
Review of the pipe standards map (Figure 4.1) shows that the drainage network within the eastern catchment does not have capacity to convey flows from the 1 EY event. Similarly, the collector drains within the catchment to the west of Frederick Road also have a standard of less than 1 EY. As such, even in minor events there is upwelling from the pits within this area.

In the 1 EY and 0.5 EY events, flows appear to be contained within the road corridor. For events larger than this, however, the capacity of road network is exceeded, resulting in inundation of a large number of residential properties.

This is first observed during the 20% AEP event within the properties to the south of the RAGC and within Leven Avenue and Tapleys Hill Road. During the 1% AEP event, deep ponding (up to 0.85 m) is observed within the Prior Avenue cul-de-sac. Similarly, flood depths of up to 0.70 m are observed within trapped low spots along Tapleys Hill Road, Meakin Terrace, and Sharpie Crescent during the 1% AEP event.

It should be noted that Prior Avenue, Peters Way and Wilford Avenue are subject to depths of flooding within the road of up to 0.30 m during the 1 EY event (i.e. significant nuisance flooding). Few other areas within the catchment reach this depth of flooding during the 1 EY event.

Overflows from the Frogmore Road pump station (within the Torrens East catchment) also contribute to this area via the pipe along Kidman Avenue. Modelling shows that, in a 20% AEP event, these flows are negligible and do not contribute to the flooding of private property observed within the 20% AEP event.



Legend

- Pump station
- Pipe
- Railway
- Flood zone
- Study area boundary
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

tonkin

0 100 200 300 m

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CITY OF CHARLES STURT

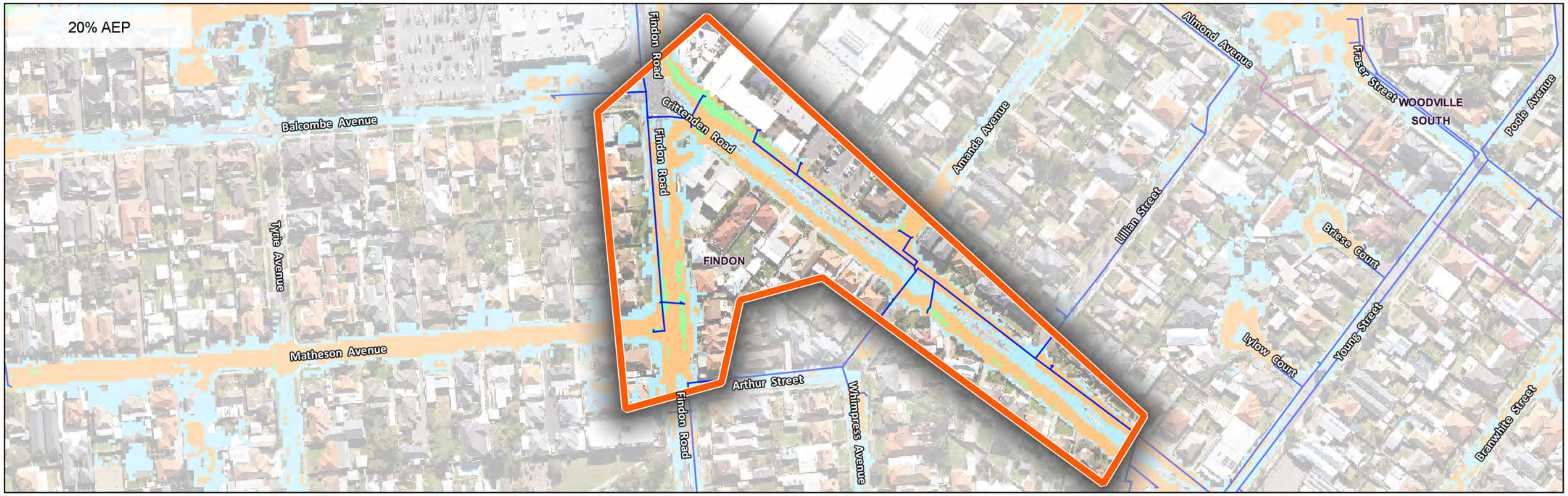
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING MEAKIN TERRACE

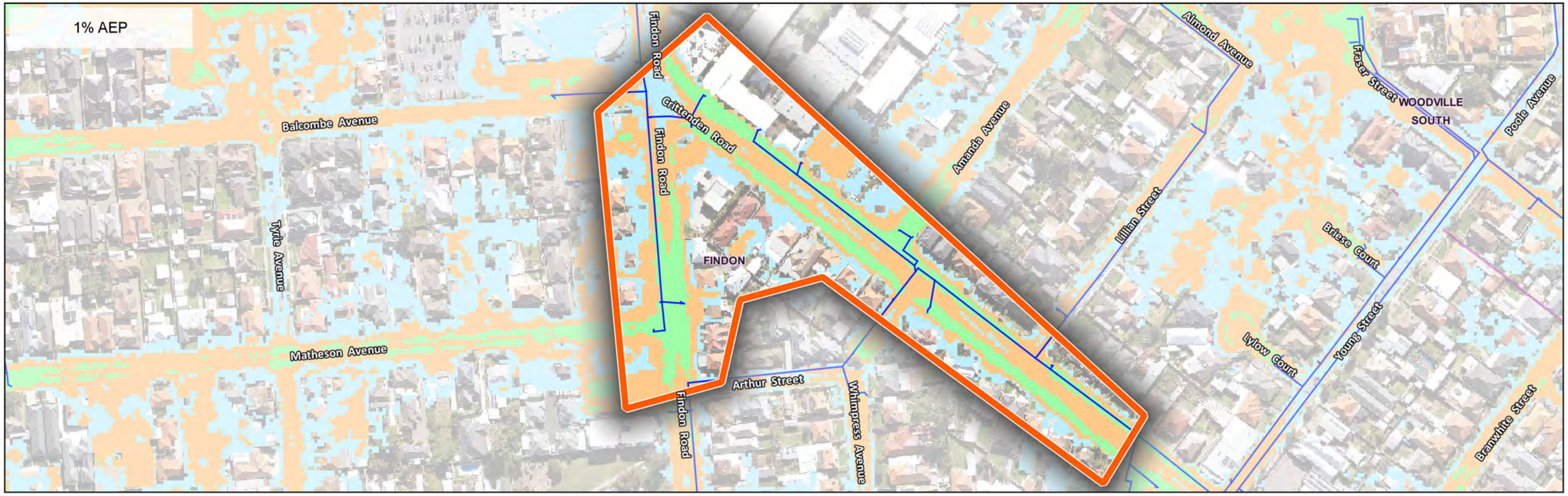
Figure 4.3

4.2.2 Findon/Crittenden

The intersection of Findon Road and Crittenden Road is a low point within the catchment, and is a known flooding hotspot. The modelling confirms that surface flooding along these roads is expected during all events. Between Matheson Avenue and Balcombe Avenue, Findon Road is served by a 300 mm diameter drain, which the modelling indicates has a standard of less than 1 EY. The trunk drain within Crittenden Road has a larger diameter (450 mm to the west of Amanda Avenue), however the drainage standard is also estimated to be less than 1 EY. The flooding within these roads is therefore attributed to a lack of capacity within the underground drainage network. A map of the 20% AEP and 1% AEP flood inundation depths is shown in Figure 4.4.

In addition to the flooding within Findon Road and Crittenden Road, Council has also reported flooding within a nearby local street (Briese Court) to the east; this is consistent with the flood mapping for the 20% AEP event.





Legend

- Pipe
- Flood zone
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 100 200 300 m

N

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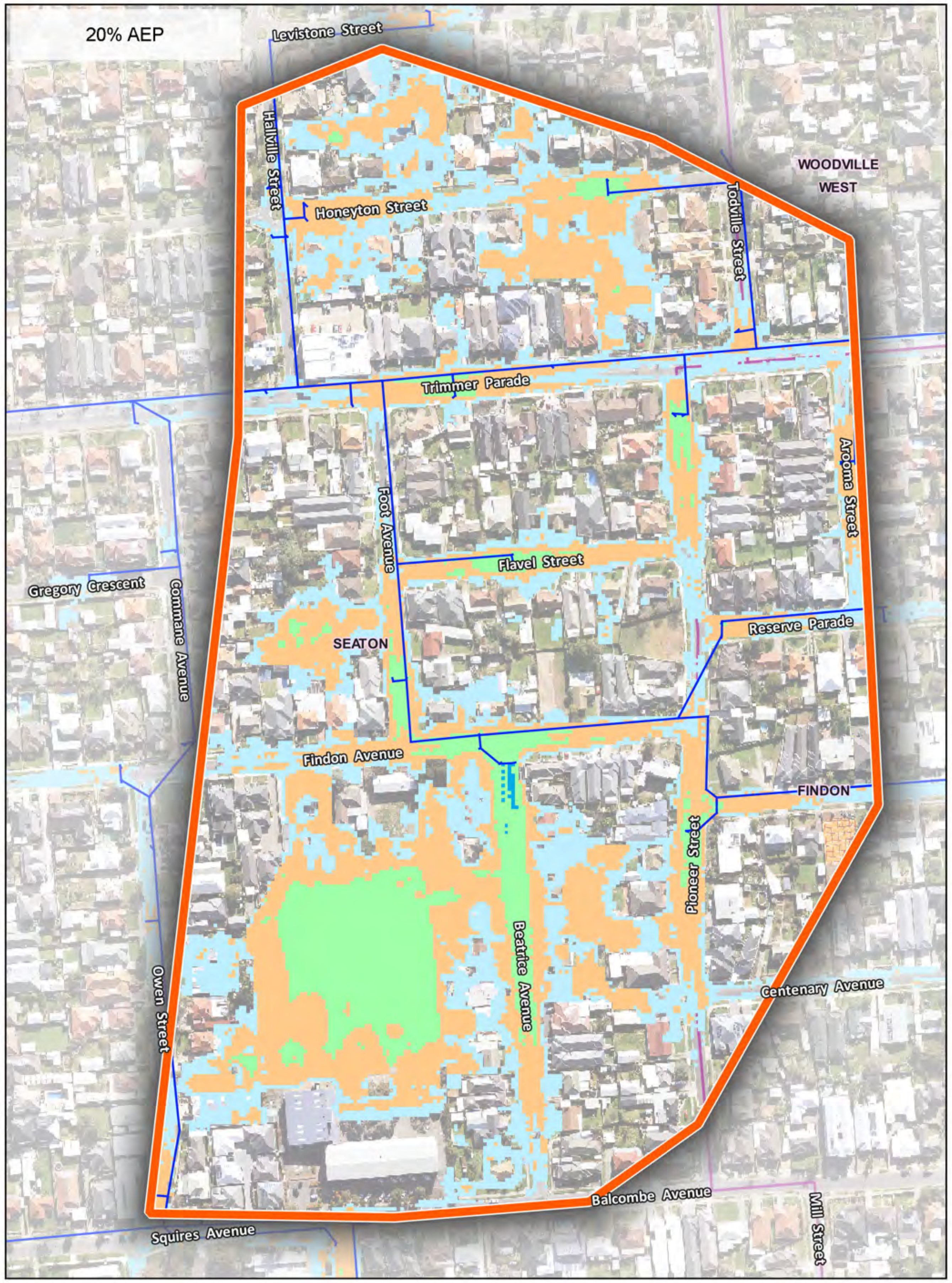
CITY OF CHARLES STURT

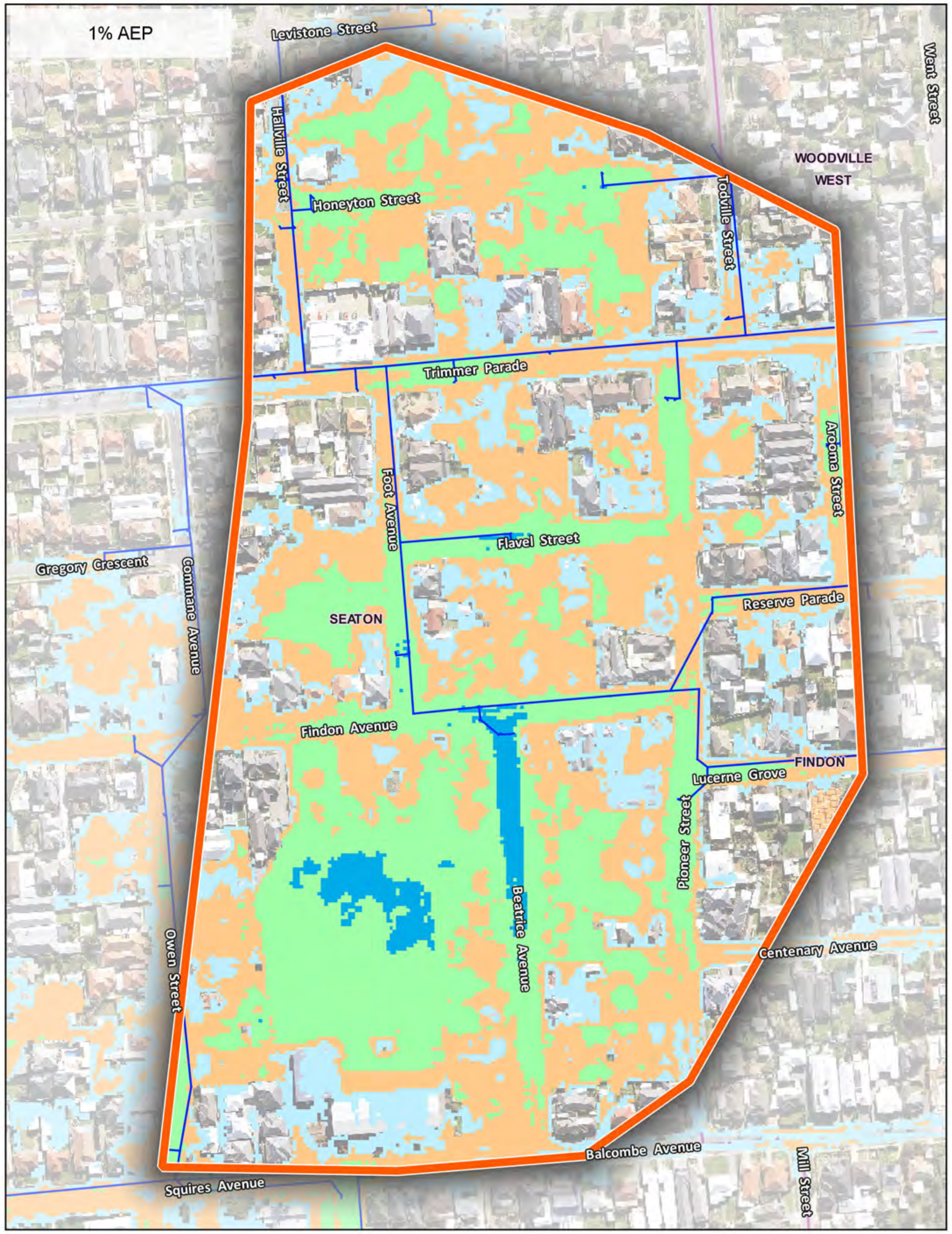
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING WITHIN FINDON ROAD AND CRITTENDEN ROAD

Figure 4.4

4.2.3 Beatrice Avenue

The modelling indicates that the underground drainage system servicing the area surrounding Beatrice Avenue (to the south of Trimmer Parade) has a standard of less than 1 EY. Runoff from Beatrice Avenue is collected via pits and pipe (300 mm) at the northern end of the street. As a result of the low underground drainage standard, flood depths within Beatrice Avenue are as high as 0.45 m during the 1 EY event. In larger rainfall events the modelling predicts widespread inundation within the roads and private properties to the north and south of Trimmer Parade. The modelled extent of inundation for the 20% AEP and 1% AEP events is shown in Figure 4.5.





Legend

- Pipe
- Flood zone
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 100 200 300 m

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CITY OF CHARLES STURT

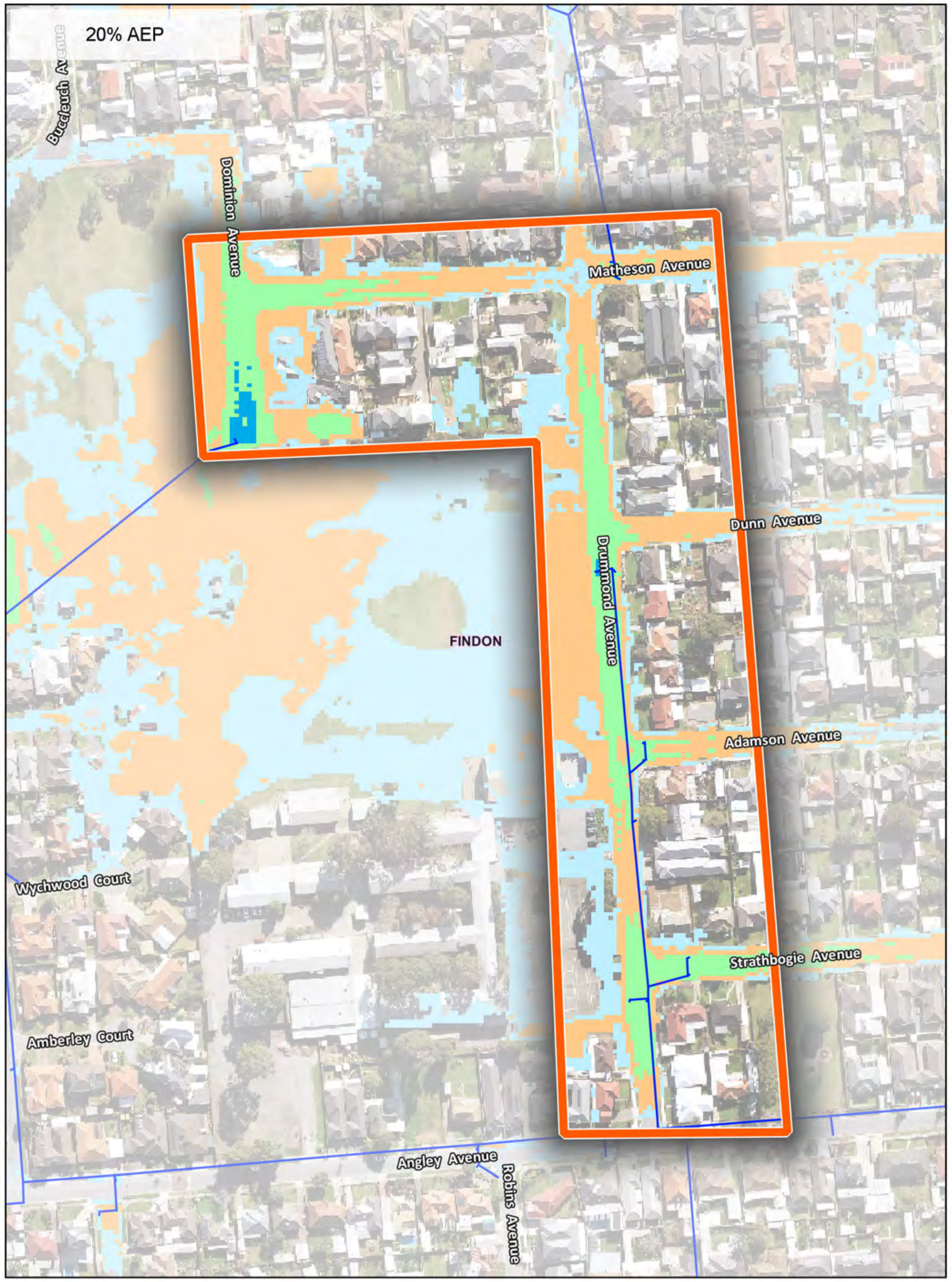
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING BEATRICE AVENUE

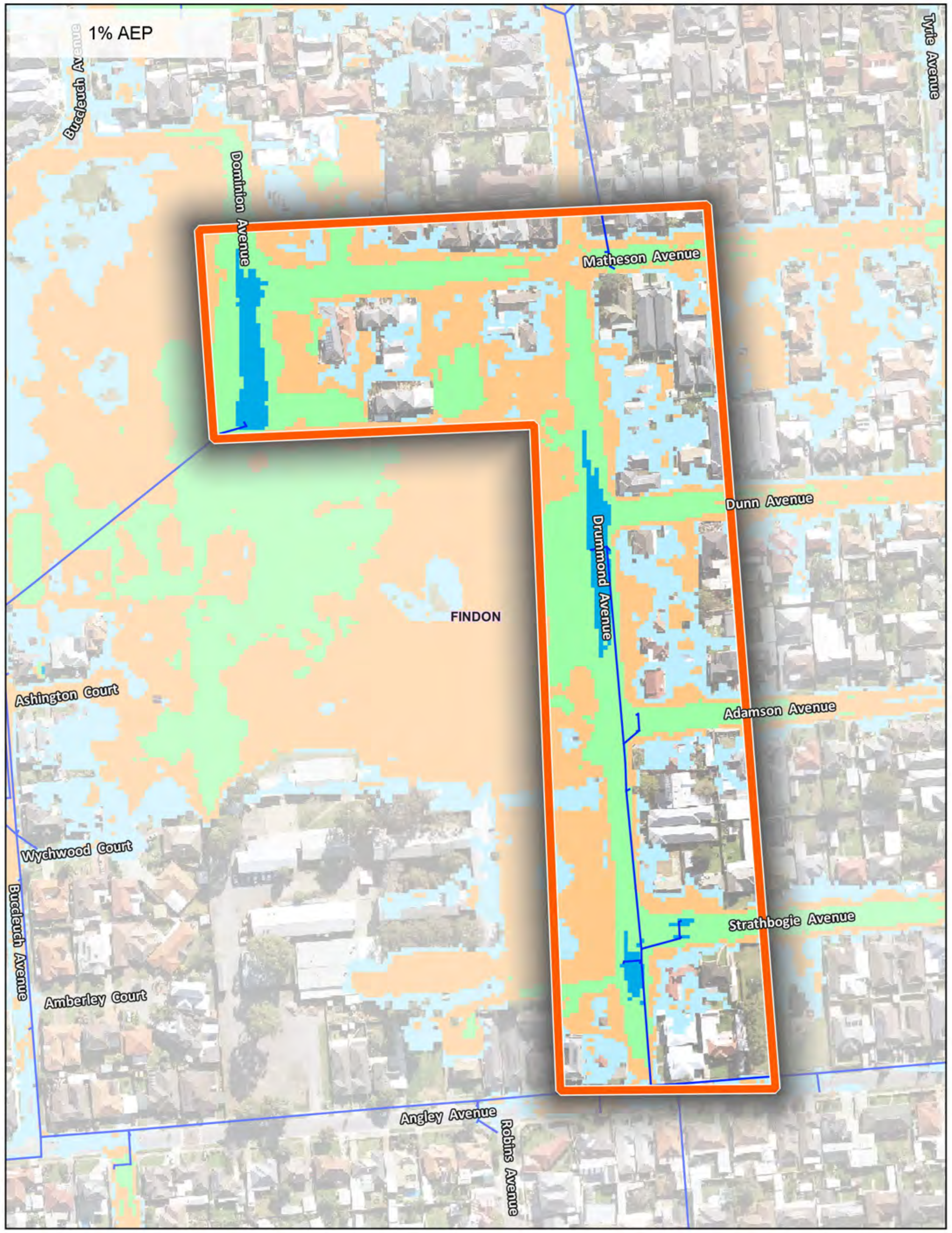
Figure 4.5

4.2.4 Drummond Avenue

The modelling results show significant depths of inundation within Drummond Avenue and Dominion Avenue during frequent rainfall events. For the 1 EY event the depth of flooding within Drummond Avenue near Dunn Avenue (a sag location) is up to 0.43 m. At the southern end of Dominion Avenue the flood depth is as high as 0.50 m. These areas therefore represent locations of significant nuisance flooding. The pipe standards map indicates that the drains within each of these streets have a standard of less than 1 EY.

While some inundation of private properties within this area is expected during the 20% AEP and 1% AEP events, the flood depths are typically less than 0.2 m. A map of the 20% AEP and 1% AEP flood depths is provided in Figure 4.6.





Legend

- Pipe
- Flood zone
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 100 200 300 m

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CITY OF CHARLES STURT

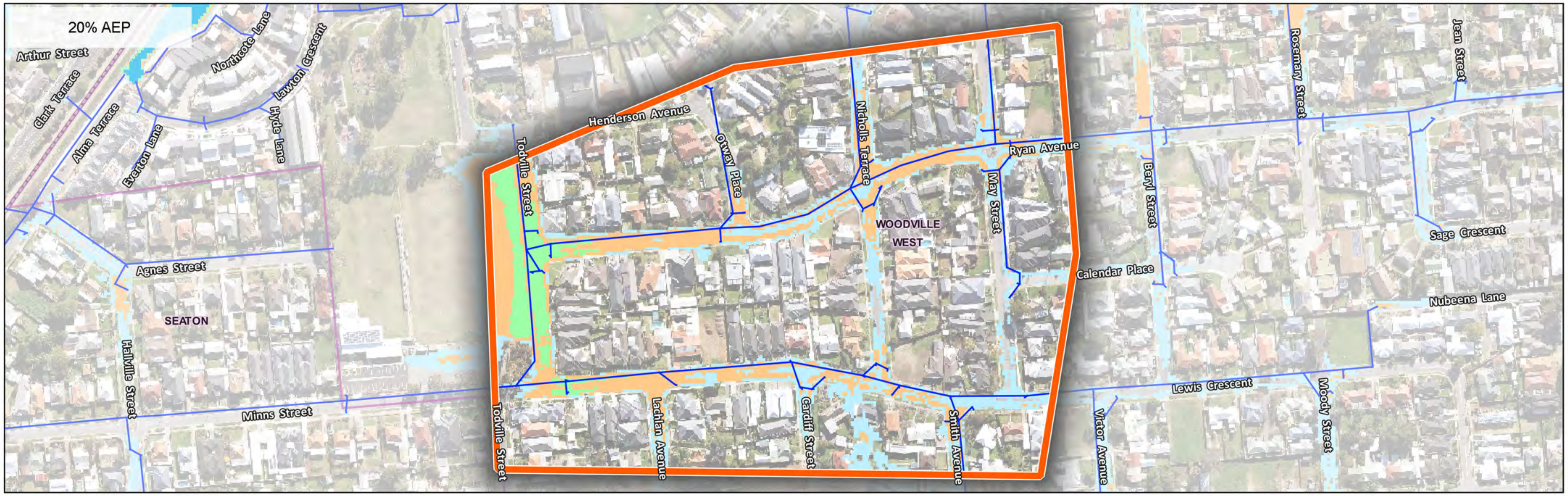
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING DRUMMOND AVENUE

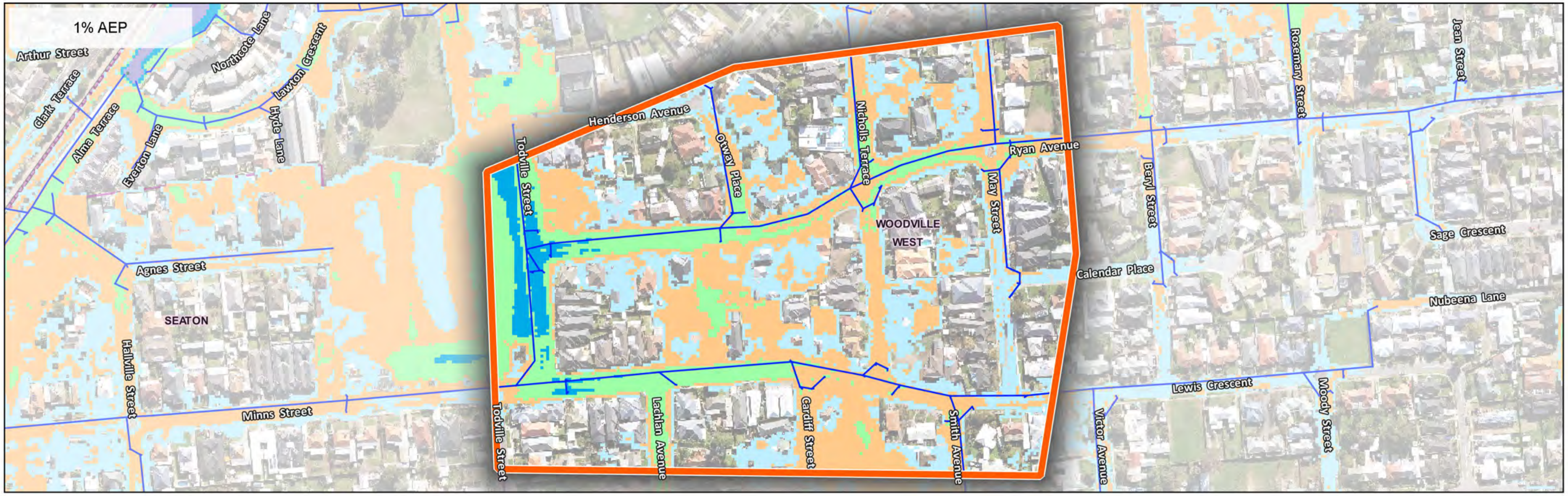
Figure 4.6

4.2.5 Frank Mitchell Reserve

Council has identified flooding issues to the east of Frank Mitchell Reserve. This has been confirmed by the flood modelling for the 1% AEP event, which shows significant flooding within the road reserves of the adjacent streets (Figure 4.7). Depths of inundation of up to 0.65 m are expected within Todville Street. Floodwaters encroach into private properties within Ryan Avenue and Lewis Crescent, typically to depths less than 0.2 m. Flooding of the road reserve within these streets is also expected during the 20% AEP event.

Review of the pipe standards map shows that the pipe network within this area has less than a 1 EY standard.





Legend

- Pipe
- Flood zone
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 100 200 300 m

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CITY OF CHARLES STURT

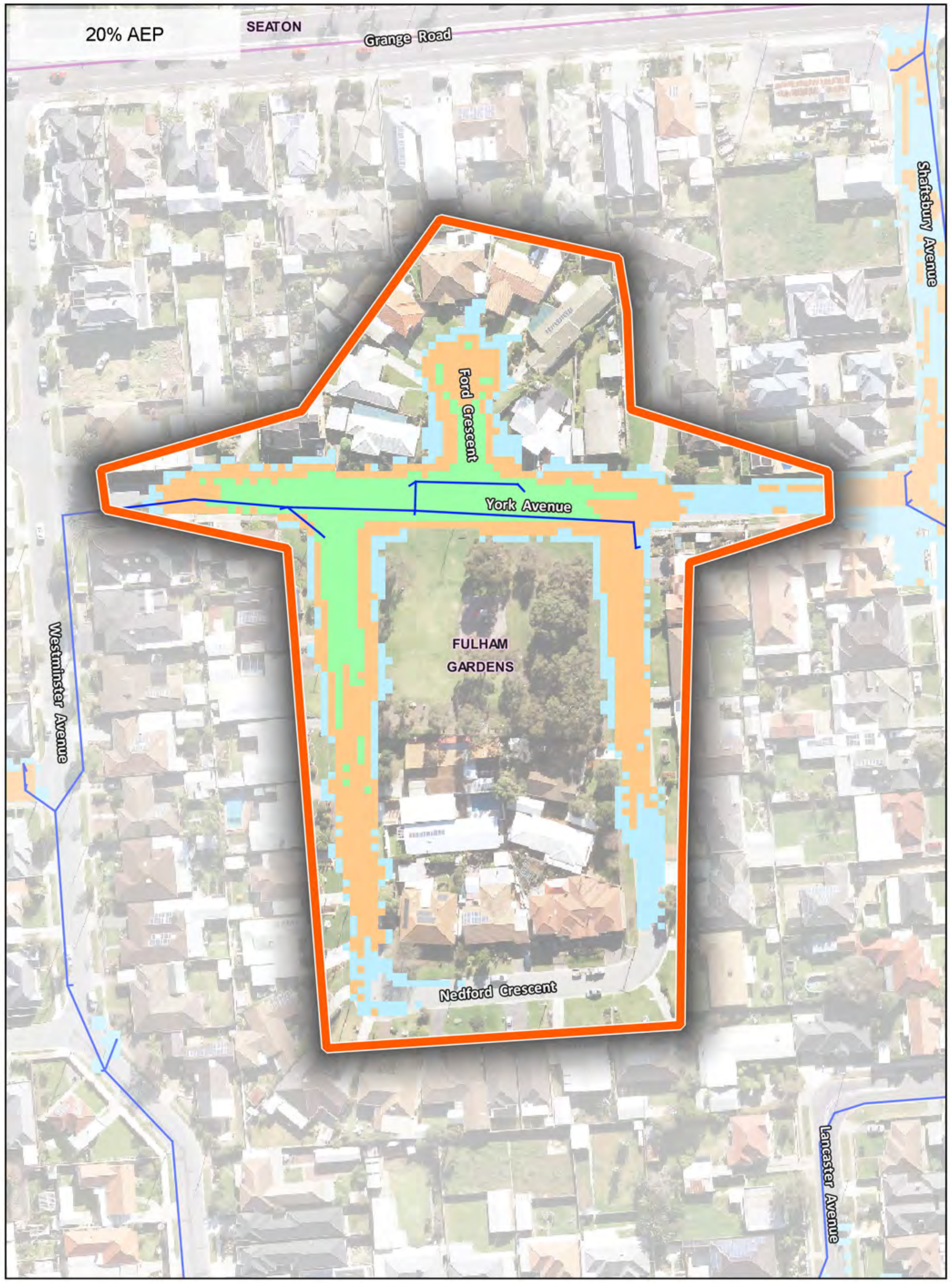
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING FRANK MITCHELL RESERVE

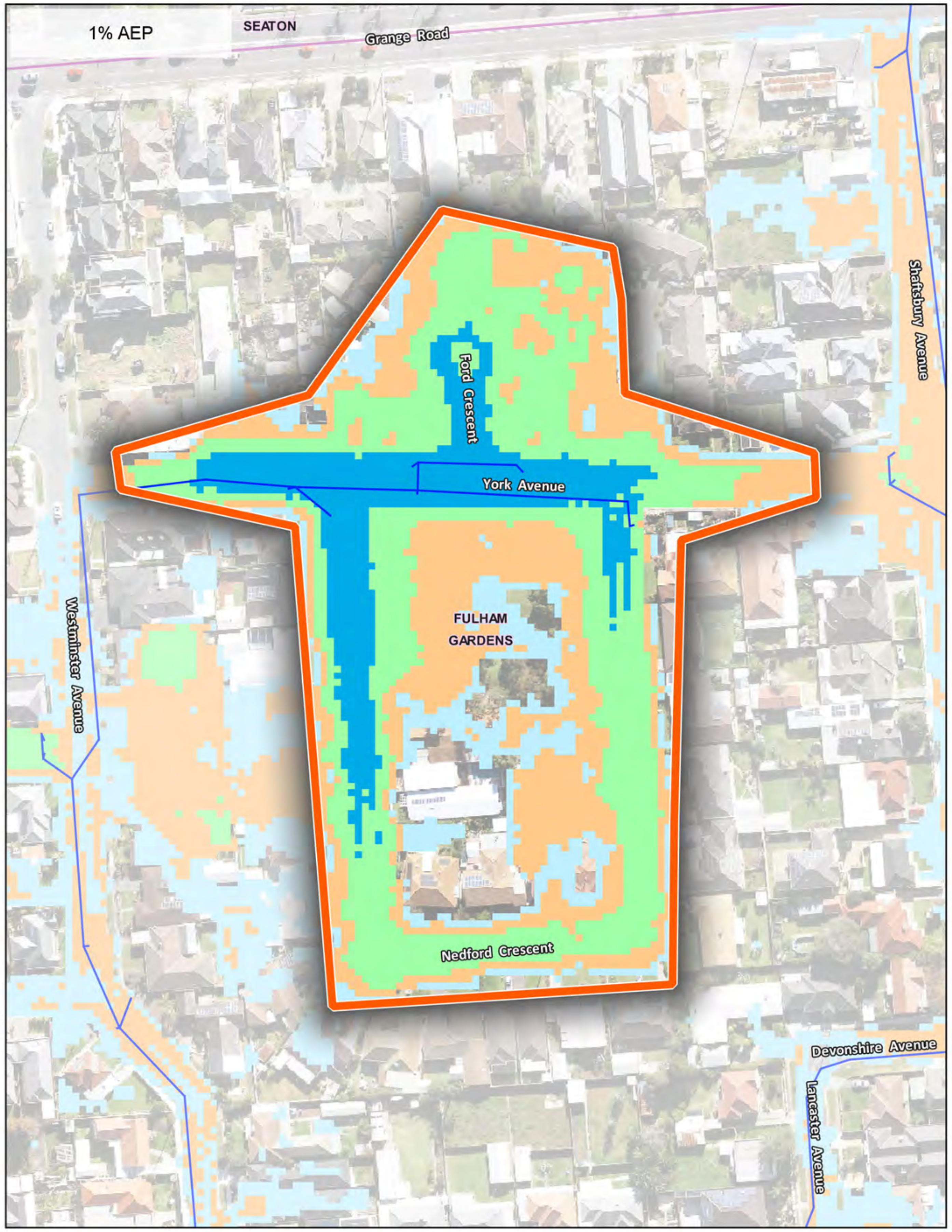
Figure 4.7

4.2.6 York Avenue

Localised flooding issues have been identified within the area surrounding York Avenue. Due to a trapped low spot within the road, modelled flood depths of up to 0.3 m are shown along York Avenue in the 20% AEP event. In events with a magnitude greater than the 5% AEP event, flood waters spilling from both York Avenue and Ford Crescent result in inundation depths of greater than 0.2 m within private properties. In a 1% AEP event, the modelled depth of inundation on private property is up to 0.5 m, with depths in excess of 0.5 m expected in the road reserve.

Extracts from the flood modelling for the 20% and 1% AEP events are provided in Figure 4.8.





Legend

- Pipe
- Flood zone
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 50 100 150 m

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING YORK AVENUE

Figure 4.8

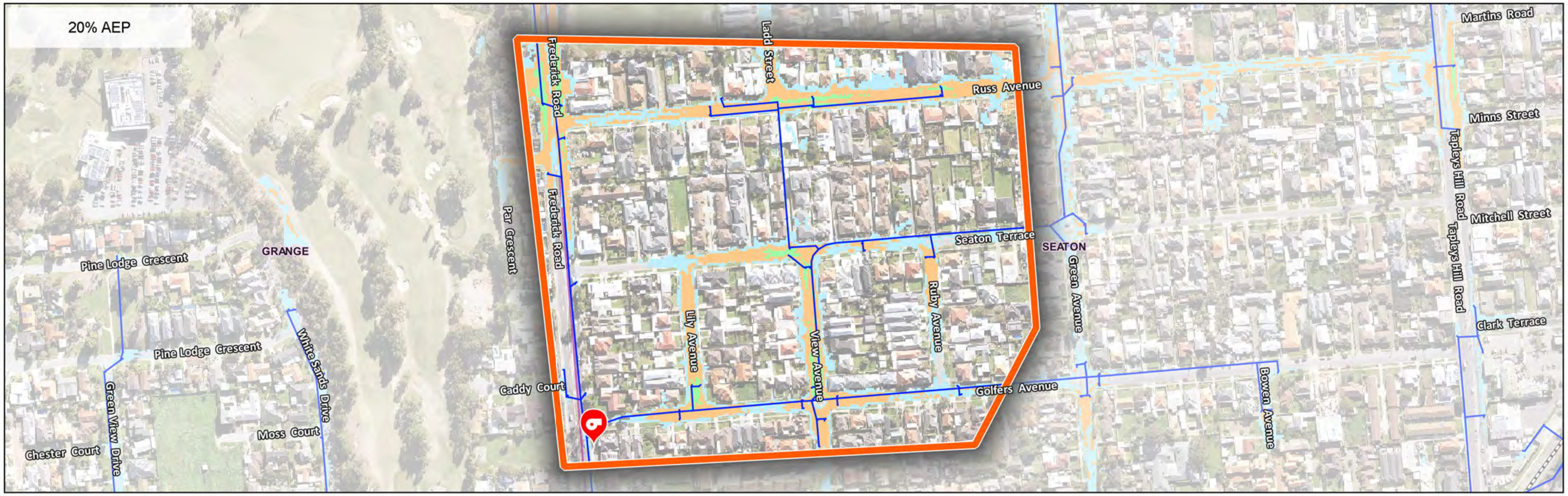
4.2.7 Golfers Avenue

Inundation of private property is observed to the north of the RAGC within the area surrounding Golfers Avenue, as shown in Figure 4.9. Information provided by Council indicates that there were reports of flooding of residential properties within this area during the 2016 heavy rainfall event.

This residential precinct is predominantly served by a single underground drainage network, beginning in Russ Avenue (450 mm x 225 mm RCBC), travelling through private property in a drainage easement to Seaton Terrace, before transfer via pump station at the western end of Golfers Avenue. Review of the standards mapping shows that within this precinct, the underground drain has a standard of less than 1 EY, with upwelling from pits occurring during each modelled event. This is attributed to capacity of both the pipes and the pumps.

The modelling shows that floodwaters would be expected to pool in low spots within the road corridor. This first occurs within View Avenue and Russ Avenue, with modelled flood depths of up to 0.2 m during the 1 EY event. This is consistent with historical observations of regular, nuisance flooding in this area.

Flows appear to spill out of the road reserve and into private property during the 10% AEP event (although flood depths within private property for this event do not exceed 0.2 m). Figure 4.9 indicates that almost all properties within this area will be subject to some degree of inundation during the 1% AEP event. Additionally, flood depths of up to 0.6 m within the road corridor are expected within View Avenue, Lily Avenue and Frederick Road in this event.



Legend

- Pump station
- Pipe
- Beatrice Avenue
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 100 200 300 m

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CITY OF CHARLES STURT

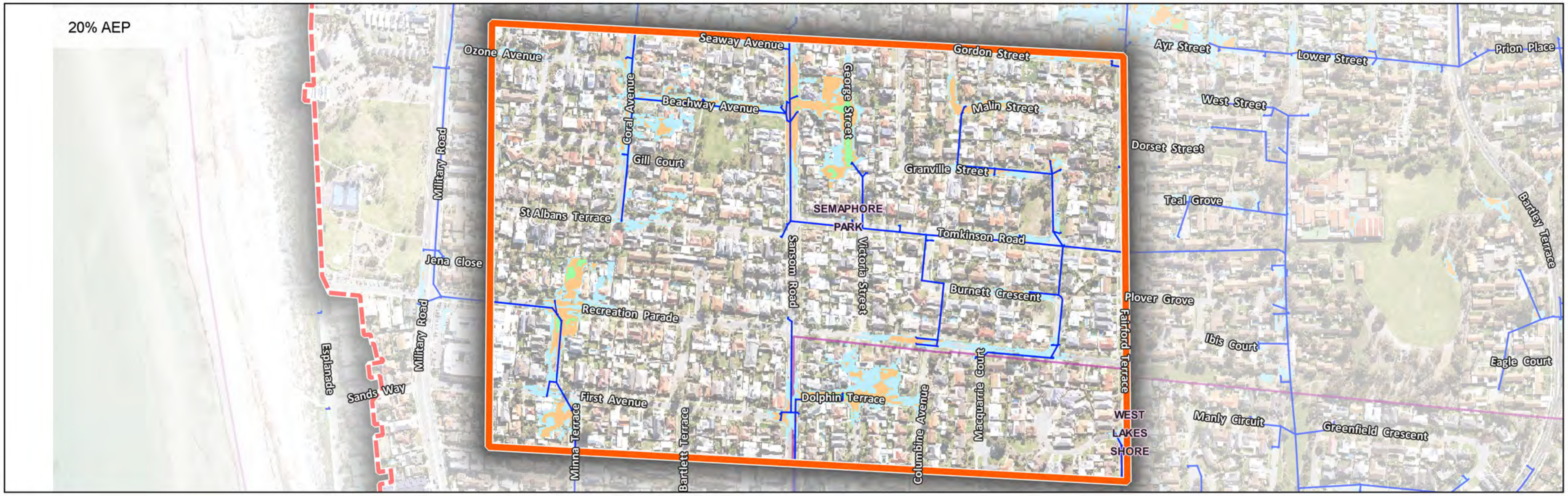
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING GOLFERS AVENUE

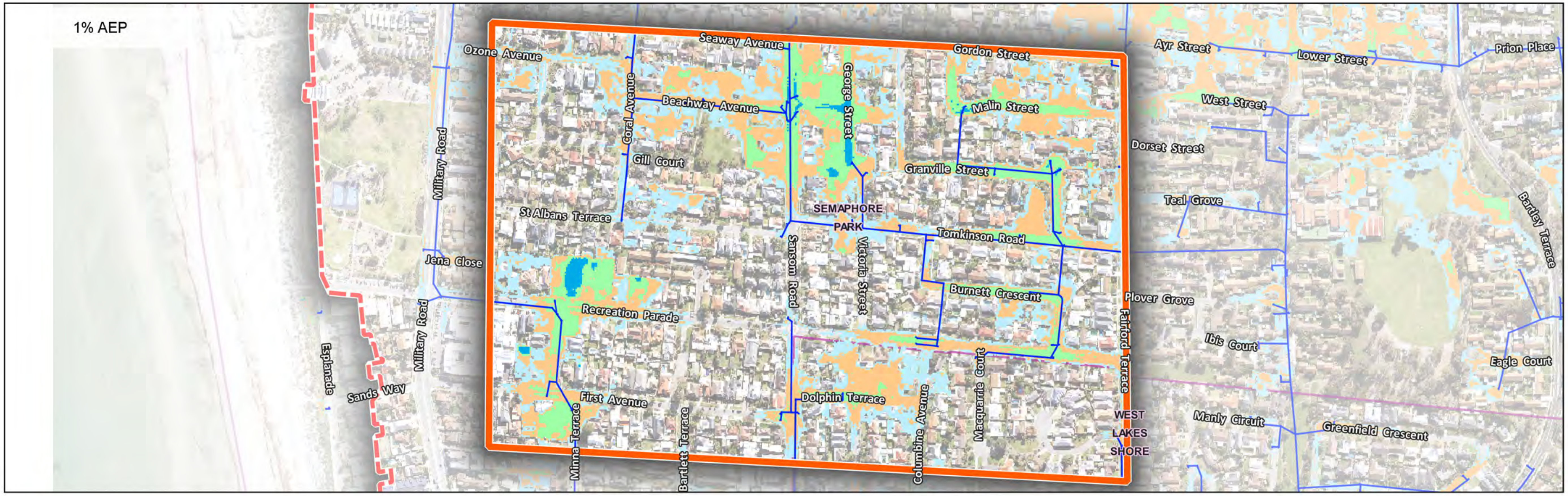
Figure 4.9

4.2.8 Sansom Road

The residential precinct surrounding Sansom Road is served by an underground drainage network that discharges directly to the Lake. Review of the standards mapping shows that the section of drain within Sansom Road, George Street and Granville Street has a drainage standard of less than 1 EY, resulting in ponding of water within the road during frequent events. Of particular concern is the modelled flooding within the southern portion of George Street, which reaches a depth of up to 0.45 m during the 20% AEP, due to insufficient capacity within the 300 mm diameter pipe.

Flooding within this area during the 20% AEP and 1% AEP events is shown in Figure 4.10. There are multiple areas of deep (up to 0.7 m) flooding within the road reserve, as well as multiple instances of ingress of floodwaters into private properties, with depths exceeding 0.2 m.





Legend

- Pipe
- Flood zone
- Study area boundary
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 100 200 300 m

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CITY OF CHARLES STURT

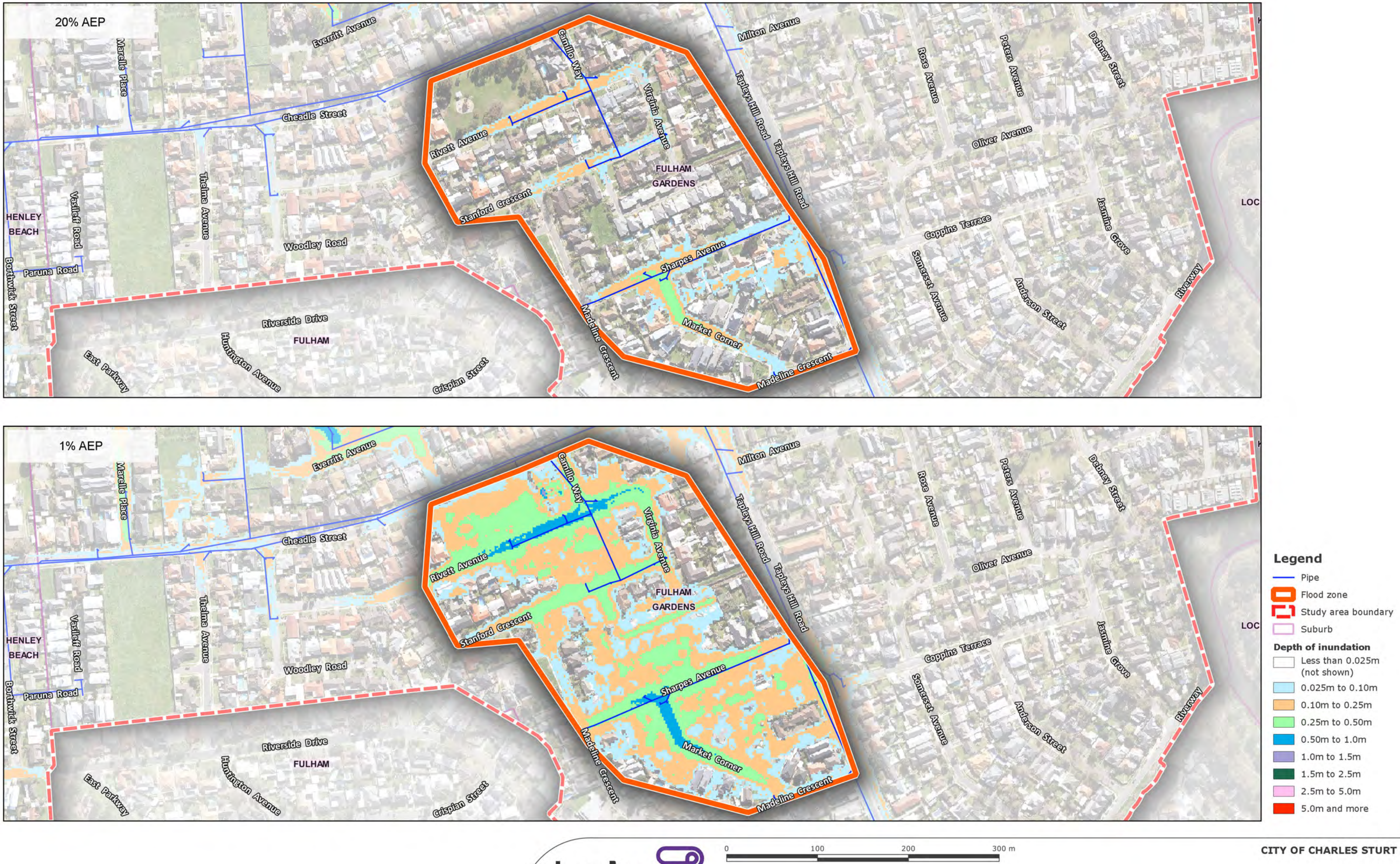
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING SANSOM ROAD

Figure 4.10

4.2.9 Market Corner

Flooding within the area surrounding Market Corner is expecting during the 20% AEP and 1% AEP event, as shown in Figure 4.11. Flood depths at localised depressions within the road are greater than 0.5 m at Rivett Avenue and 0.65 m at Market Corner, resulting in potentially unsafe driving conditions along these roads. The capacity of the aboveground drainage system is exceeded at most locations within this area, resulting in widespread inundation within private properties during the 1% AEP event.

Of particular note is the flood depth at the northern end of Market Corner (a sag location), which exceeds 0.3 m in the 0.5 EY (frequent) event, and is therefore a location of nuisance flooding. Runoff is collected via pits and pipe (375 mm), however review of the standards mapping indicates that this system (Market Corner and Sharpes Avenue) has a standard of less than 1 EY. The frequent ponding of runoff within the road at this location is therefore primarily caused by a lack of capacity in the underground drainage system.



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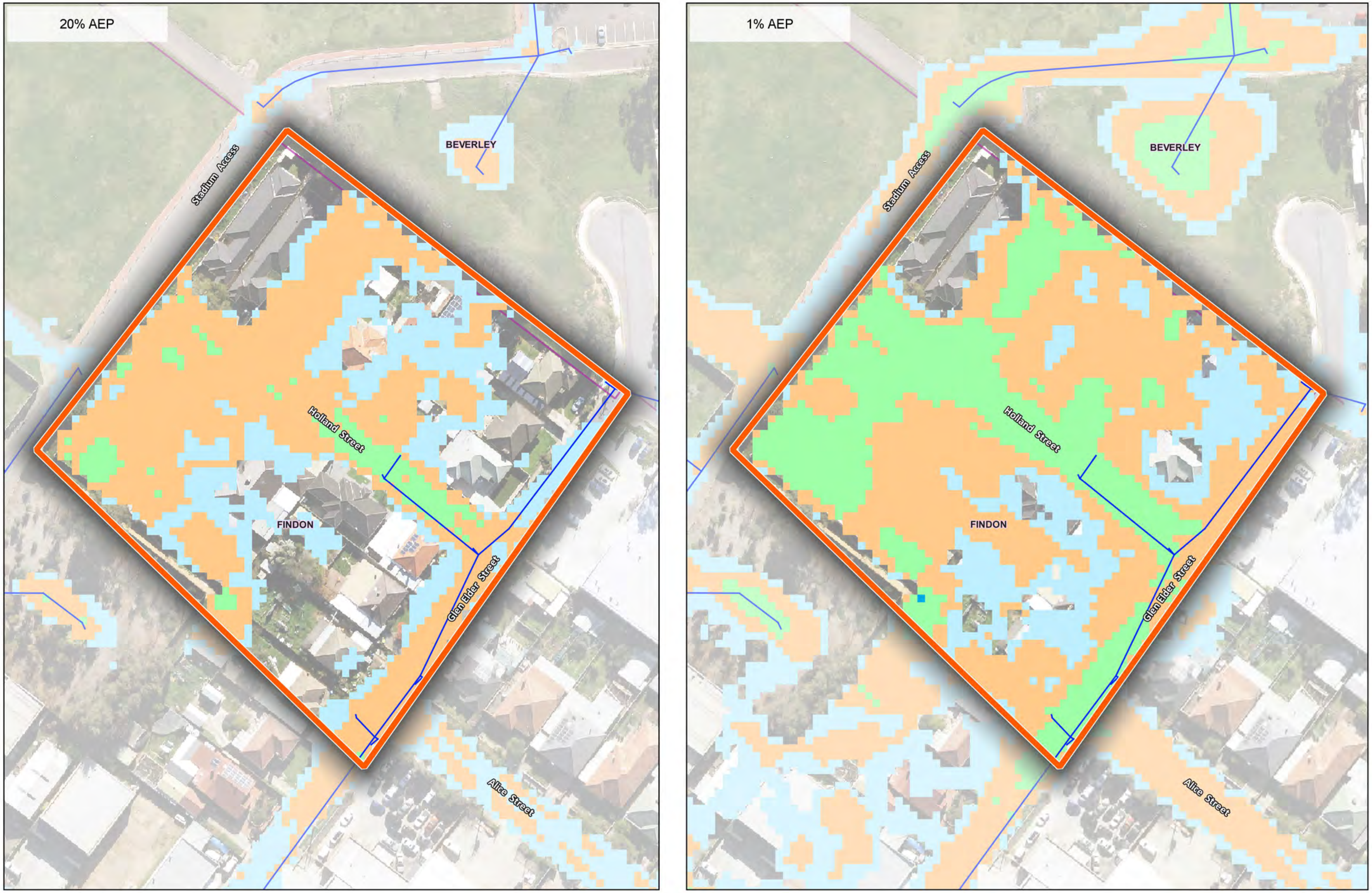
CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING MARKET CORNER

Figure 4.11

4.2.10 Holland Street

The road reserve as well as a number of properties within Holland Street are subject to inundation during all events. Inlets located at a sag point towards the eastern end of the street are used to direct runoff to the underground drainage network. The standard of the network within this area is less than 1 EY. Ponding at the sag reaches depths of up to 0.3 m during the 20% AEP event and 0.45 m in the 1% AEP event. The 20% AEP and 1% AEP inundation depths are shown in Figure 4.12.



Legend

- Pipe
- Flood zone
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 25 50 75 m

N

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CITY OF CHARLES STURT

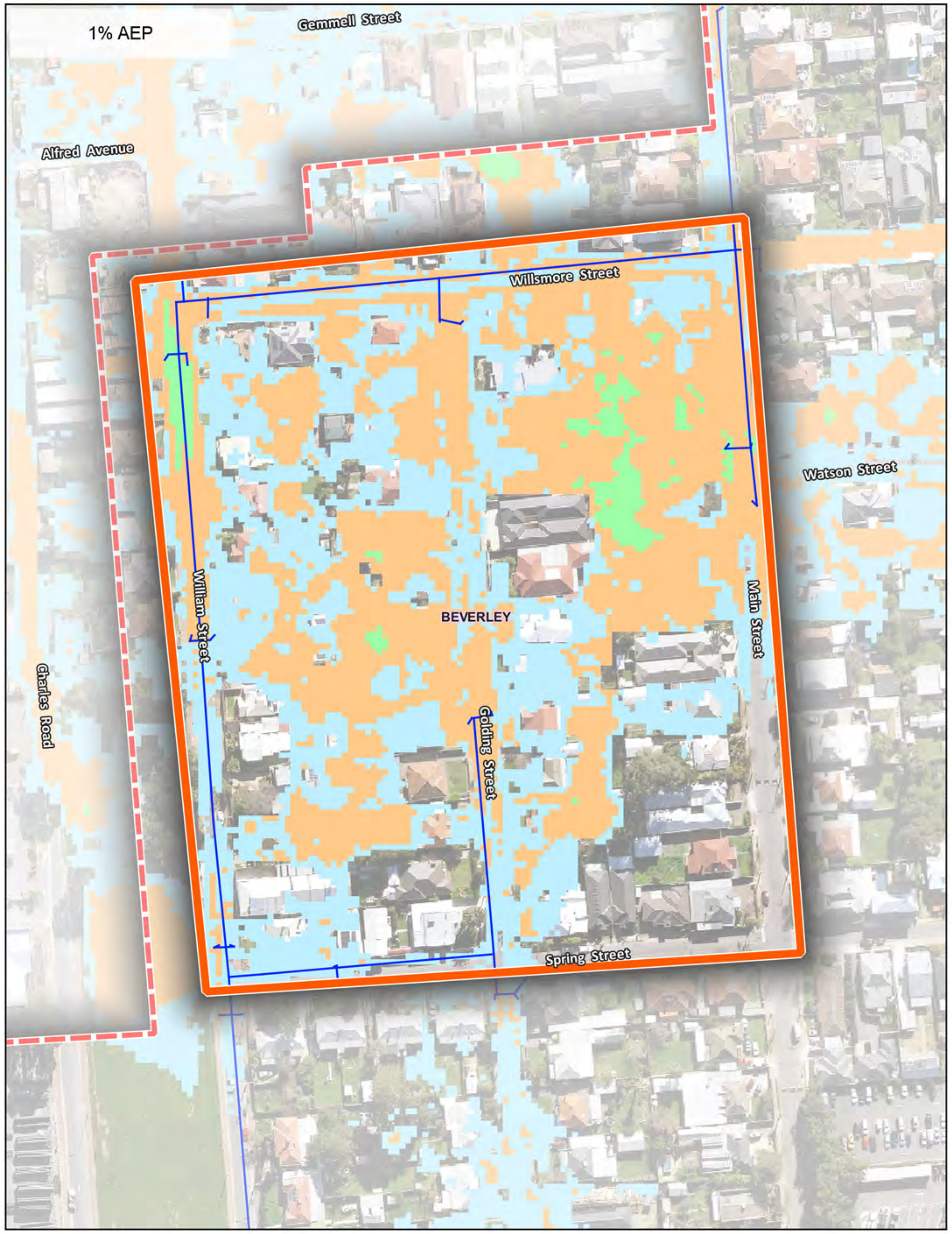
WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING HOLLAND STREET

Figure 4.12

4.2.11 Main Street

Runoff within Main Street is directed to an underground drain (300 mm diameter) at a sag location adjacent to Watson Street. Review of the pipe standards map shows that this drainage run has less than a 1 EY standard. This is consistent with the flood mapping which shows ponding of water within the road to a depth of up to 0.15 m during the 1 EY event. As such, flooding within this area is likely due to a lack of capacity within the underground drainage network.

Additionally, ingress of floodwaters into private property along the western side of Main Street is expected for all events. The extents of inundation for the 20% AEP and 1% AEP events are shown in Figure 4.13. Deep ponding (up to 0.35 m) is observed within a localised depression near the intersection of William Street and Willsmore Street during the 1% AEP event.



Legend

- Pipe
- Flood zone
- Study area boundary
- Suburb

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 50 100 150 m

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Roads and railways from Data SA, 2019

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WEST LAKES STORMWATER MANAGEMENT PLAN
FLOODING SURROUNDING MAIN STREET

Figure 4.13

4.3 Flood hazard

Flooding is a hazard which has the potential to cause damage to the property and a risk to life. Given the nature of the West Lakes SMP area, it would be expected that flood waters would typically be shallow and slow moving. Deep, fast moving flows may occur in open channels such as Grange Lakes.

Flood hazard mapping assists with identifying the relative degree of hazard in a floodplain. This allows for effective floodplain management and emergency response planning.

Flood hazard maps for the West Lakes catchment were produced using the combined flood hazard threshold curves developed by Smith et al (2014), as shown in Figure 4.14. The combined flood hazard curves are divided into a number of hazard classifications that are based on thresholds for the stability of people, vehicles and buildings in floods. These thresholds are influenced by a number of factors, predominantly the velocity and depth of floodwaters.

The flood hazard map for the 1% AEP event (long term development (2070) with climate change) is included with the flood depth maps in Appendix C.

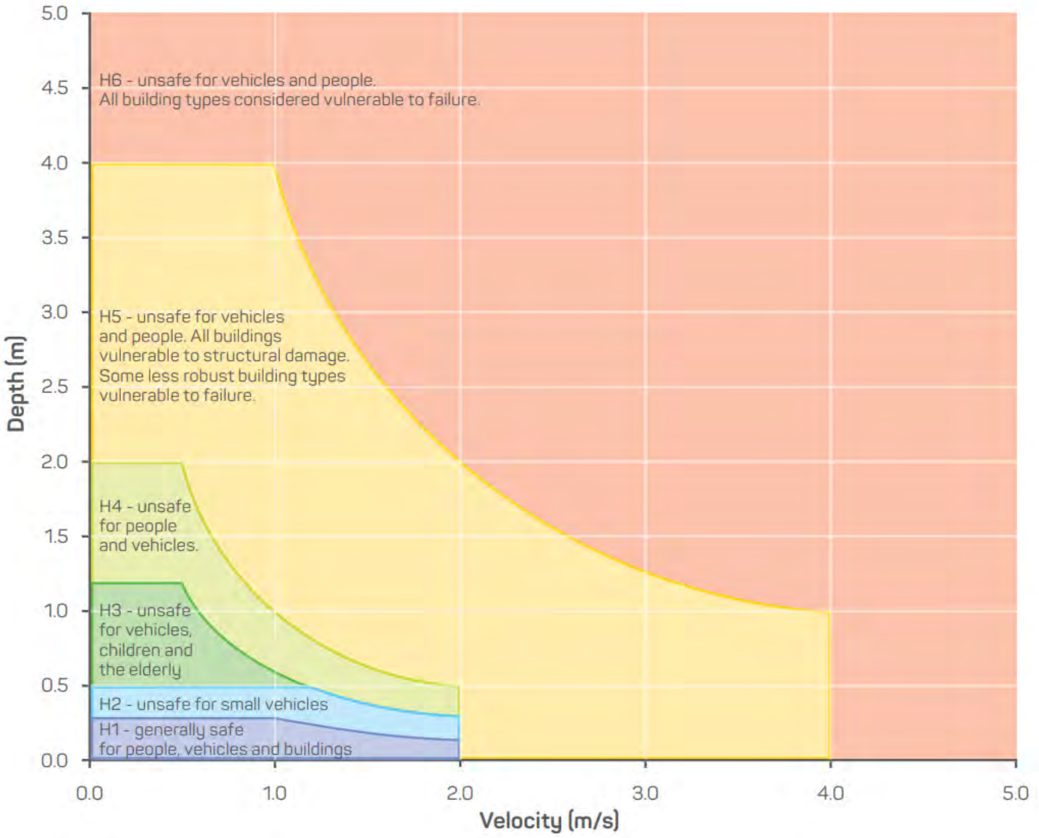


Figure 4.14 Combined flood hazard curves (Smith et al. 2014)

Review of the 1% AEP hazard map shows that despite the extensive inundation across large areas of the study area, the shallow and slow moving nature of the flows means that in most areas within the catchment, the associated hazard will be low (H1). This means that safe evacuation will generally be possible and the direct risks to life and structural damage to buildings will be generally life. Other impacts to the community including psychological impacts and damage to property may still occur.

Areas of higher hazard generally occur at areas of deep ponding within the roads. Each of the key flood prone areas identified in Section 4.2 contains a segment of road with a hazard classification of H3. These areas should be noted when preparing flood response management plans.

5 Flood damages

Floods can have large social, economic and environmental consequences for communities and individuals. Within the West Lakes catchment, the most likely immediate consequence of a flood will be damage to property, although loss of life may also occur.

The cost of damages caused by a flood provides important information that can be used to prioritise flood mitigation or prevention measures. It can indicate the magnitude of damage caused by a design flood event of given annual exceedance probability.

The magnitude of the damages is dependent on a number of factors, including the extent of flooding, property value, property size and the preparedness of the community affected by flooding (i.e. whether they are prepared to respond to a flood threat). These factors and others have been included in the damage calculation process.

Flood damages have been estimated using the Rapid Appraisal Method (RAM) developed by the Victorian Department of Natural Resources and Environment (DNRE, 2000). This approach allows for a rapid and consistent evaluation of floodplain management measures in a cost-benefit analysis framework.

The assessment includes consideration of damage to residential and non-residential properties. In the absence of surveyed floor levels, it has been assumed that the floor level is 150 mm above ground level at the centroid of the allotment for residential buildings, and 100 mm above ground level for non-residential buildings. Damage to public infrastructure, such as roads, has not been included in the analysis as it has been assumed that these damages would be small.

The estimates of damage also include consideration of direct damages and indirect damages (costs that are incurred by a community during and after a flood event that are not related to damage of property).

Further details regarding the methodology are provided in Appendix D.

5.1 Damage results

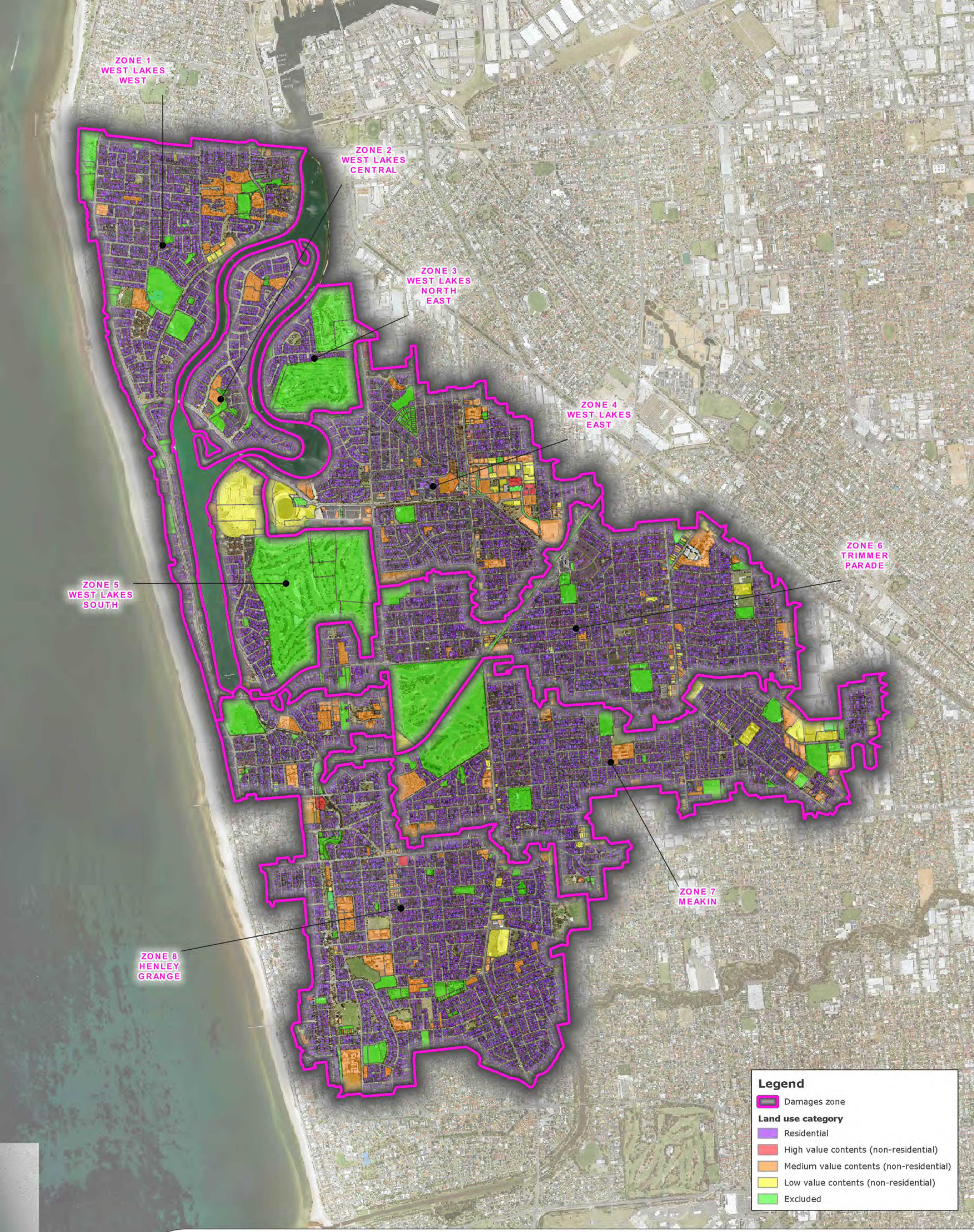
Damages across the study area have been calculated for the full range of modelled flood events (63% to 0.2% AEP). The damages were categorised based on the following zones, representative of the major sub-catchments:

- Zone 1 – West Lakes West
- Zone 2 – West Lakes Central
- Zone 3 – West Lakes North East
- Zone 4 – West Lakes East
- Zone 5 – West Lakes South
- Zone 6 – Trimmer Parade
- Zone 7 – Meakin
- Zone 8 – Henley Grange.

The boundaries of each zone, as well as the land use type used to quantify the damages, are shown in Figure 5.1.

The flood damages across these zones are summarised in Table 5.1 for each of the modelled flood events. The annual average damages (AAD) are presented in Table 5.2. The AAD were calculated based on the assumption that there are no damages in a 12 exceedances per year (EY) storm event.

It can be seen that the greatest damages occur within Zones 6, 7 and 8, as a result of flooding to residential properties along shallow natural valleys within the landscape. There is minimal damage within Zones 2 and 3. These areas are relatively small catchments, discharging directly to the Lake.



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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
FLOOD DAMAGES ASSESSMENT ZONES

Figure 5.1

Table 5.1 Flood damages ($ million) (future climate and development, existing stormwater infrastructure)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	0.07	0.11	0.37	0.57	1.38	3.02	4.43	11.06
2 West Lakes Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
3 West Lakes North East	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.11
4 West Lakes East	0.08	0.19	0.29	0.59	1.45	3.32	6.18	12.50
5 West Lakes South	0.24	0.34	0.49	0.66	0.89	1.19	1.80	3.76
6 Trimmer Parade	0.09	0.31	1.17	2.49	5.26	12.08	18.91	39.75
7 Meakin	0.19	0.67	2.25	4.70	8.45	15.20	20.64	31.49
8 Henley Grange	0.05	0.12	0.34	0.97	3.26	8.08	14.19	33.73
Total	0.74	1.74	4.92	9.98	20.70	42.92	66.18	132.50

Table 5.2 Annual average damages (future climate and development, existing stormwater infrastructure)

Zone	AAD ($)
1 West Lakes West	$340,000
2 West Lakes Central	$0
3 West Lakes North East	$8,000
4 West Lakes East	$381,000
5 West Lakes South	$359,000
6 Trimmer Parade	$1,231,000
7 Meakin	$1,833,000
8 Henley Grange	$718,000
Total	$4,870,000

Interrogation of the flood modelling results has been undertaken to identify the number of flood-affected properties for each storm event. A flood affected property is defined as any property that has some water at the centroid. It should be noted that these numbers are based on existing cadastre and do not take into account future subdivision of land. They are considered a suitable measure for comparative purposes (pre and post-mitigation).The results are summarised in Table 5.3. The number of residential properties with above floor flooding (based on existing cadastre)are summarised in Table 5.4.

It is expected that almost 900 residential properties would be subject to over floor flooding during a 1% AEP event.

Table 5.3 Number of flood-affected properties (future development and climate change with existing stormwater infrastructure)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	27	40	59	89	126	220	300	633
2 West Lakes Central	0	0	0	0	0	1	2	4
3 West Lakes North East	3	4	4	4	4	9	13	49
4 West Lakes East	16	33	59	95	147	292	428	715
5 West Lakes South	3	4	8	9	11	14	24	63
6 Trimmer Parade	36	72	157	274	476	858	1203	1814
7 Meakin	58	107	250	395	560	750	952	1364
8 Henley Grange	13	16	48	109	284	573	816	1408
Total	156	276	585	975	1608	2717	3738	6050

Table 5.4 Number of flood-affected properties (future development and climate change with existing stormwater infrastructure)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	0	0	5	7	21	48	69	178
2 West Lakes Central	0	0	0	0	0	0	0	0
3 West Lakes North East	0	0	0	0	0	0	0	0
4 West Lakes East	0	1	1	3	9	28	61	131
5 West Lakes South	0	0	0	0	0	0	5	12
6 Trimmer Parade	0	2	12	30	70	171	272	646
7 Meakin	1	8	25	49	98	203	283	439
8 Henley Grange	0	0	0	2	38	108	206	510
Total	1	11	43	91	236	558	896	1916

6 Flood management strategies

The management strategies presented here address the key SMP objective of providing an acceptable level of flood protection (Goals F1, F2 and F3). They target the key flood prone areas identified in Section 4.2. Both structural (capital works) and non-structural strategies (such as education and awareness) are discussed.

6.1 Structural mitigation strategies

A set of flood maps showing the post-mitigation inundation and hazard is available in Appendix C. The post-mitigation maps show the effects of implementing the structural mitigation strategies. Change maps showing the difference in flood depth between the pre- and post-mitigation scenarios are also included. Figure 6.1 shows the location of the structural mitigation options investigated.

The structural flood mitigation strategies include a combination of pipe upgrades and detention storage options. Modelling has demonstrated that, from a hydraulics perspective, in most locations the temporary storage of runoff can either be achieved either within a detention basin or an underground tank. Most of the open spaces within the study area are heavily utilised by the community. On this basis, the SMP generally recommends underground storage tanks.

Further consideration, including community consultation, should be given to the selection of an underground storage tank or an open basin during the design development stages of the relevant mitigation strategies. Typically, the underground tanks will have a higher cost than an open basin option.

6.1.1 Gleneagles Reserve underground tank

Underground detention within Gleneagles Reserve was identified as a recommended standalone solution to mitigate flooding in the area surrounding Meakin Terrace and Leven Avenue. The reserve is upstream of the Leven Avenue flooding hotspot, and therefore provides an opportunity to capture and detain surface runoff prior to it being conveyed through the problem area. Underground detention, as opposed to an open basin has been recommended due to the high levels of use of the reserve.

Consideration of upgrading the Frogmore Road pump station to reduce overflows into the area was also considered during the options development, but it was not found to provide effective flood reduction.

An underground detention tank with a storage volume of 30,000 m^3 is proposed for the ultimate state of development. The modelling assumes a surface area of 15,000 m^2 (i.e. approximately half of the area of the reserve) and depth of 2 m, although alternative configurations are feasible. In practice, the detention may be constructed as a number of smaller tanks built progressively, allowing Council to adapt to increased runoff as a result of increased infill development in addition to projected increases in rainfall intensities due to climate change.

The tank will receive inflows via diversion of the underground drainage networks within Leven Avenue (DN675) and Dumfries Avenue (1200 x 600 RCBC). An outlet from the storage (DN375) will connect into the drain on Dumfries Avenue. A schematic concept design for this option is provided in Figure 6.2.

The resultant reductions in flooding for the 20% AEP and 1% AEP events are shown in Figure 6.3 and Figure 6.4, respectively. It can be seen that the tank provides a significant reduction in the flooding of private property downstream.

During the detailed design process, opportunities to incorporate infiltration (subject to site geotechnical conditions) and/or storage and reuse to provide water for irrigation of the reserve may be considered to increase the benefits associated with construction of the storage.

ID	Report section	Description
1	6.1.1	Gleneagles Reserve underground tank
2	6.1.2	Findon Road / Crittenden Road pipe upgrades
3	6.1.3	Beatrice Avenue / Trimmer Parade pipe upgrades
4	6.1.4	Matheson Reserve underground tank
5	6.1.5	Frank Mitchell Reserve underground tank
6	6.1.6	Nedford Reserve detention basin
7	6.1.7	Golfers Avenue pipe and pump upgrades
8	6.1.8	Sansom Road pipe upgrades
9	6.1.9	Recreation Parade detention basin
10	6.1.10	Market Corner pipe upgrades
11	6.1.11	Holland Street pipe upgrades
12	6.1.12	Main Street pipe upgrades

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WEST LAKES STORMWATER MANAGEMENT PLAN
OVERVIEW OF STRUCTURAL MITIGATION STRATEGIES

Figure 6.1


LOCALITY PLAN
Brebner Drive
Jetty Street
Port Road
Marlborough Street
Valetta Road
Flinders Parade
Hardey Road
Parkhouse Avenue
Parkhouse Avenue
Divert pipe networks from Leven Avenue and Dumfries Avenue into tank
Dumfries Avenue
1200 x 600
1200 x 600
1200 x 600
1200 x 600
1200 x 600
1200 x 600
1200 x 600
ø750
ø750
ø375
ø675
ø675
ø675
ø300
Underground tank storage volume 30,000 m³
Leven Avenue
Pape Avenue
Marinoff Street
Ailsa Avenue
ø450
ø450
ø450
ø450
ø300
ø375
ø375
Montrose Avenue
Troon
Legend
Junction box (new)
Pipe (existing)
Pipe to be removed
Pipe (new)
Underground detention tank
tonkin
0
50
100
150 m
N
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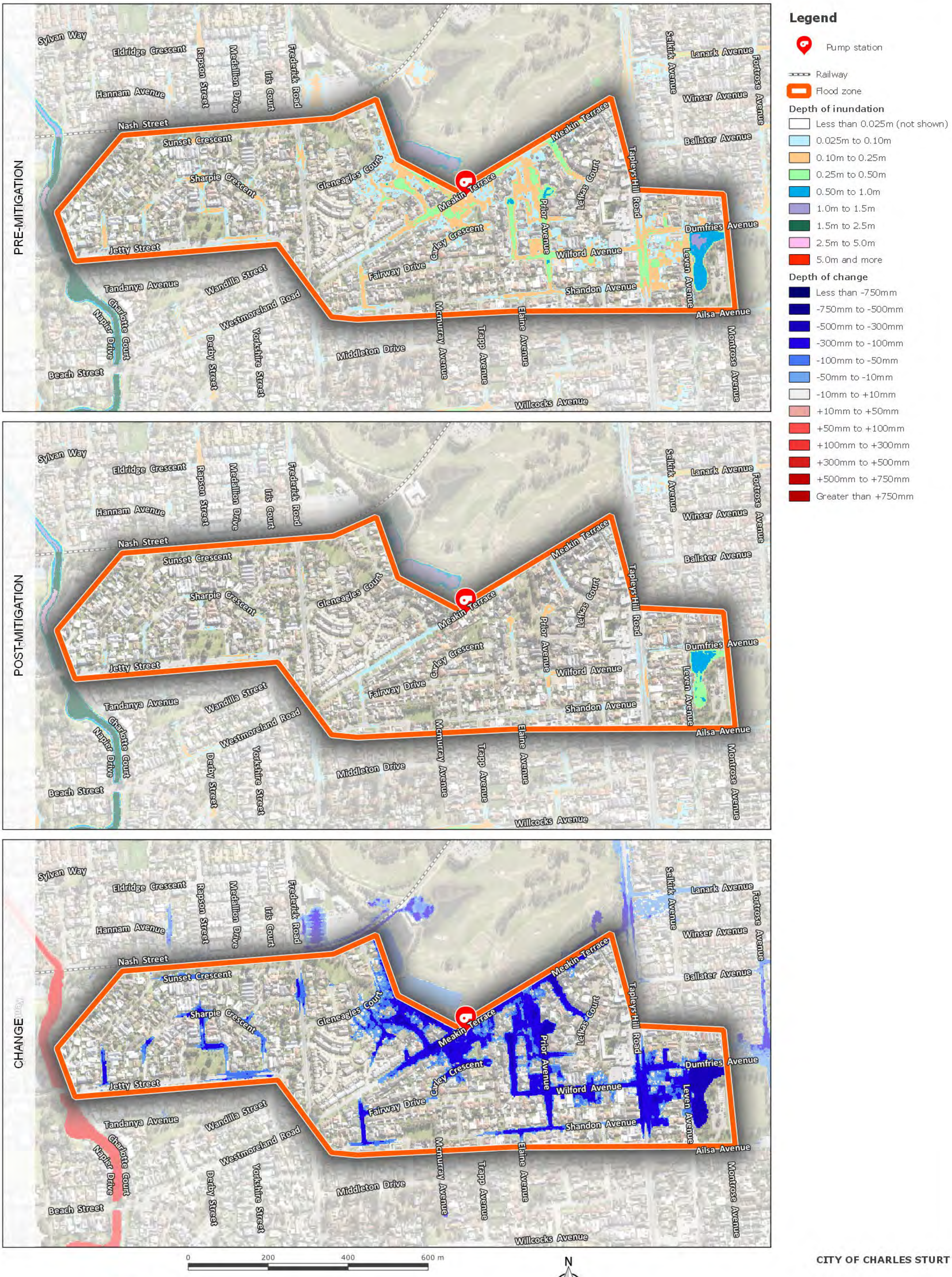
WEST LAKES STORMWATER MANAGEMENT PLAN
GLENEAGLES RESERVE UNDERGROUND TANK

Figure 6.2



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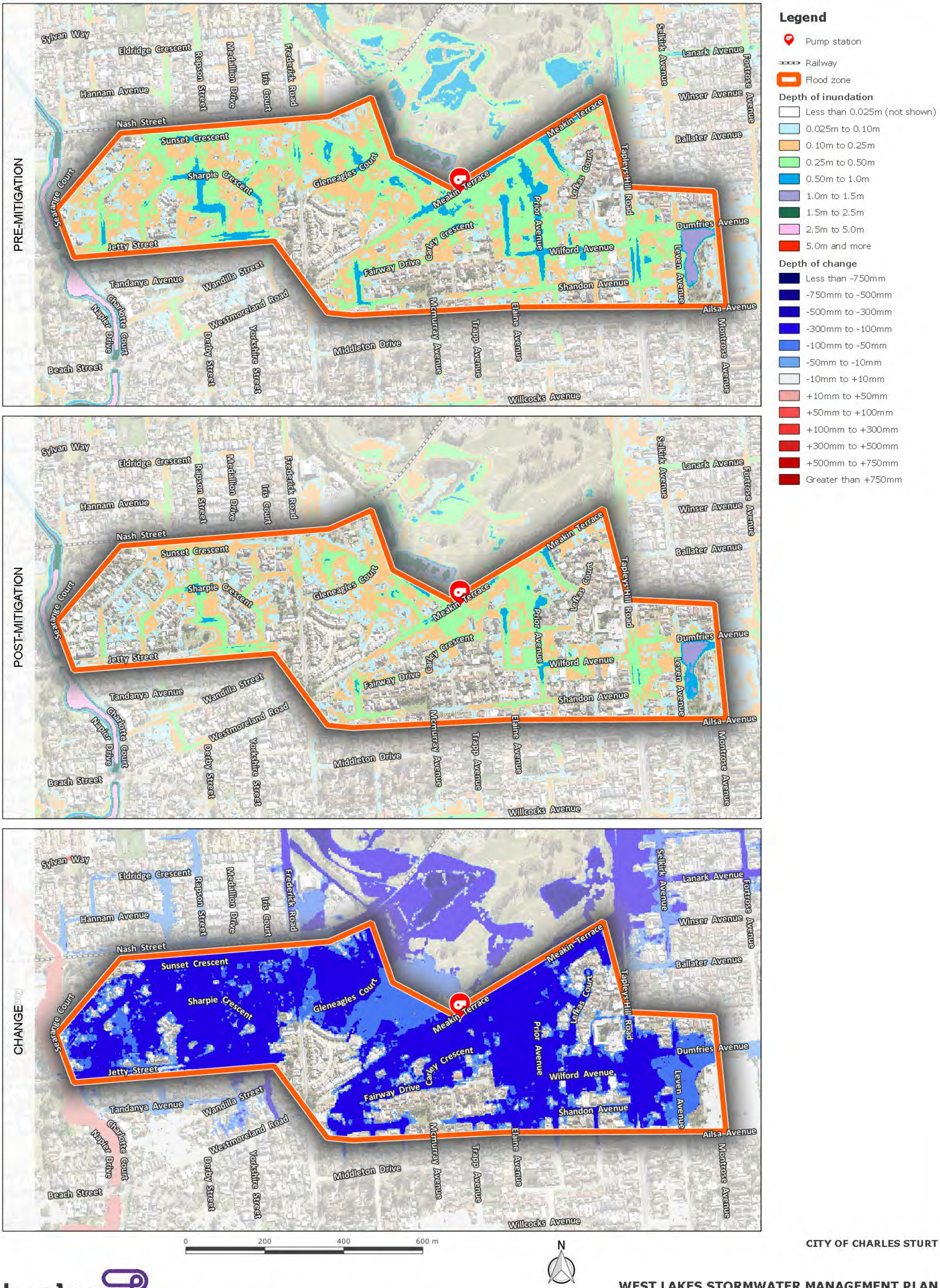
WEST LAKES STORMWATER MANAGEMENT PLAN
GLENEAGLES RESERVE UNDERGROUND TANK
20% AEP CHANGE MAP

Figure 6.3



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WEST LAKES STORMWATER MANAGEMENT PLAN
GLENEAGLES RESERVE UNDERGROUND TANK
1% AEP CHANGE MAP

Figure 6.4

6.1.2 Crittenden Road to Grange Lakes pipe upgrades

The area in the vicinity of the Findon Road and Crittenden Road intersection has a documented history of flooding. The potential for flooding was also identified by the flood mapping undertaken during the development of this SMP.

Two separate drainage systems service this area. The upstream end of the Trimmer Parage system drains Findon Road in a northerly direction. This system diverts runoff into the existing underground storage within Don Klaebe Reserve before heading west along Trimmer Parade. Upgrades of this system are not proposed. The second drainage network commences within Crittenden Road and conveys runoff from the eastern portion of the catchment in a southerly direction along Findon Road, before heading in a westerly direction to a direct outlet to Grange Lakes at the western end of Brogan Court.

A number of options were considered to mitigate the flooding issues at this location. Options that were considered included localised pipe upgrades and additional detention within the contributing catchment. However, the results of the modelling indicated that the primary issue contributing to the flooding is the limited capacity of the downstream trunk drainage system. Only minimal flood mitigation benefits could be realised with the implementation of local drainage upgrades.

The modelling indicates that the upgrade of the entire downstream drainage network to the Grange Lakes outlet (a total distance of approximately 5.5 km) is required to provide a measurable reduction in flooding in the vicinity of Crittenden Road and Findon Road. The preliminary modelling indicates that the existing capacity of the trunk drainage network would need to be tripled. Increased inlet capacity, through the provision of additional inlet pits is also required within the areas of existing flooding. Opportunity exists to incorporate raingardens along the length of the pipe upgrade, to improve water quality and promote urban greening.

An alternative drainage alignment was also explored, with flows diverted south along Findon Road with an outlet to the River Torrens. While this would potentially reduce the pipe upgrade distance to approximately 3 km, review of the elevation profile along the alignment shows that terrain increases from an elevation of 7.2 mAHD at the low point near Crittenden Road to 10 mAHD at the river.

The maximum invert of the upstream end of the pipe would be 5.6 mAHD. Assuming 0.2% grade to the Torrens, the invert of the outfall would be below 0 mAHD. By comparison, the invert of the River in this area is in the order of 2 mAHD. On this basis, the diversion of flows to the Torrens is not considered to be practicable.

The layout of the recommended upgrades is shown in Figure 6.5. The impact of the proposed upgrades on the 20% AEP and 1% AEP flood extents is shown in Figure 6.6 and Figure 6.7, respectively.

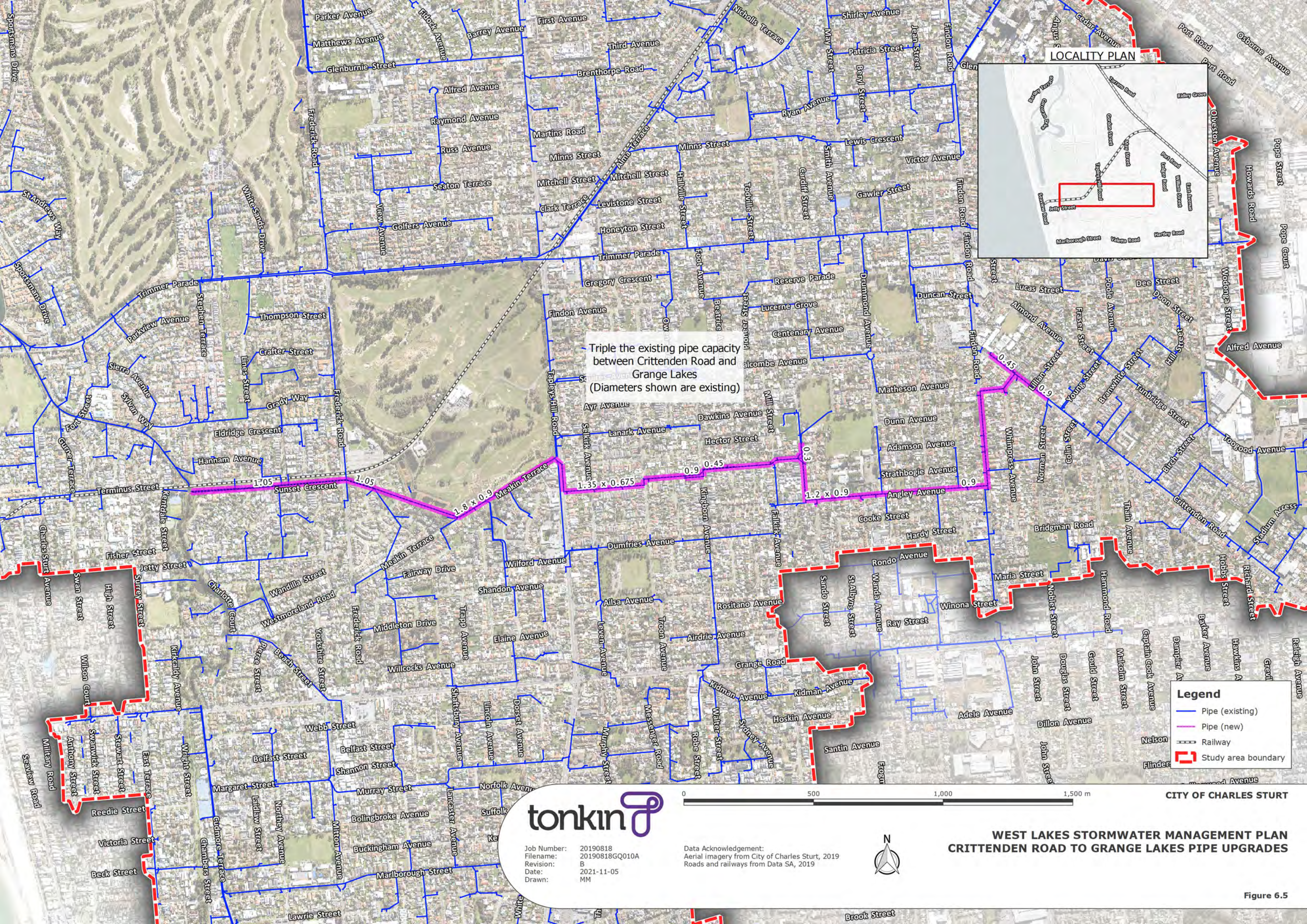
In the 20% AEP event, reductions in flood depths of up to 200 mm are observed within both Findon Road and Crittenden Road. Upgrading this system also alleviates some of the pressure from the Findon Road network to the north and the Lillian Street/Amanda Avenue network to the east; reductions of up to 150 mm are observed within these areas. Additionally, the increased capacity allows flood depths to be reduced within Briese Court (known area of flooding) by approximately 70 mm (although flood depths above kerb height are still observed within the low spot in the street).

Significant benefits are also achieved further downstream along the proposed route of the pipe upgrade, especially within the vicinity of McAllan Avenue, Seaton (approximately 1.1 km west of the intersection of Findon Road and Crittenden Road). The flood modelling for the pre- and post-mitigation scenarios shows that there are at least 14 residential properties in this area that will no longer be subject to the entry of floodwaters in the 20% AEP event. A change map for this section of the catchment is provided in Figure 6.8.

Additionally, Council has previously identified flooding issues within Gluyas Avenue, Grange. Previous investigations (Tonkin, 2017) identified that works were required to lower the hydraulic grade line (HGL) in the trunk drainage system to improve flooding within this area. The proposed Crittenden Road to Grange Lakes pipe upgrades achieve this, and will result in reductions in flood depths within Gluyas Avenue for the 20% AEP event.

It is recognised that there are a number of challenges associated with such extensive pipe upgrades through heavily developed areas, not least of which is capital costs and the presence of existing services. Consideration should be given to constructing the upgrades within the reserve adjacent Sunset Crescent, and within open land along the edge golf course. Alternative alignments for the upstream sections of pipe may also be considered. During the subsequent design phases, consideration should be given to alternative pipe configurations, including a reduced number of pipes with a larger diameter.

The flooding improvements realised by construction of the Gleneagles Reserve underground tank (Section 6.1.1) and Matheson Reserve underground tank (Section 6.1.4) are not dependent on these pipe upgrades being completed.


Triple the existing pipe capacity between Crittenden Road and Grange Lakes
(Diameters shown are existing)
1.05
1.05
1.8 x 0.9
1.35 x 0.675
0.9
0.45
0.3
1.2 x 0.9
0.9
0.45
0.9
LOCALITY PLAN
Legend
Pipe (existing)
Pipe (new)
Railway
Study area boundary
0
500
1,000
1,500 m
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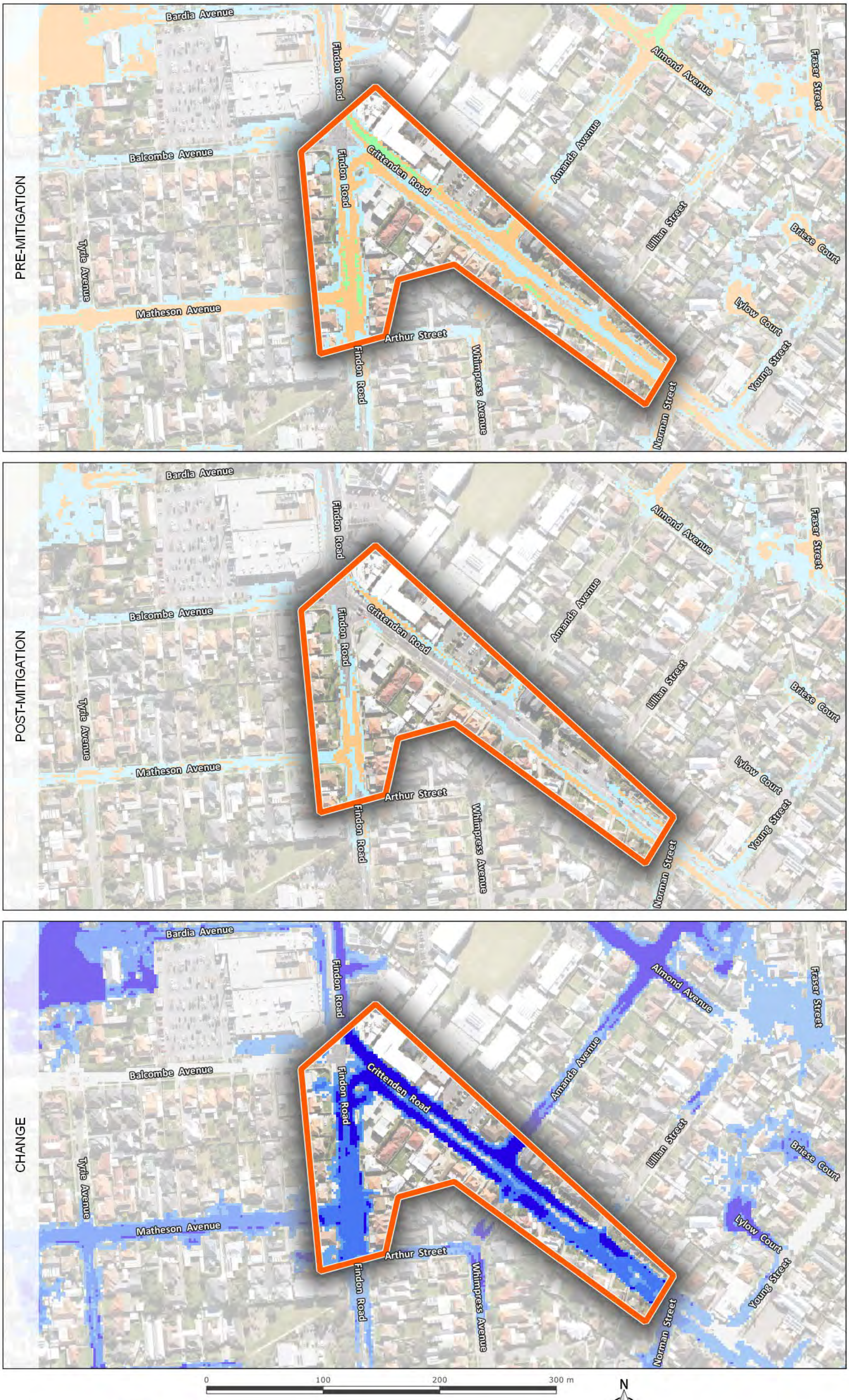
CITY OF CHARLES STURT
WEST LAKES STORMWATER MANAGEMENT PLAN
CRITTENDEN ROAD TO GRANGE LAKES PIPE UPGRADES
Trimmer Parade
Terminus Street
Sunset Crescent
Meakin Terrace
Tapleys Hill Road
Angley Avenue
Findon Road
Crittenden Road
Frederick Road
Grange Road
Dumfries Avenue
Kingston Avenue
Fairway Drive
Figure 6.5



Legend

Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

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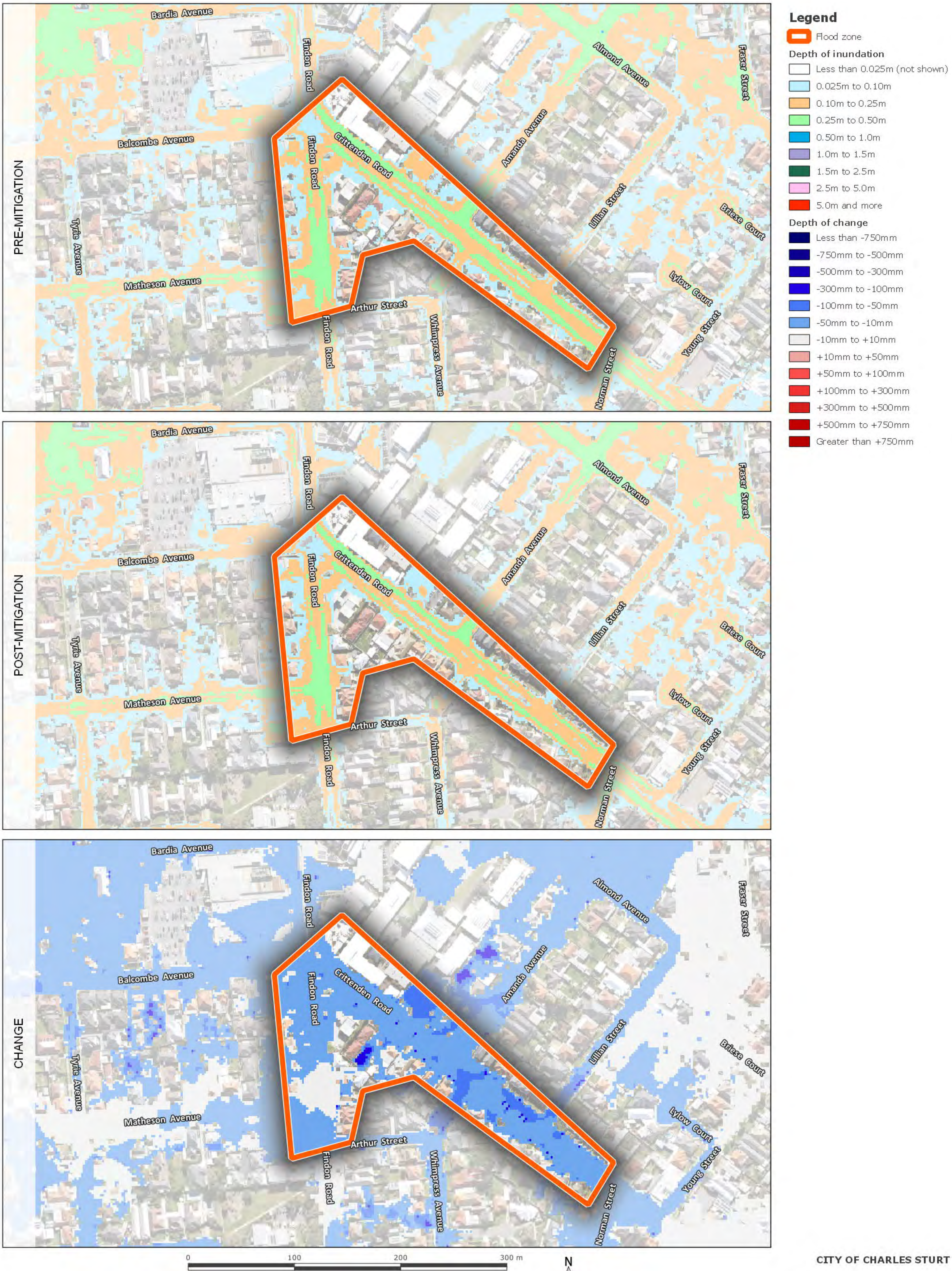
WEST LAKES STORMWATER MANAGEMENT PLAN
CRITTENDEN ROAD TO GRANGE LAKES PIPE UPGRADES
20% AEP CHANGE MAP

Figure 6.6



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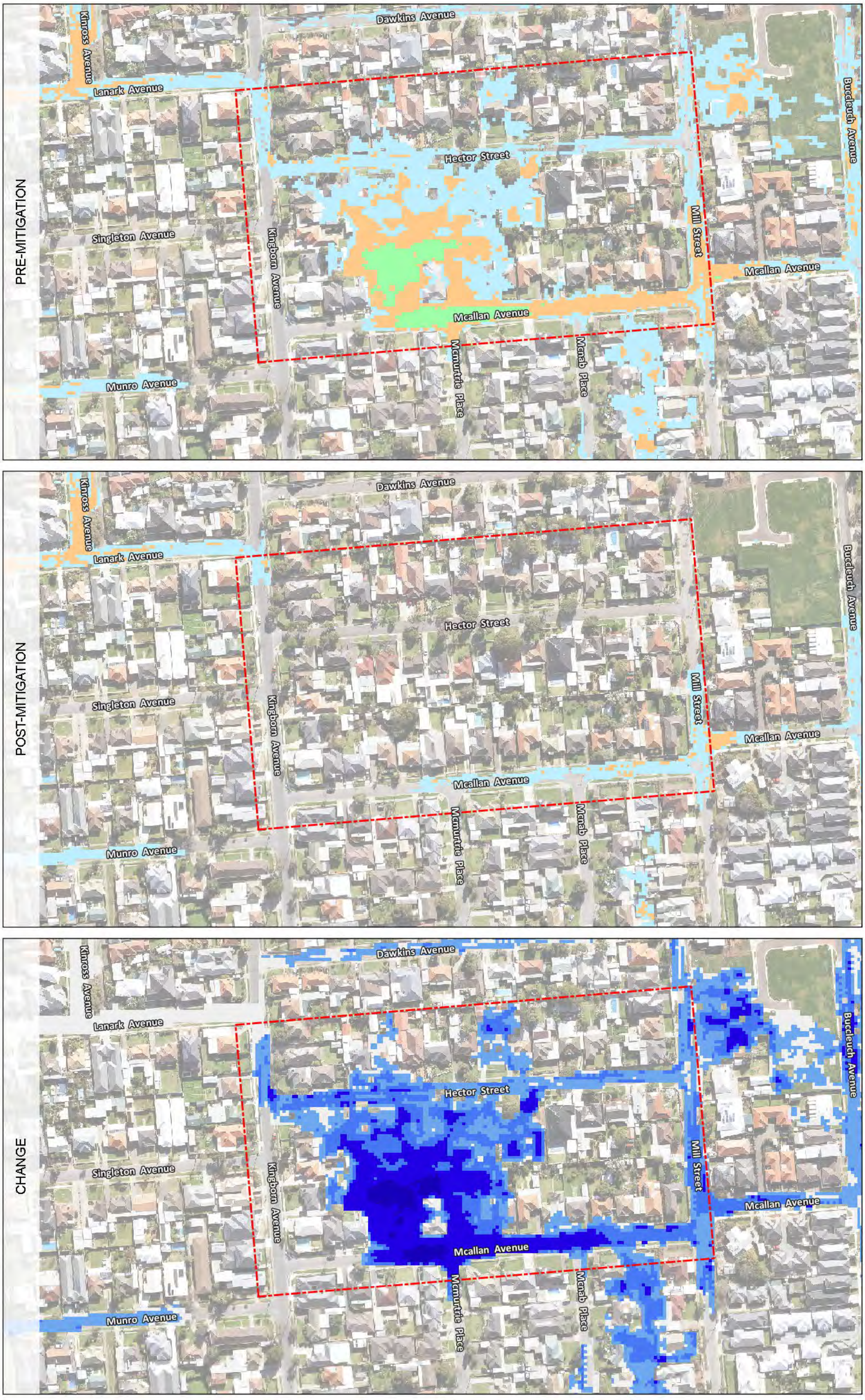
WEST LAKES STORMWATER MANAGEMENT PLAN
CRITTENDEN ROAD TO GRANGE LAKES PIPE UPGRADES
1% AEP CHANGE MAP

Figure 6.7



Legend

Area of flooding

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 50 100 150 m

N

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WEST LAKES STORMWATER MANAGEMENT PLAN
CRITTENDEN ROAD TO GRANGE LAKES PIPE UPGRADES
20% AEP CHANGE MAP - MCALLAN AVENUE

Figure 6.8

6.1.3 Beatrice Avenue and Trimmer Parade pipe upgrades

Flooding within the area surrounding Beatrice Avenue is a known issue, which has been confirmed by the flood mapping undertaken as part of the development of this SMP. The area is currently served by a local drainage network (pipe sizes up to DN525), which connects to the Trimmer Parade trunk drain. In order to alleviate the flooding within this area, improving the capacity of this existing drainage network is proposed.

During the development of the SMP, a number of options looking at localised upgrades were assessed, however it was determined that the effectiveness of these upgrades was limited by the downstream capacity of the Trimmer Parade trunk drain. Pipe upgrades within Trimmer Parade are required to provide a suitable level of flood protection to private property within the Beatrice Avenue area.

The required pipe upgrades are shown in Figure 6.9. The works include the following:

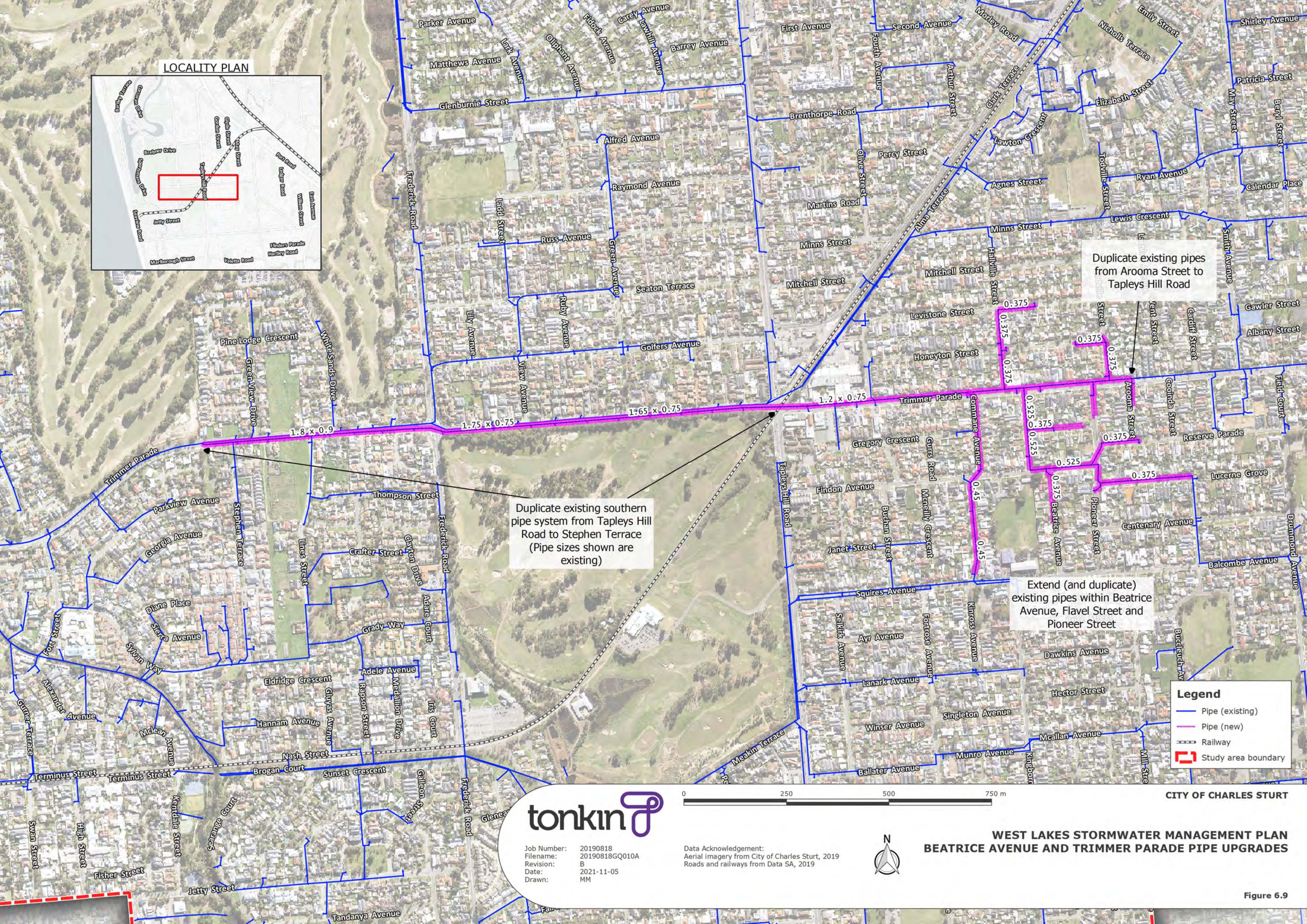
- Duplication of the lateral drains within and surrounding Beatrice Avenue.
- Extension of the drains within Beatrice Avenue, Flavel Street and Pioneer Street.
- Duplication of the Trimmer Parade trunk drain between Arooma Street and Tapleys Hill Road.
- Duplication of the southern Trimmer Parade trunk drain between Tapleys Hill Road and Stephen Terrace.

No upgrades of the Trimmer Parade trunk drain are proposed beyond Stephen Terrace as the modelling shows that the system has sufficient capacity from this point onwards (4x DN1500). The total length of pipe upgrade required is approximately 4.2 kilometres. In addition to the duplication of pipes, an increased inlet capacity will also be required in some locations, which can be achieved through the installation of additional inlet pits. Opportunities to incorporate water sensitive urban design elements should also be considered as part of the detailed design of the works.

As with the Crittenden Road pipe upgrades, it is recommended that a staged approach to construction be undertaken, with sections of the network constructed incrementally, beginning at the downstream end. Alternative pipe configurations, such as removal of the existing pipe network and replacement with pipes of a larger diameter, are also feasible; these details will be confirmed during detailed design.

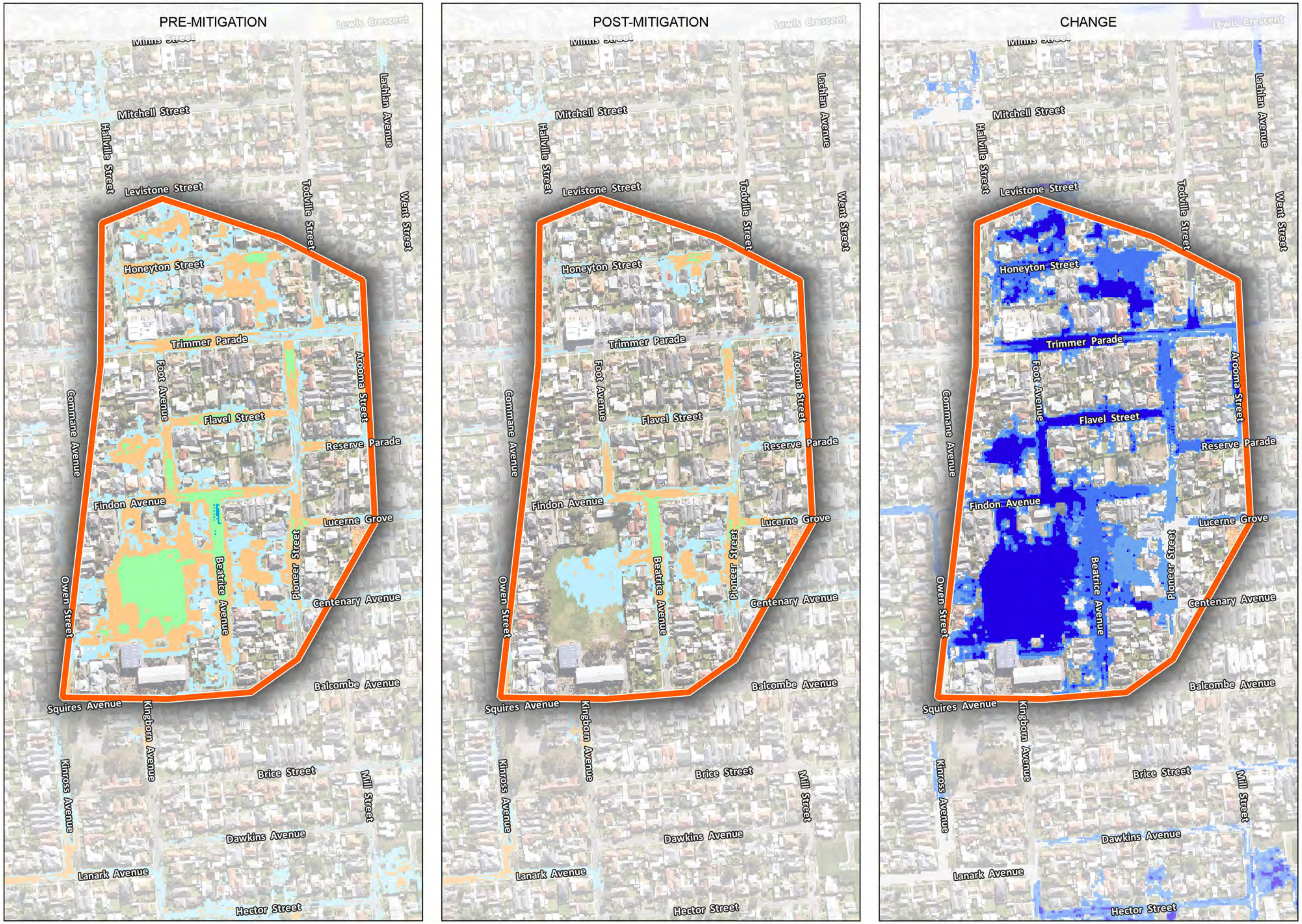
The post-mitigation flood extents for the 20% AEP and 1% AEP events are shown in Figure 6.10 and Figure 6.11, respectively. The results for the 20% AEP event show that there is some residual flooding through private property within Beatrice Avenue and Pioneer Street. However, property flooding within the remaining streets is almost entirely alleviated, in addition to significant (100-200 mm) reductions in flood depth within the road corridors.

An assessment of the flooding benefits provided by an underground tank/detention basin within the Seaton Park Primary School was also undertaken (as an alternative to the pipe upgrade strategy). This would involve diversion of pipe flows from Beatrice Avenue into the school oval (identified as a nearby area of open space). It was found that this option provided some reduction in surrounding flood depths, but not to the extent of the pipe upgrades (generally less than 80 mm). It has therefore not considered further as part of this SMP, but could be considered as a standalone option to provide some reduction in flooding depending on the proposed construction timeframes for the recommended pipe upgrades.



WEST LAKES STORMWATER MANAGEMENT PLAN
BEATRICE AVENUE AND TRIMMER PARADE PIPE UPGRADES

Figure 6.9



Legend

Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 100 200 300 m

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Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2019

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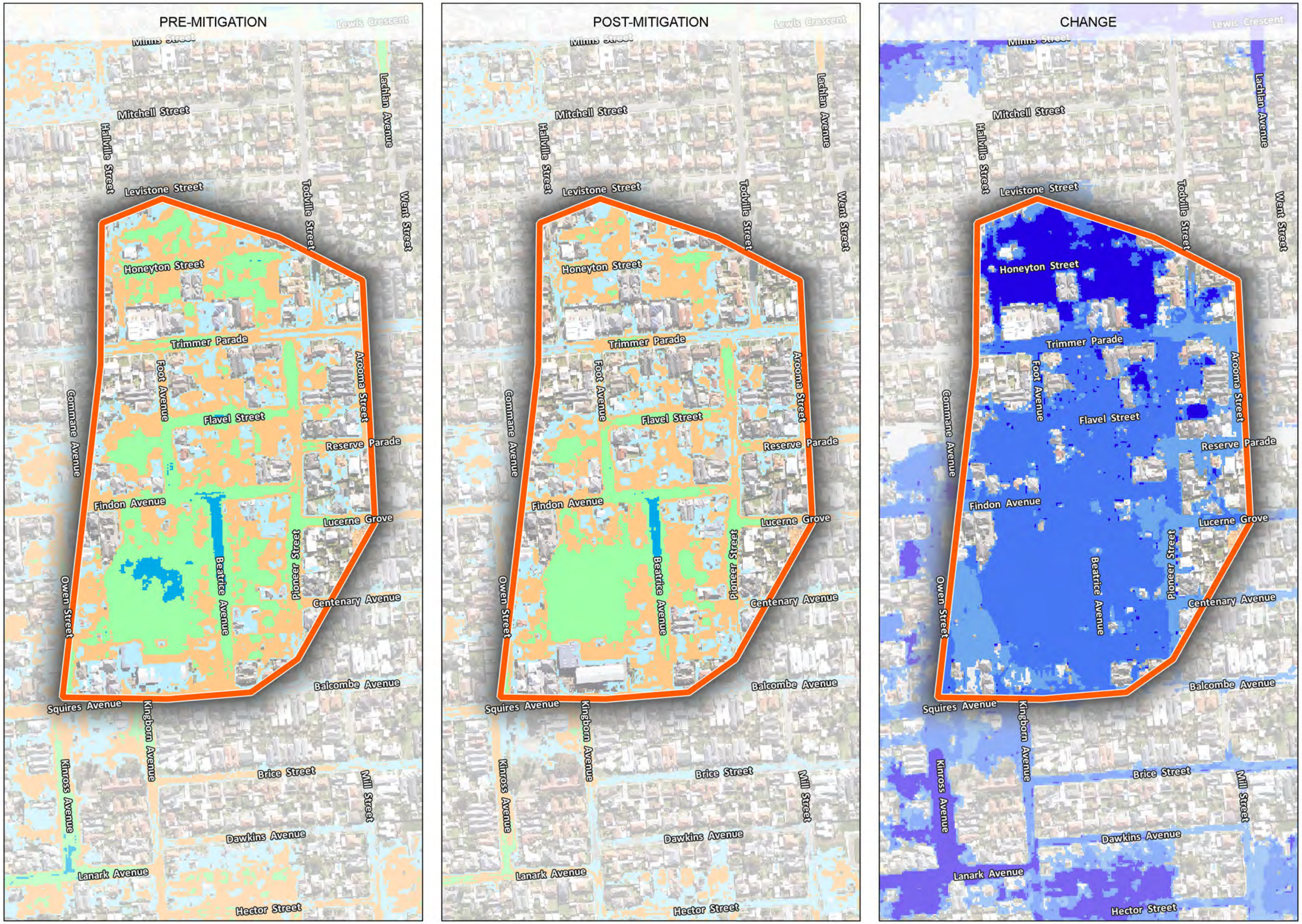
WEST LAKES STORMWATER MANAGEMENT PLAN
BEATRICE AVENUE AND TRIMMER PARADE PIPE UPGRADES
20% AEP CHANGE MAP

Figure 6.10



Legend

Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 100 200 300 m

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WEST LAKES STORMWATER MANAGEMENT PLAN
BEATRICE AVENUE AND TRIMMER PARADE PIPE UPGRADES
1% AEP CHANGE MAP

Figure 6.11

6.1.4 Matheson Reserve underground tank

There is significant ponding of runoff within Drummond Avenue and Dominion Avenue, in addition to some flooding of private property, during the 20% AEP event. Tonkin has previously undertaken an assessment of potential flood mitigation strategies within this area (Tonkin, 2016). It was found that upgrades to the existing pit and pipe drainage system would not reduce the incidence of flooding at the low spot. Given the adjacent area of open space within Matheson Reserve, an assessment of the flood mitigation benefits that could be provided by an underground tank within the reserve has been undertaken.

The flood modelling incorporated a detention tank with a storage volume of 20,000 m^3. This volume is based on an assumed surface area of 10,000 m^2 and depth of 2 m. As with the Gleneagles Reserve underground tank, this storage could be constructed progressively to cater for the increased flows that will result from infill development within the upstream catchment.

The tank will receive inflows via diversion of the underground drainage network that begins at the southern end of Dominion Avenue and passes through the reserve (DN300), as well as the system that begins near the intersection of Drummond Avenue and Dunn Avenue (DN450). Diversion of the second system would require acquisition of a drainage easement through the Findon High School sports field. The outlet from the storage will connect into the existing drainage system in Buccleuch Avenue. The configuration of this proposed strategy is provided in Figure 6.12.

During the detailed design process, opportunities to incorporate infiltration (subject to site geotechnical conditions) and/or storage and reuse to provide water for irrigation of the reserve may be considered to increase the benefits associated with construction of the storage.

Difference maps for the 20% AEP and 1% AEP events are provided in Figure 6.13 and Figure 6.14, respectively. Results for the 20% AEP event show that there is no longer any flooding of private property within the vicinity of the proposed works. Additionally, within both Dominion Avenue and Drummond Avenue, significant reductions (greater than 300 mm within both roads) in the depth of ponding are observed. Some residual flooding at the low point within Drummond Road (adjacent to Dunn Avenue) remains.

A minor improvement (between 50-70 mm) in road and property flooding is achieved during the 1% AEP event.

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0 50 100 150 m

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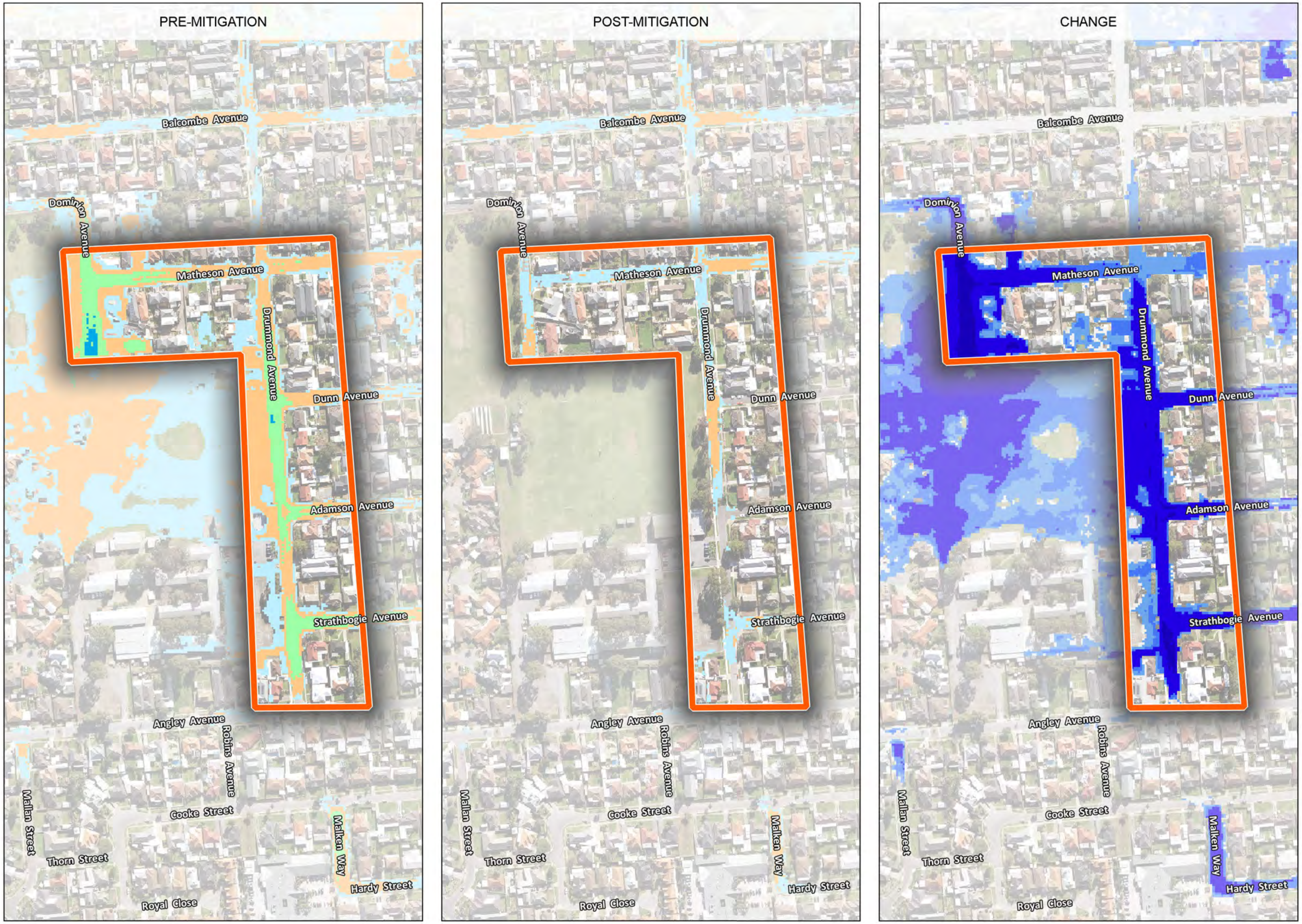
WEST LAKES STORMWATER MANAGEMENT PLAN
MATHESON RESERVE UNDERGROUND TANK

Figure 6.12



Legend

Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 100 200 300 m

N

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Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
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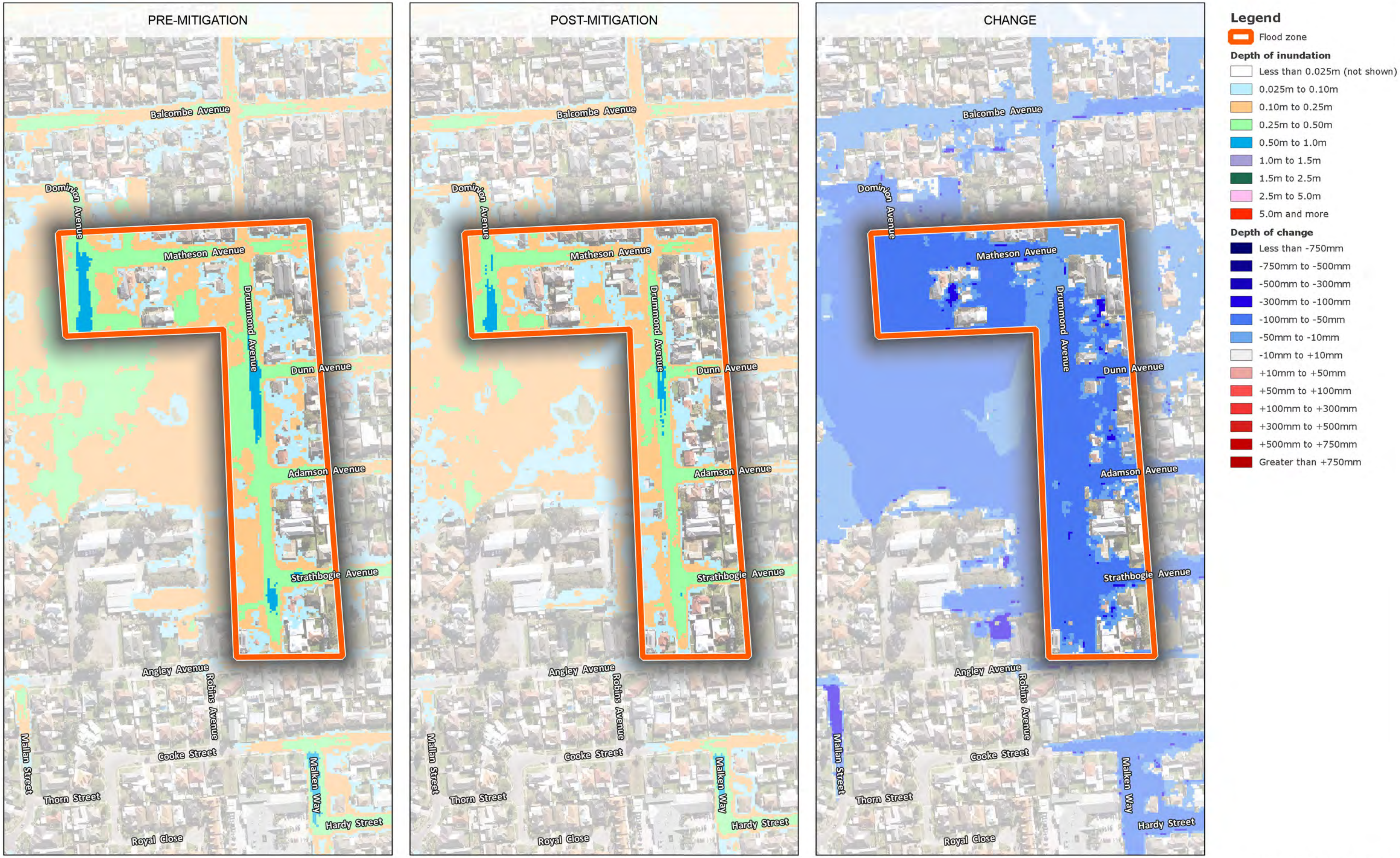
WEST LAKES STORMWATER MANAGEMENT PLAN
MATHESON RESERVE UNDERGROUND TANK
20% AEP CHANGE MAP

Figure 6.13



0 100 200 300 m

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Data Acknowledgement:
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WEST LAKES STORMWATER MANAGEMENT PLAN
MATHESON RESERVE UNDERGROUND TANK
1% AEP CHANGE MAP

Figure 6.14

6.1.5 Frank Mitchell Reserve underground tank

Modelling undertaken to assess options to reduce flooding in the vicinity of Todville Street identified the option of an underground detention storage within Frank Mitchell Reserve. The park was identified as a suitable location for the construction of an underground storage given its close proximity to the area of flooding. The modelling utilised a storage volume in the order of 36,000 m^3, with a nominal footprint of 12,000 m^2 and depth of 3 m. Diversion of flows into the reserve will be via the DN1350 pipe at the intersection of Todville Street and Ryan Avenue. The outlet from this tank will then connect back into this existing system further downstream. The layout of this proposed upgrade is shown in Figure 6.15, while the changes in flooding for the 20% AEP and 1% AEP events are shown in Figure 6.16 and Figure 6.17, respectively.

Results for the 20% AEP event show that the construction of the tank results in reductions in flood depth of approximately 300 mm at the low point within Todville Street (adjacent to Ryan Avenue) as well as some improvements within Ryan Avenue and Minns Street. The 1% AEP event flood map shows that the tank also provides additional downstream benefits, with flooding improvements observed towards Alma Terrace and the railway line.

As with the other proposed tank storages, opportunities for water harvesting and reuse as well as infiltration should be considered during the design development.

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0 25 50 75 m

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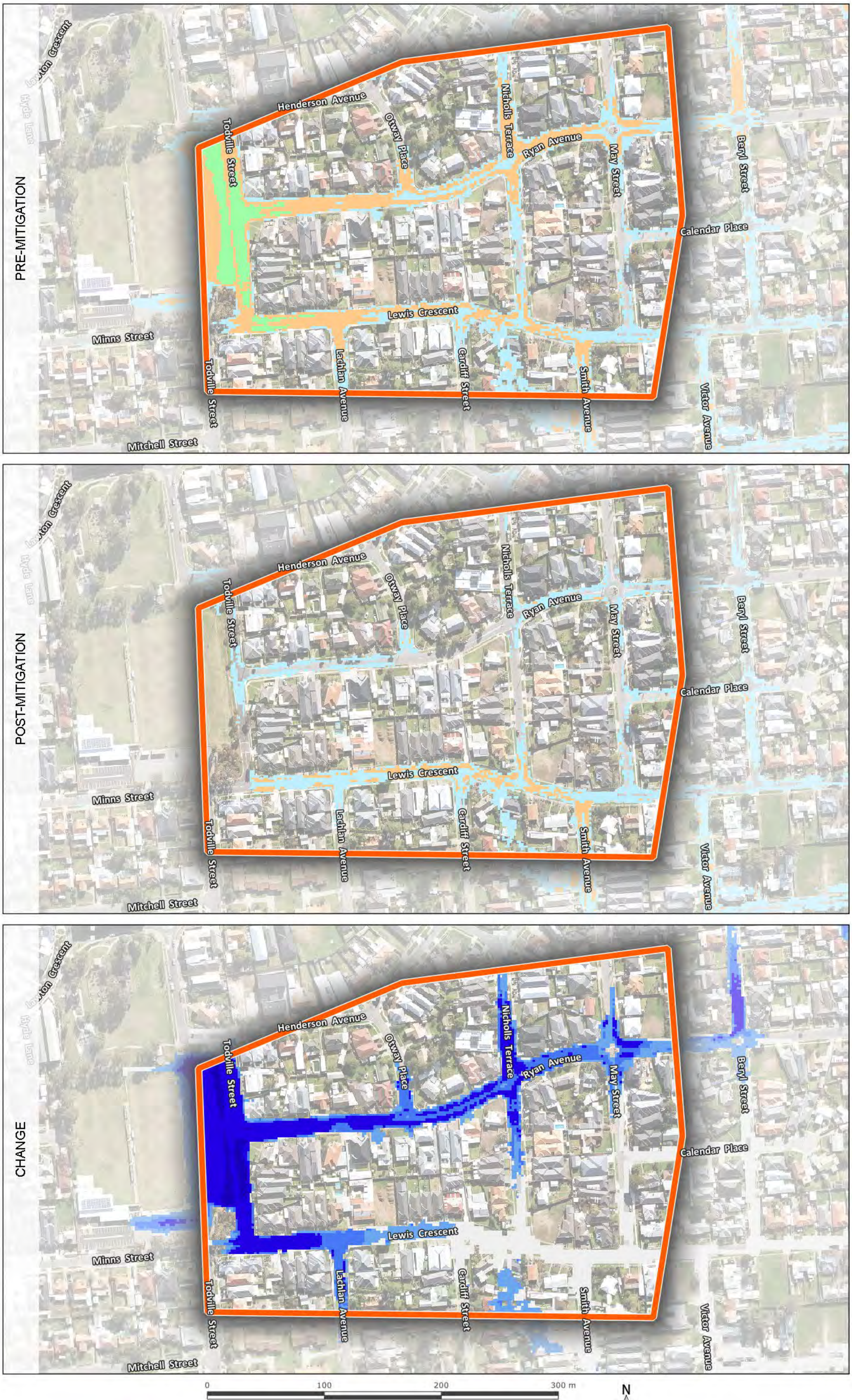
WEST LAKES STORMWATER MANAGEMENT PLAN
FRANK MITCHELL RESERVE UNDERGROUND TANK

Figure 6.14



Legend

Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

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Roads and railways from Data SA, 2019

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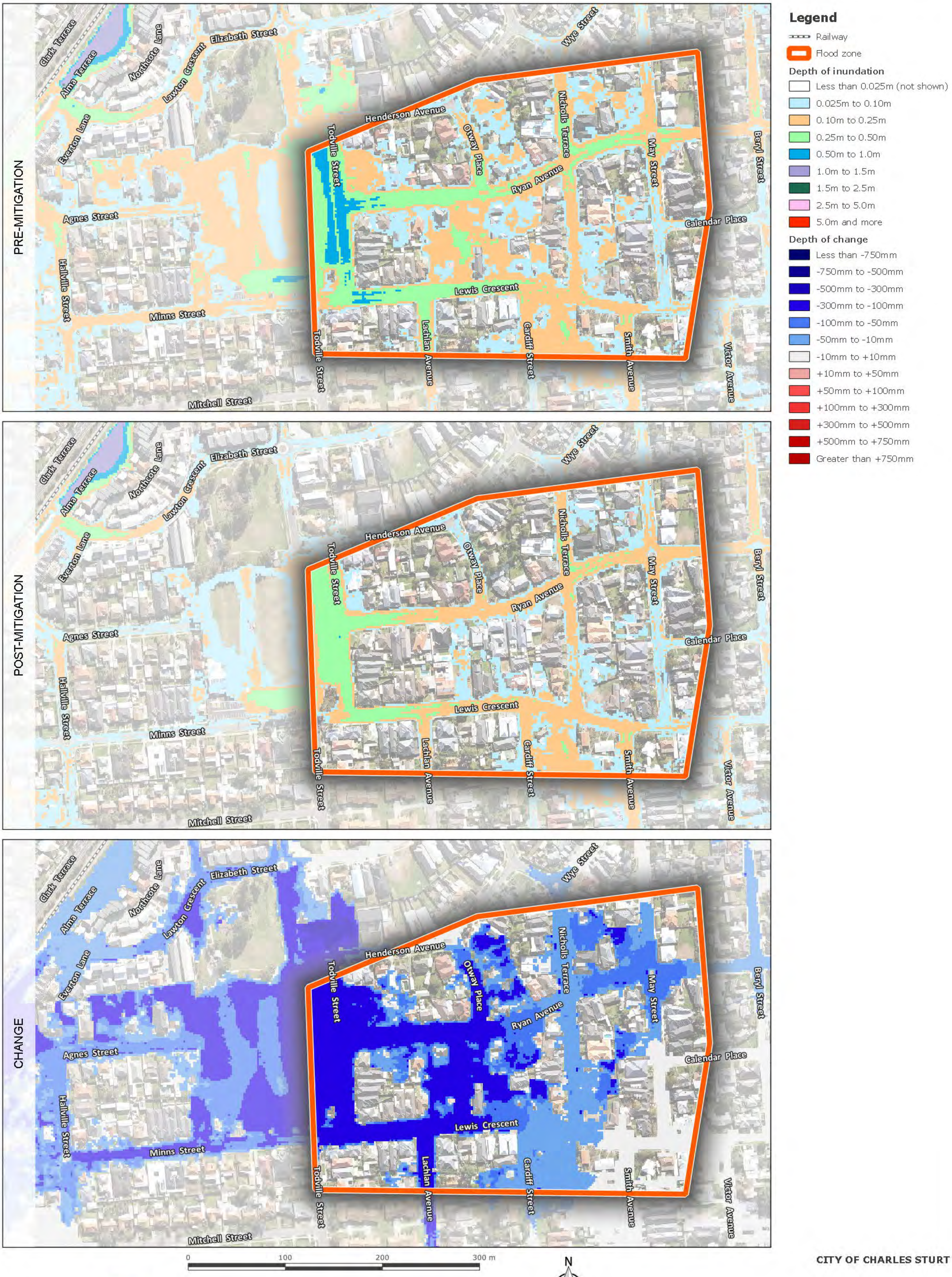
WEST LAKES STORMWATER MANAGEMENT PLAN
FRANK MITCHELL RESERVE UNDERGROUND TANK
20% AEP CHANGE MAP

Figure 6.16



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WEST LAKES STORMWATER MANAGEMENT PLAN
FRANK MITCHELL RESERVE UNDERGROUND TANK
1% AEP CHANGE MAP

Figure 6.17

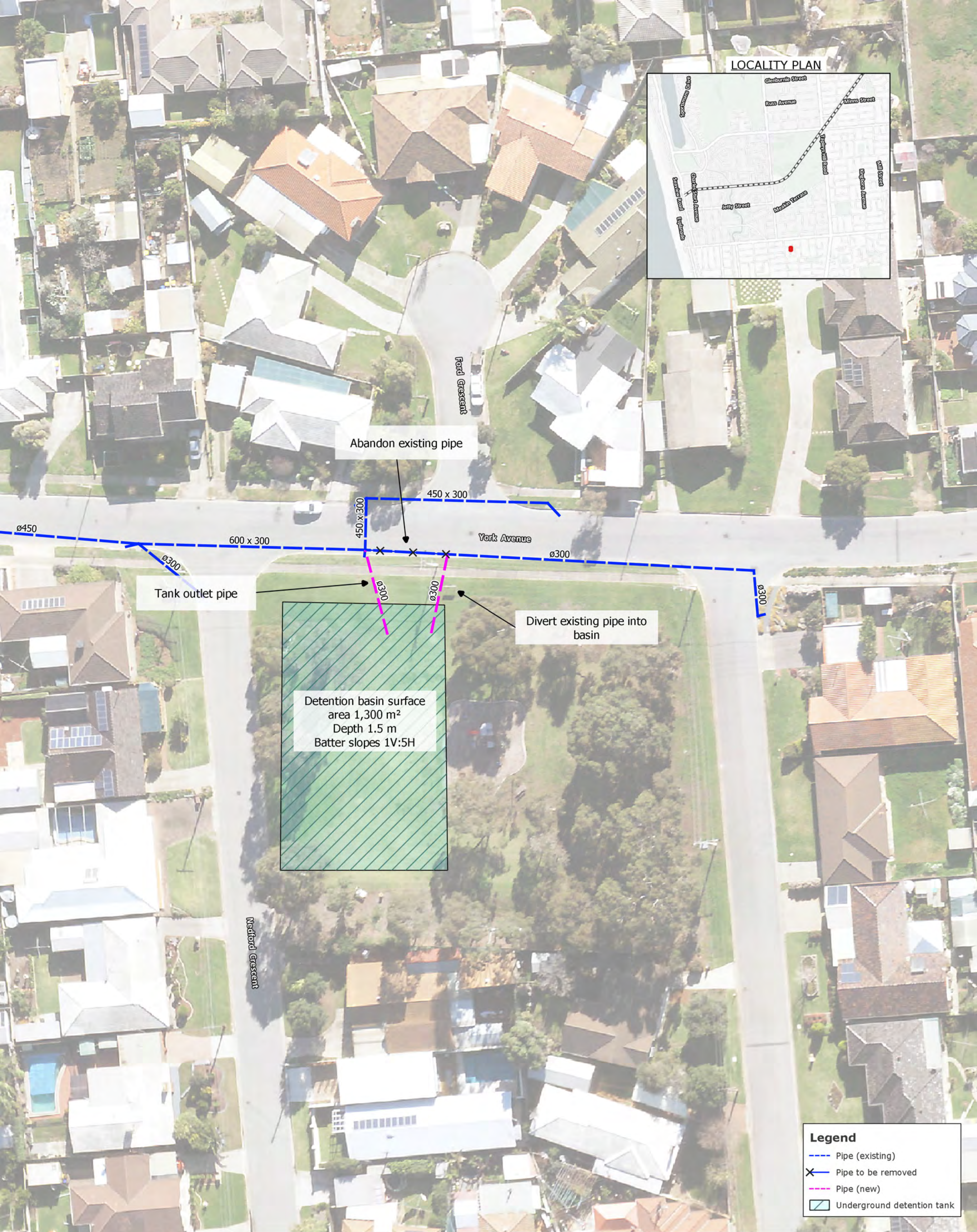
6.1.6 Nedford Reserve detention basin

The results of the flood modelling suggest that ponding of runoff within York Avenue adjacent to Ford Crescent is estimated to exceed 300 mm in the 20% AEP event (although anecdotally flooding to this depth has not been reported). In order to improve the modelled flooding, it is proposed that a detention storage be constructed within the adjacent reserve (Nedford Reserve). Unlike a number of the reserves identified within this report for flood storage, Nedford Reserve is not used as an active sports field. As such, it is considered that there is an opportunity to construct an open detention basin (rather than an underground tank).

The modelling indicates that a basin with a surface area of approximately 1,300 m^2 is required. This would occupy slightly less than half the area of the reserve. Flows will be directed into the basin via diversion of the existing DN300 within York Avenue, and will be discharged via a DN300 connecting into the same network. This configuration is shown in Figure 6.18.

Opportunities for landscaping with a variety of native species should be considered during the design process. This will contribute to greening of the study area in addition to improved biodiversity. Opportunities for the treatment of low flows via infiltration or other means should also be considered.

Results of the modelling for the 20% AEP event (Figure 6.19) show that the basin provides a significant reduction in flood depths (reduction of 150 mm – 200 mm) within York Avenue and Nedford Crescent. However, some residual flooding within York Avenue remains. The basin does not provide any flood improvement benefits for the 1% AEP event (refer Figure 6.20).



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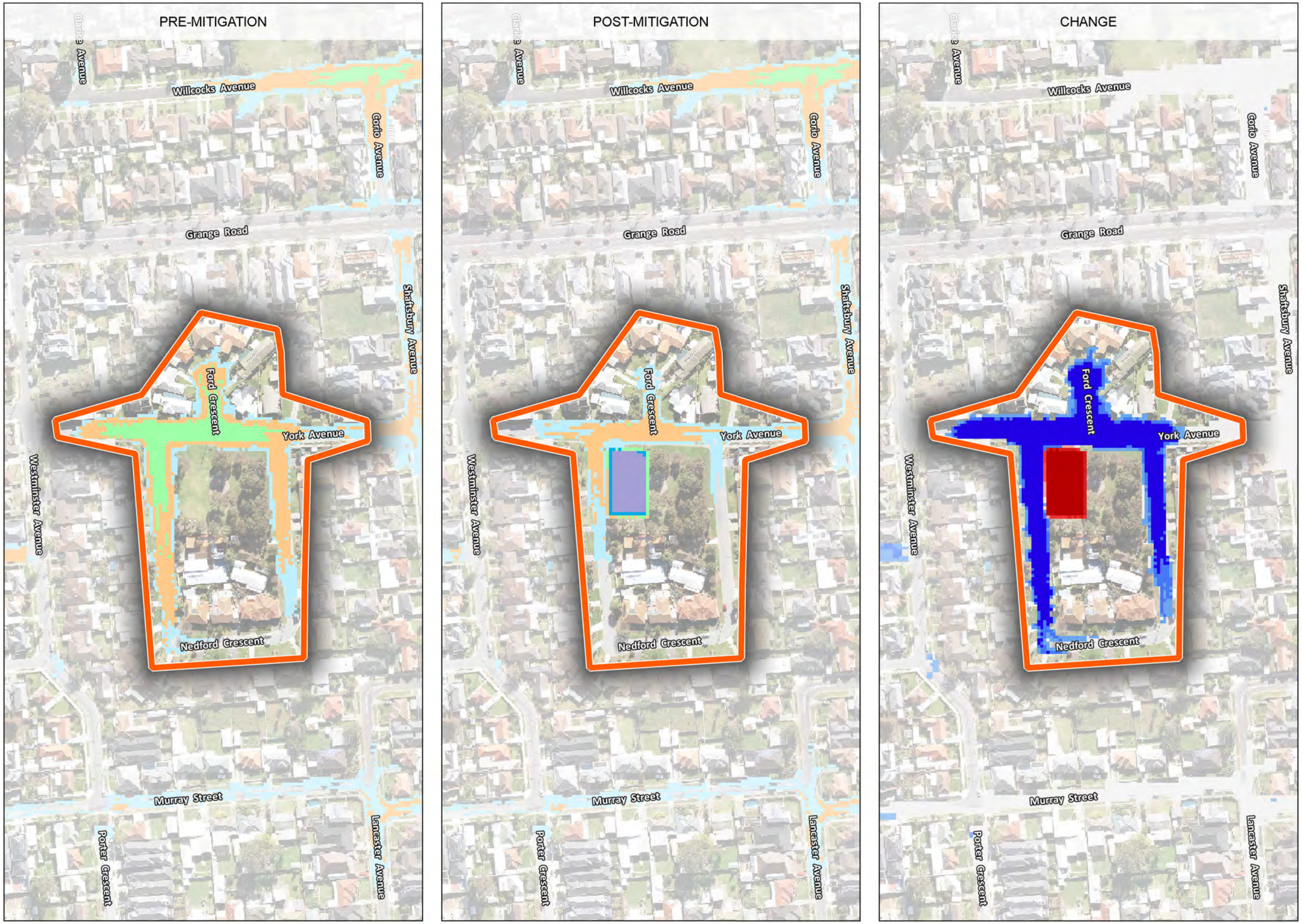
WEST LAKES STORMWATER MANAGEMENT PLAN
NEDFORD RESERVE DETENTION BASIN

Figure 6.18



Legend

- Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 50 100 150 m

N

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Aerial imagery from City of Charles Sturt, 2019
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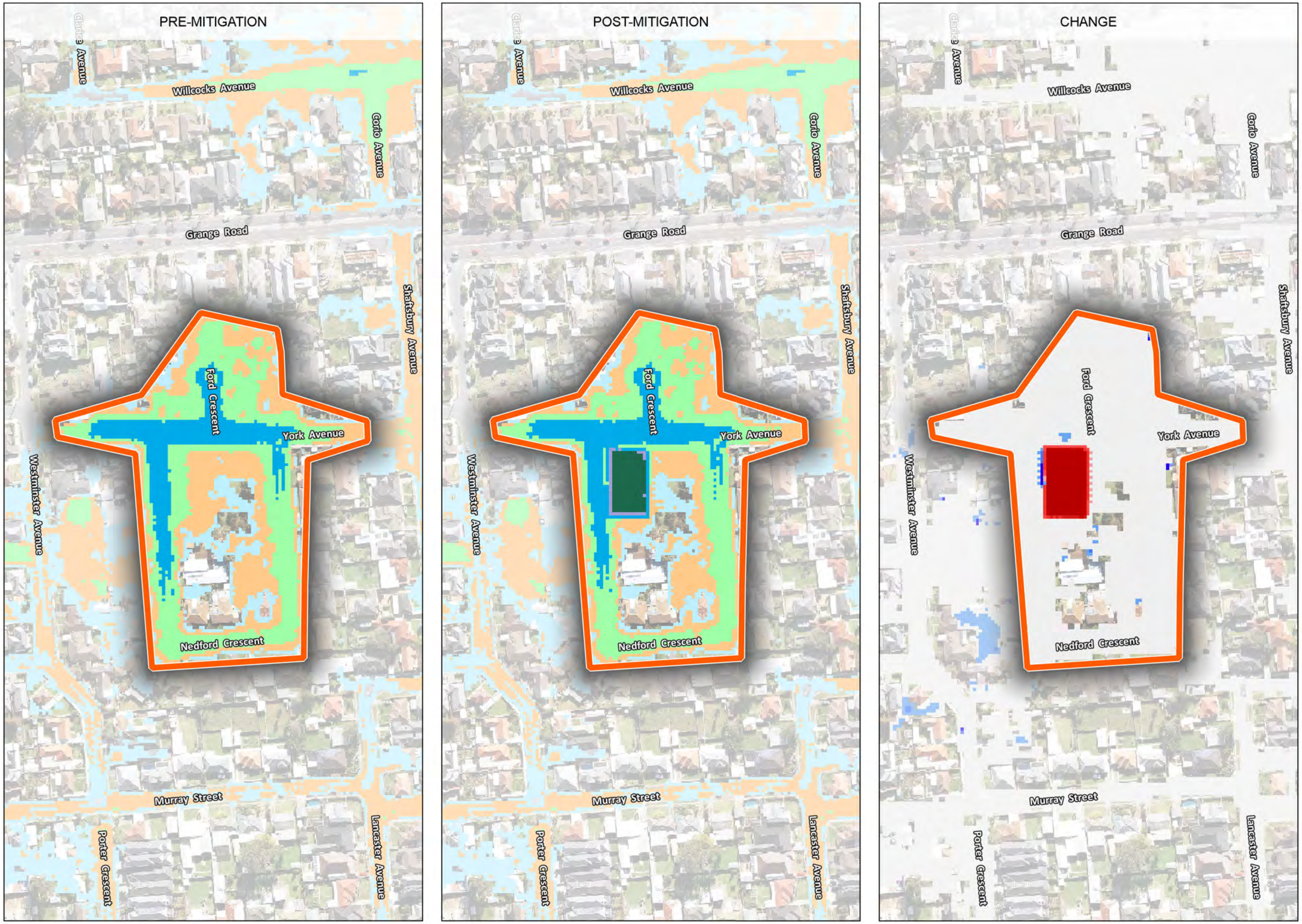
WEST LAKES STORMWATER MANAGEMENT PLAN
NEDFORD RESERVE DETENTION BASIN
20% AEP CHANGE MAP

Figure 6.19



Legend

Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 50 100 150 m

N

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WEST LAKES STORMWATER MANAGEMENT PLAN
NEDFORD RESERVE DETENTION BASIN
1% AEP CHANGE MAP

Figure 6.20

6.1.7 Golfers Avenue pipe and pump upgrades

The flood modelling for the 20% AEP event shows significant ponding within the roads surrounding Golfers Avenue and Frederick Road. This area is currently served by an underground drainage network which connects to the Trimmer Parade trunk drain at Frederick Road. A pump station at the intersection of Golfers Avenue and Frederick Road is used to convey runoff from the low point to the Trimmer Parade drain.

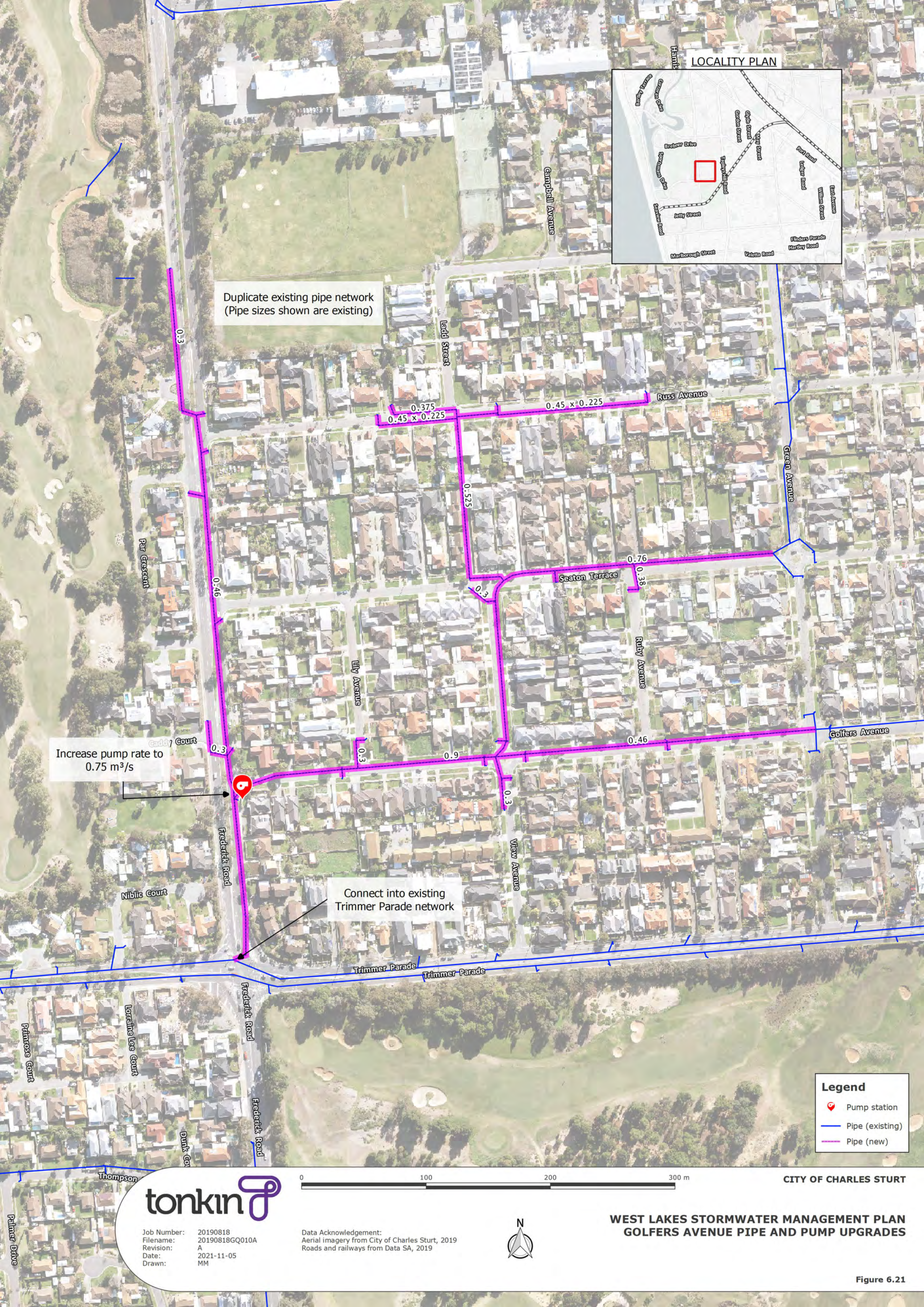
In order to alleviate the ponding within the road during this event, upgrades to the pipe network and pump capacity are proposed. Given the large capacity of the Trimmer Parade drain downstream (west) of Frederick Road, it was determined that only localised pipe upgrades are required.

The modelling indicates that the capacity of the existing pipe network needs to be duplicated (either with the addition of a parallel drainage run, or replacement of the existing system with pipes of a larger diameter). Additionally, the pump rate from the Golfers Avenue pump station needs to increase from 0.25 m^3/s to 0.75 m^3/s. A concept layout for this mitigation scenario is shown in Figure 6.21. The 20% AEP and 1% AEP change maps are shown in Figure 6.22 and Figure 6.23, respectively.

The results of the 20% AEP modelling show that while there is some residual ponding of runoff within the road, significant reductions can be achieved, most notably at the following locations:

- Frederick Road and Russ Avenue intersection (reduction of up to 250 mm)
- Lily Avenue (reduction of up to 200 mm)
- View Avenue (reduction of up to 130 mm).

Some minor reductions in flood depths (up to 50 mm) are also observed throughout this region for the 1% AEP event. Flooding of private property within this area is still a widespread issue for this event.



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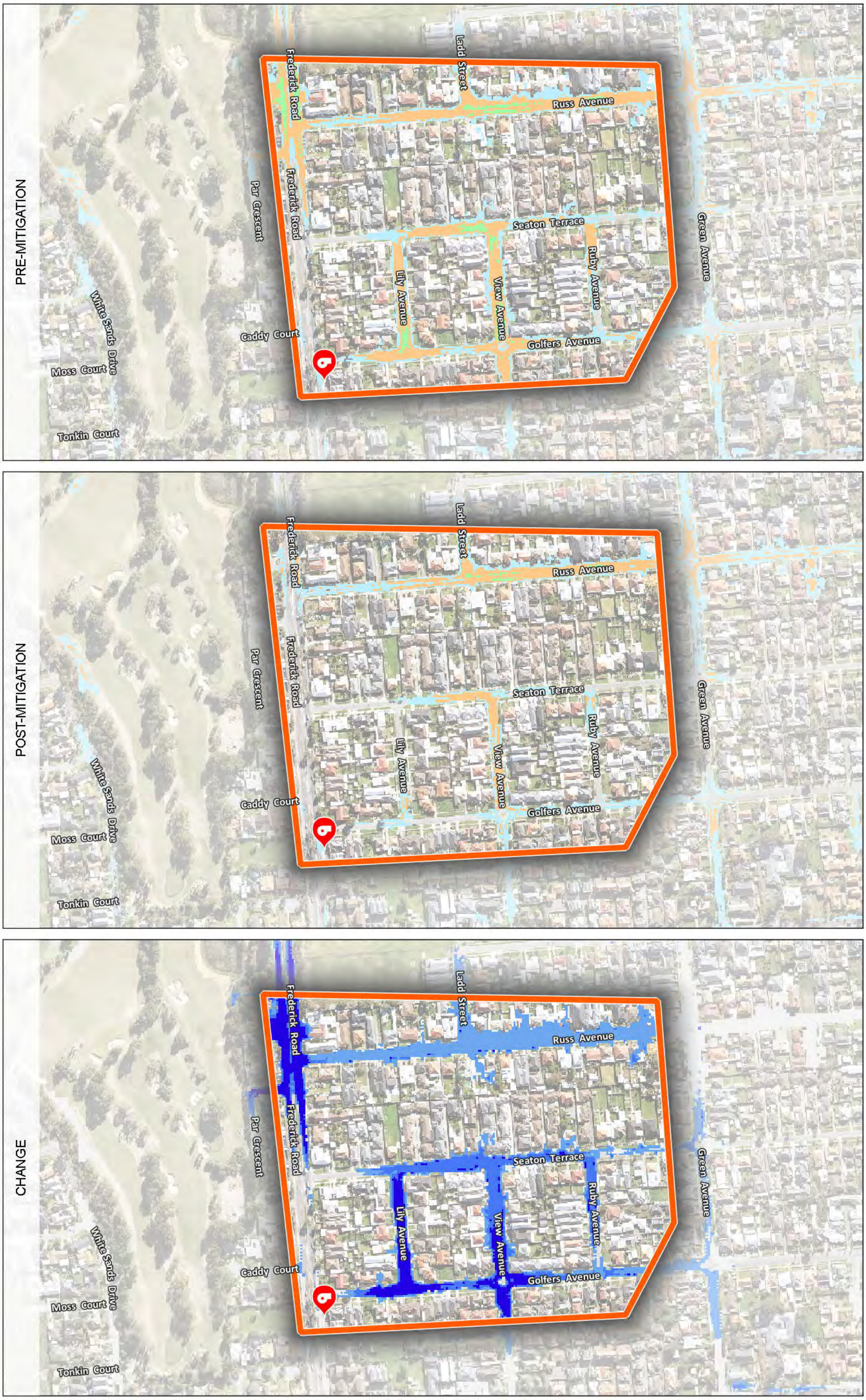
WEST LAKES STORMWATER MANAGEMENT PLAN
GOLFERS AVENUE PIPE AND PUMP UPGRADES

Figure 6.21



Legend

- Pump station
- Flood zone

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 100 200 300 m

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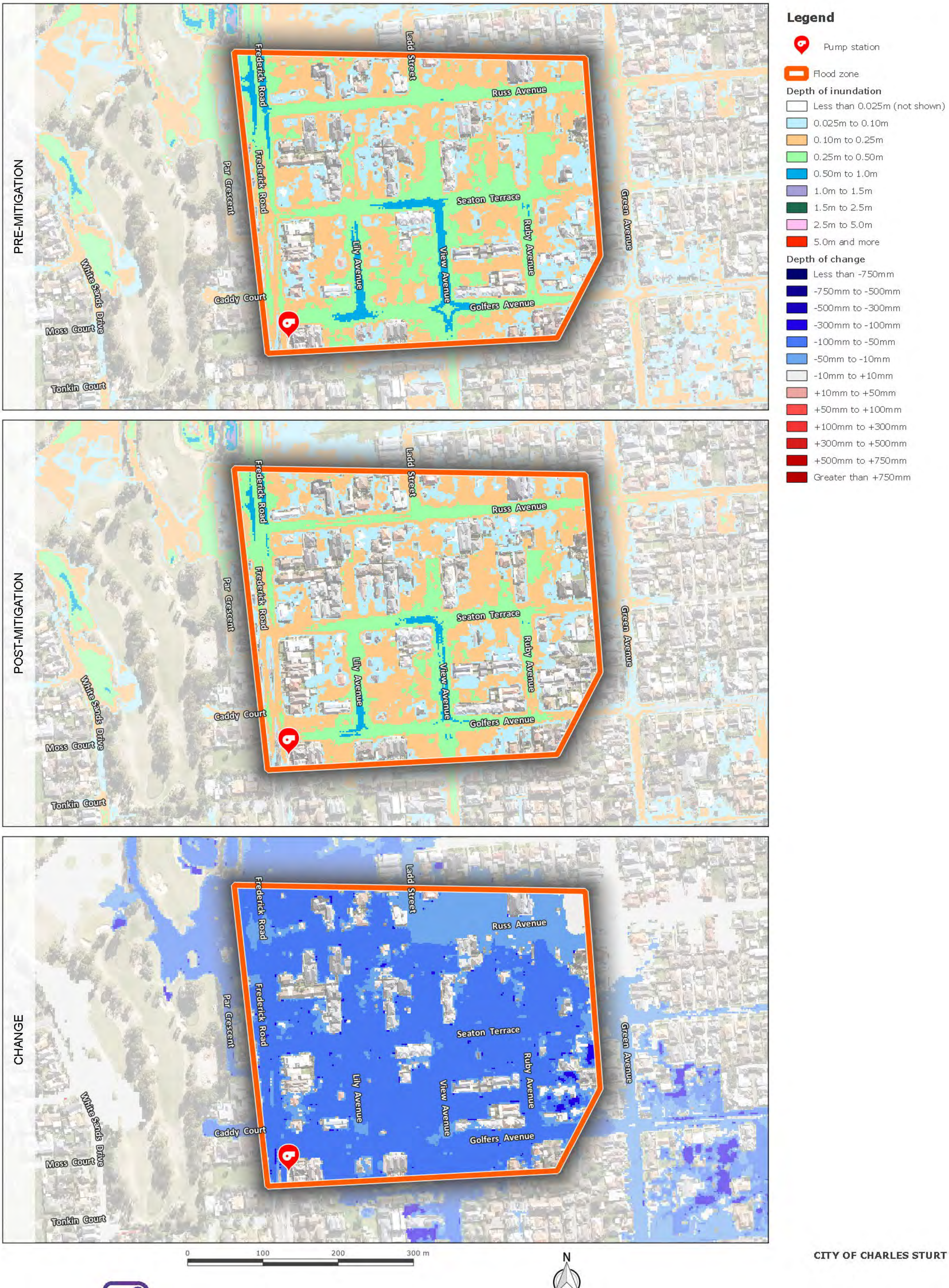
WEST LAKES STORMWATER MANAGEMENT PLAN
GOLFERS AVENUE PIPE AND PUMP UPGRADES
20% AEP CHANGE MAP

Figure 6.22



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WEST LAKES STORMWATER MANAGEMENT PLAN
GOLFERS AVENUE PIPE AND PUMP UPGRADES
1% AEP CHANGE MAP

Figure 6.23

6.1.8 Sansom Road pipe upgrades

Modelling has been undertaken to assess the reductions in flooding that can be achieved by upgrading the existing underground drainage network within the area surrounding Sansom Road. Flooding within Sansom Road during the 20% AEP event is estimated to reach a depth of 150 mm, while flooding in George Street exceeds 300 mm. The existing pipe network servicing the area outfalls to West Lakes approximately 1.4 km away. The proposed upgrades include duplication of this system all the way to the outlet, as shown in Figure 6.24. The changes in flood depth associated with this strategy are shown in Figure 6.26 (20% AEP) and Figure 6.27 (1% AEP).

Though there is some residual flooding within the roadway for the 20% AEP event, the reduction in flood depth is approximately 130 mm in Sansom Road and 240 mm in George Street, and the flooding of private properties within the area is alleviated completely. Additionally, benefits are provided in the 1% AEP event, with flooding reduced by up to 200 mm to the east of Sansom Road.

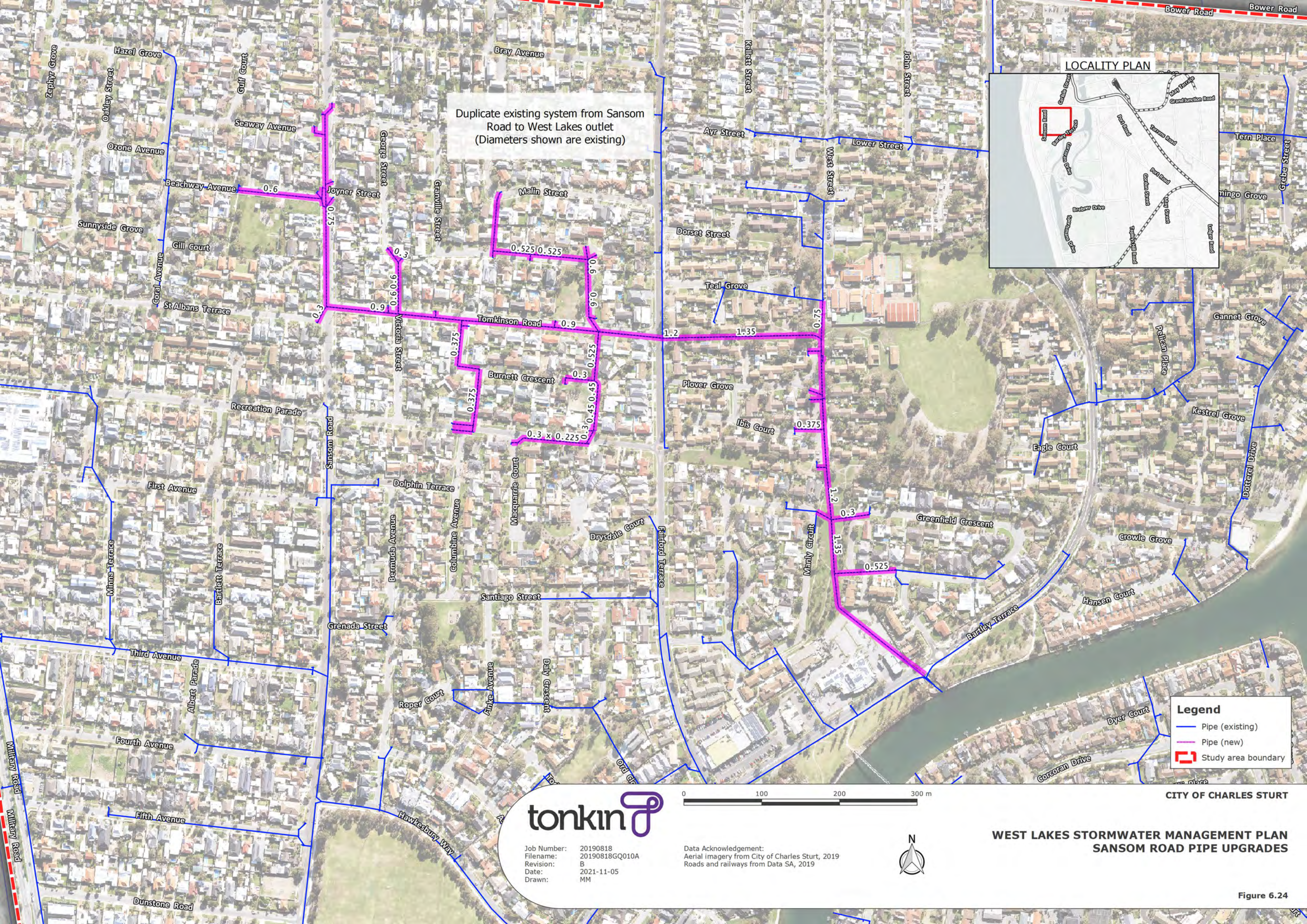
Opportunities to incorporate WSUD into the proposed works, including daylighting the stormwater network in the green space in Manly Circuit could be considered to provide additional benefits associated with water quality improvement and urban greening.

6.1.9 Recreation Parade detention basin

Review of the flood mapping for the 20% AEP event shows that there is some inundation of private properties near the intersection of Recreation Parade and Victoria Parade (low point). There are historical reports of flooding at this location as well.

As the flooding issue is quite localised, rather than upgrading the adjacent pipe network all the way to the outlet (an approximate distance of 1.8 km), it is proposed that the flooding be mitigated via detention. The modelling indicates that a detention storage with a volume of approximately 1,700 m^3 is required. This may be provided in a number of forms including an open basin or within the road reserve. The location of proposed upgrade is shown in Figure 6.25.

Results of the flood modelling for this mitigation measure for the 20% AEP and 1% AEP events are included within the change maps for the Sansom Road pipe upgrades (Figure 6.26 and Figure 6.27). The results confirm that construction of the basin will prevent inundation of private property in the 20% AEP event. There is also a reduction in flood depths within Victoria Parade of 200 mm for this event.



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WEST LAKES STORMWATER MANAGEMENT PLAN
SANSOM ROAD PIPE UPGRADES

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Data Acknowledgement:
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Figure 6.24

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Aerial imagery from City of Charles Sturt, 2019
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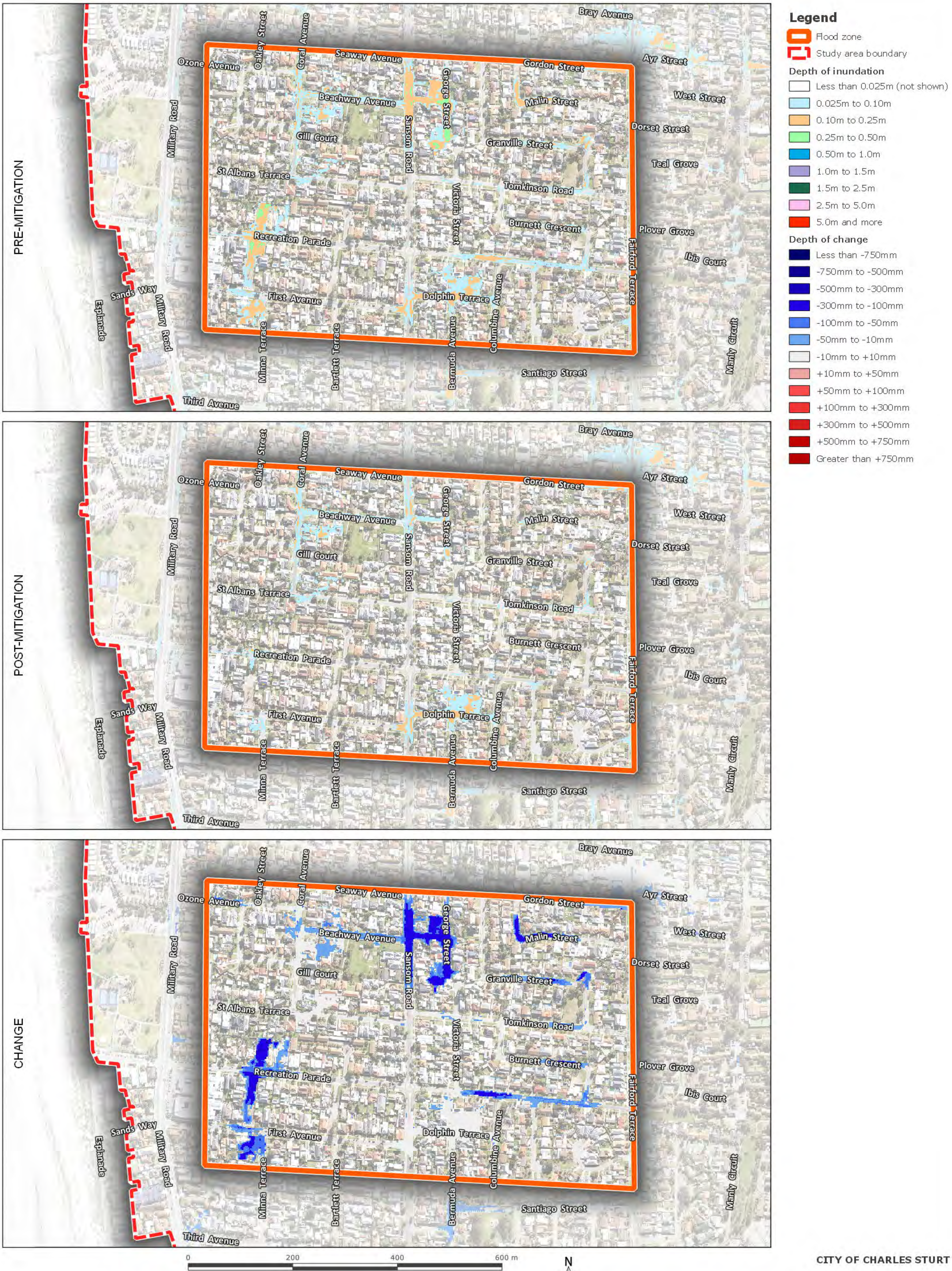
CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
RECREATION PARADE DETENTION BASIN

Figure 6.25



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WEST LAKES STORMWATER MANAGEMENT PLAN
SANSOM ROAD PIPE UPGRADES AND RECREATION PARADE DETENTION BASIN
20% AEP CHANGE MAP

Figure 6.26

Legend

- Flood zone
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

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Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2019

WEST LAKES STORMWATER MANAGEMENT PLAN
SANSOM ROAD PIPE UPGRADES AND
RECREATION PARADE DETENTION BASIN
1% AEP CHANGE MAP

Figure 6.27

6.1.10 Market Corner pipe upgrades

A number of options were investigated to address flooding issues within the vicinity of Market Corner and Rivett Avenue. The investigations included consideration of pipe upgrades and detention storages. Based on the results of the modelling, pipe upgrades are recommended.

Drainage from this area is currently provided by two separate lateral drainage networks, both of which ultimately connect to the trunk drain within Cheadle Street. Given that this trunk drain has larger capacity than the lateral drains, upgrade of the trunk drain is not proposed. Instead, the upgrades are localised to the areas surrounding Market Corner and Rivett Avenue, as shown in Figure 6.28. The upgrade includes duplication of these existing systems. Removal and replacement of the existing pipes with single pipes of a larger diameter would also be feasible. The results of the modelling for the pipe duplication scenario for the 20% AEP is shown in Figure 6.29. The upgrades result in a moderate reduction in flooding. Most of the ponding within Rivett Avenue is alleviated, however there is still an area of deep ponding (over 300 mm) within Market Corner.

6.1.11 Holland Street pipe upgrades

A number of strategies to reduce the flooding within Holland Street have been investigated, including pipe upgrades and diversion of runoff to a basin within Toogood Reserve. Each of these strategies resulted in a minor reduction in flooding only (approximately 15 mm in the 20% AEP event).

It is not recommended that the Holland Street mitigation options be considered further at this point.

6.1.12 Main Street pipe upgrades

A pipe upgrade scenario to address the flooding of private property within Main Street has been assessed. The proposed upgrades included duplication of the local drainage network within Matin Street, Willsmore Street and William Street. Results of the modelling for the 20% AEP event show that upgrade of the existing drainage network will result in additional flood inundation within William Street due to the additional volume of runoff being transferred to this location and exceeding the capacity of the pipes. On this basis, the pipe duplication would need to extend further to connect into the upgraded Meakin Terrace system. It is not considered that the magnitude of flooding warrants such a significant pipe upgrade.

Consideration was also given to construction of a detention basin within the long, narrow reserve to the west of William Street. This scenario was modelled, and while the results demonstrated a slight reduction of ponding within the road at William Street and Golding Street, the change in flood depths within private properties in Main Street was negligible. The detention basin option is therefore also not recommended.

6.1.13 Minor infrastructure upgrades

In addition to the structural mitigation strategies described in the previous sections, additional flood protection benefits for private properties may be achieved through localised minor infrastructure upgrades on both public and private land. These upgrades, which could be done on a partnership basis, could include regrading of the footpath/crossovers (public infrastructure) and/or modifications to private driveways. Council may consider potential minor infrastructure upgrades on a partnership case-by-case basis.

6.2 Bower Road culvert upgrade

The Western Adelaide Region Climate Change Adaptation Plan (Tonkin, 2015) recommended an upgrade to the Bower Road causeway to mitigate the impacts of sea level rise and flooding from the Port River into West Lakes. Further investigation is recommended once a mean sea level increase of 300 mm has been recorded. Based on current projections this will likely be around 2050.

Consideration of pumping to assist manage water quality in the lake was also recommended as a long-term strategy (post 2050). The pumps could also be used to draw down the Lake prior to a forecast heavy rainfall event.

These works, which will be the responsibility of DIT as the operator of the lake, are recommended as a high priority action in addition to the stormwater upgrade works identified in the preceding section.

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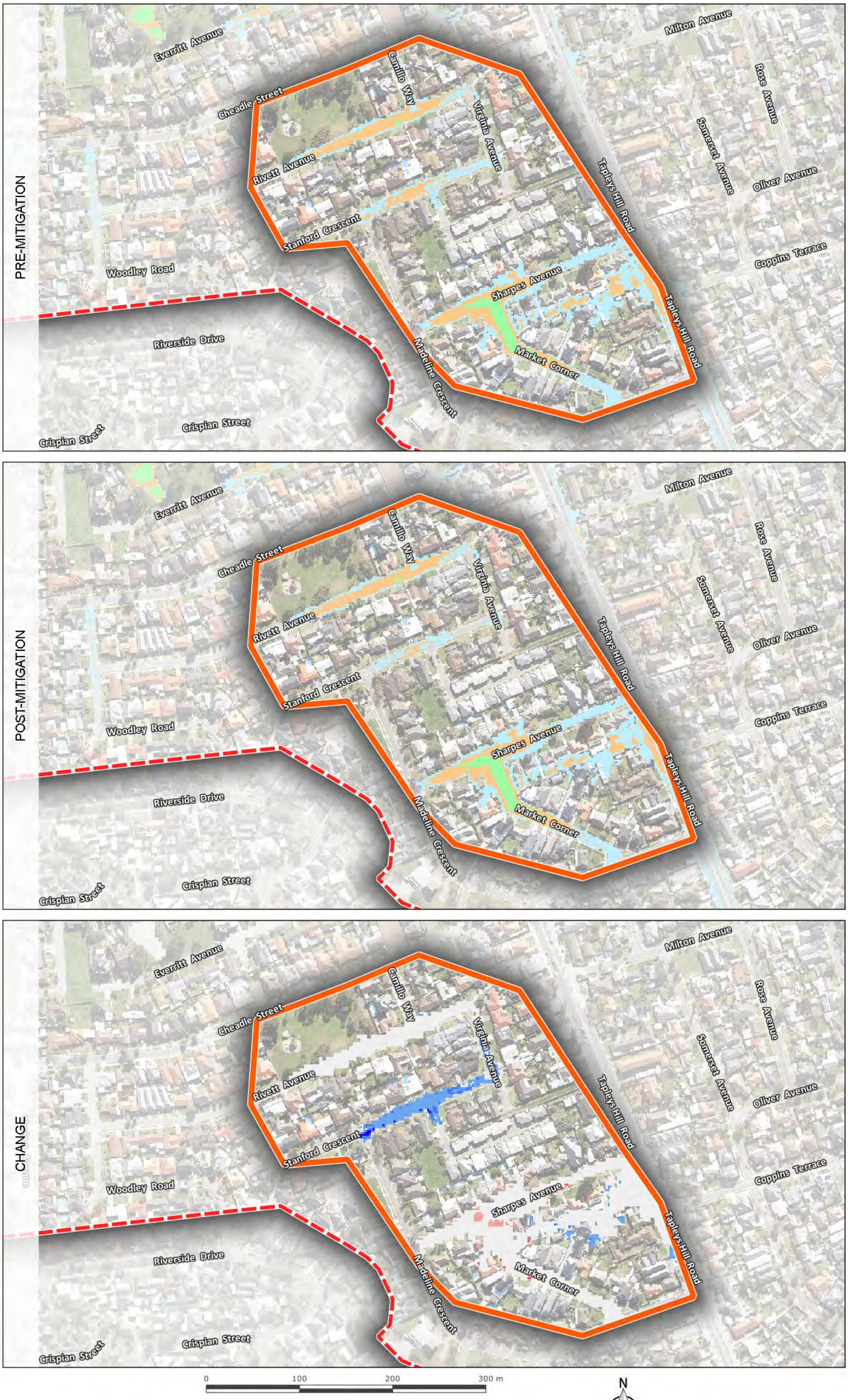
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2019

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
MARKET CORNER PIPE UPGRADES

Figure 6.28



Legend

- Flood zone
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

Depth of change

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

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WEST LAKES STORMWATER MANAGEMENT PLAN
MARKET CORNER PIPE UPGRADES
20% AEP CHANGE MAP

Figure 6.29

6.3 Non-structural mitigation strategies

In addition to the structural flood mitigation strategies described in the preceding sections, there are a number of non-structural strategies that should be considered for reducing the impacts of flooding within the West Lakes catchment. Non-structural strategies generally require low capital investments (compared to the structural strategies) and hence can be cost effective measures for reducing flood damages.

6.3.1 Education and awareness

Detailed floodplain mapping of the catchment has been developed as part of this SMP. This information should be made widely available to the community so that they are informed about where flooding is likely to occur. Being aware of the flood risk can allow the community to better manage the risk, likely resulting in a reduction in flood damages. The information could be provided through mail-outs to flood affected property owners, accessible via the internet or made available at public places such as libraries and Council's office. Businesses and residents can be encouraged to develop flood action plans to reduce damages in the event of a flood and change the way in which valuable items are stored.

The State Emergency Service (SES) flood website provides information about flood preparedness and recommends measures to be taken before, during and after a flood. An informed community is likely to be more resilient to flooding. Simple actions such as relocating valuable items can significantly reduce the long-term impacts of a flood event.

Education and awareness addresses Goal F3 of this SMP.

6.3.2 Use of flood mapping outputs

The results of the catchment flood mapping should be utilised in the planning of new developments to ensure that they are designed such that they have adequate flood protection (Goal RA1). It is recommended that the flood maps developed as part of this SMP should be incorporated into the Planning and Design Code flood overlay such that planning decisions can be made on the basis of the most up-to-date information.

Flood mapping outputs can also be uploaded onto the DEW Flood Awareness website.

6.3.3 Flood warning

Typically, if the community is given sufficient warning of the potential for flooding, the magnitude of the social and economic damages can be reduced significantly. Given some warning, the community and emergency services would have additional time to sandbag flood prone areas and remove valuable portable property from areas that may have otherwise suffered flood damages. The potential reduction in flood damages when more than 12 hours of warning is provided, as opposed to less than two hours, can range from 20% up to 50%, depending on the relative experience of the community in dealing with flooding (DNRE, 2000).

Council currently has a flood preparation process which is implemented when the forecast rain exceeds 15 mm. The current process involves:

- Contacting residents on known flood affected parcels advising of the availability of sandbags.
- Checking net type GPTs at critical locations to ensure that they are empty and that the release mechanisms are functional.
- Notify Jet Vac crew of forecast rain, and checking of SEPs at known flooding hot spots.
- Liaising with DIT to understand if the lake level can be lowered.
- Proactive checking of SEPs in known flooding areas during the rainfall event.

In more severe events Council also liaises with SES.

Flood warning is useful in large riverine catchments where a significant warning time could be provided. Given the relatively short response time for the local catchments (typically less than one hour), it is considered that Council's current approach is sufficient.

On this basis, it is recommended that Council retain their current approach of warning in advance of forecast heavy rainfall events and focus on increasing education and awareness to improve the flood resilience of the community.

6.4 Reduction in damages

Comparison of the pre- and post-mitigation flood mapping confirms that implementation of the proposed structural flood management strategies will result in a reduced number of inundated properties for any given storm event. A summary of the modelled number of flood-affected properties for the post-mitigation scenario (assuming implementation of all of the works) is provided in Table 6.1. Residential properties with above floor flooding are summarised in Table 6.2.

Table 6.1 Number of flood-affected properties (post-mitigation)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	27	34	43	61	94	169	244	575
2 West Lakes Central	0	0	0	0	0	1	2	4
3 West Lakes North East	3	4	4	4	4	9	13	49
4 West Lakes East	16	33	59	95	147	280	415	707
5 West Lakes South	3	4	8	9	11	14	24	63
6 Trimmer Parade	16	29	76	147	300	629	919	1642
7 Meakin	36	53	106	172	298	511	714	1144
8 Henley Grange	13	15	43	96	222	480	730	1324
Total	114	172	339	584	1076	2093	3061	5508

Table 6.2 Number of residential properties with above-floor flooding (post-mitigation)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	0	0	0	3	8	30	50	141
2 West Lakes Central	0	0	0	0	0	0	0	0
3 West Lakes North East	0	0	0	0	0	0	0	0
4 West Lakes East	0	1	1	3	9	28	60	130
5 West Lakes South	0	0	0	0	0	0	5	12
6 Trimmer Parade	0	0	2	7	21	94	187	497
7 Meakin	0	0	3	6	25	66	116	339
8 Henley Grange	0	0	0	2	21	76	163	466
Total	0	1	6	21	84	294	581	1585

It can be seen that implementation of the proposed flood mitigation strategies results in 6 residential properties being subject to over-floor inundation in a 20% AEP event, a significant reduction on the 43 identified at risk of flood damage pre-mitigation measures. In a 1% AEP event, the modelling indicates that the number of residential properties subject to over floor inundation would decrease from 896 to 581.

The flood damages for the post-mitigation flooding were estimated using the same approach as detailed in Section 5, and are shown in Table 6.3. The AADs, including the reduction in AAD between the pre- and post-mitigation scenarios, are summarised in Table 6.4. The results demonstrate an average reduction in damages of $2.1 million per year.

Table 6.3 Post-mitigation flood damages ($ million)

Zone	Annual exceedance probability							
	63%	39%	20%	10%	5%	2%	1%	0.2%
1 West Lakes West	0.07	0.09	0.14	0.34	0.78	2.14	3.48	9.14
2 West Lakes Central	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09
3 West Lakes North East	0.01	0.01	0.01	0.01	0.01	0.02	0.03	0.11
4 West Lakes East	0.08	0.19	0.29	0.59	1.45	3.29	6.10	12.40
5 West Lakes South	0.24	0.34	0.49	0.66	0.90	1.20	1.82	3.78
6 Trimmer Parade	0.04	0.06	0.26	0.73	1.73	7.51	13.81	32.38
7 Meakin	0.09	0.17	0.49	0.99	2.46	6.08	10.39	24.39
8 Henley Grange	0.06	0.12	0.26	0.95	2.58	6.63	12.30	30.98
Total	0.59	0.98	1.94	4.26	9.91	26.52	47.94	113.28

Table 6.4 Change in annual average damages

Zone	Annual average damage ($)		
	Pre-mitigation	Post-mitigation	Reduction
1 West Lakes West	$340,000	$229,000	$111,000
2 West Lakes Central	$0	$0	$0
3 West Lakes North East	$8,000	$8,000	$0
4 West Lakes East	$381,000	$380,000	$1,000
5 West Lakes South	$359,000	$359,000	$0
6 Trimmer Parade	$1,231,000	$583,000	$648,000
7 Meakin	$1,833,000	$619,000	$1,214,000

Zone	Annual average damage ($)		
	Pre-mitigation	Post-mitigation	Reduction
8 Henley Grange	$718,000	$624,000	$94,000
Total	$4,870,000	$2,803,000	$2,068,000

6.5 Economic analysis

Cost estimates have been prepared for each of the structural flood mitigation strategies (provided in Appendix E). To assist in understanding the relative economic benefits of offsetting flood damages via structural mitigation strategies, a benefit-cost ratio (BCR) has been determined for each of the damage assessment zones. This provides an indication of which projects in the catchment are most beneficial in terms of cost.

The reduction in AAD associated with each strategy was converted to a net present value using a discount rate of 4% across a 50-year horizon (Commonwealth of Australia, 2018). The BCRs were calculated using the ratio of the net present value of reduced damages to the cost of the works. The BCRs within each zone are summarised in Table 6.5.

Table 6.5 Benefit-cost ratios (by damage zone)

Zone	BCR	Flood mitigation strategies
1 West Lakes West	0.23	Sansom Road pipe upgrades; Recreation Parade detention basin
6 Trimmer Parade	0.51	Frank Mitchell Reserve underground tank; Golfers Avenue pipe and pump upgrades; Beatrice Avenue and Trimmer Parade
7 Meakin	0.57	Gleneagles Reserve underground tank; Crittenden Road to Grange Lakes pipe upgrades; Matheson Reserve underground tank
8 Henley Grange	2.96	Nedford Reserve detention basin; Market Corner pipe upgrades

6.6 Decision-making framework

A decision-making framework has been developed to provide decision-makers with a tool to assess and compare the net benefits of proposed strategies for the management of stormwater within the West Lakes catchment (Tonkin, 2020a). The approach is generally consistent with the 'Optimised Decision Making Guidelines' (ODMG) (NZNAMSG, 2004). The framework is intended to allow a range of objectives to be considered when making a decision.

The process includes consideration of the problem, identification of options and then assessment against an agreed multi-criteria framework. Its intent is to guide the development of sustainable stormwater management solutions.

For the purpose of the West Lakes SMP, the multi-criteria assessment framework includes consideration of flood protection, beneficial use of stormwater, social values, environmental benefit and costs. Full details of the decision-making methodology are provided in Appendix F.

When identifying problems and potential solutions within the West Lakes SMP, it was determined that due to the heavily developed nature of the catchment with limited available space, in most instances there was only one viable solution (such as pipe upgrade or detention) for each of the flooding hotspots. Similarly, the options to address water quality were limited. While the identification of solutions did consider social and environmental constraints and opportunities, it was not possible to utilise the decision-making framework.

It is hoped that the decision-making framework will provide Council with a useful tool for assessing and prioritising small-scale stormwater upgrades across the catchment, where they may be more opportunities to incorporate social and environmental benefits into stormwater works.

6.7 Priorities

The economic analyses described in the preceding sections provide only a single input into the determination of priorities for the recommended works. Consistent with the intent of the decision making framework, other measures that have been taken into account when assigning priorities to the proposed strategies include "flooding hot-spots", the number of properties that stand to benefit from the works, impacts on development and opportunities to leverage other benefits (such as water quality improvement).

The following criteria have been used to assign priorities:

High priority:

- addresses high frequency flooding hot-spots
- reduces flooding for a large number of properties
- small-scale, relatively low-cost actions with interim benefits.

Medium Priority:

- flood risk to a small number of properties with good benefit to cost ratio.

Low priority

- flood risk to a small number of properties with low benefit to cost ratio.

6.8 Summary of flood management actions

Table 6.6 provides a summary of the flood mitigation options described in the preceding sections. A priority and budget estimate are also provided for each option.

Table 6.6 Summary of flood mitigation options

Priority	Project/ Activity Title	Budget estimate	SMA Funding Eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit		Other Benefits	
					Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Quantification or Description of Benefit	Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit
High	F1 Gleneagles Reserve storage	$12,726,000	Y	$2,000	D, P	$1,214,000 (in combination with Priority F4 and F5) Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 14 properties subject to above floor flooding)	M	Limited disturbance of open space Opportunities for infiltration/reuse Can be staged
Medium	F2 Nedford Reserve detention basin	$248,000	Y	$2,000	D, Q	$94,000 (in combination with Priority F10) Significant reduction (~180 mm) in flood depths within the road corridor in the 20% AEP event	H	Possibility for landscaping for improved amenity and biodiversity
High	F3 Beatrice Avenue and Trimmer Parade pipe upgrades	$9,117,000	Y	-	D, P	$648,000 (in combination with Priority F8 and F9) Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 7 properties subject to above floor flooding)	-	Opportunity to incorporate WSUD
Medium	F4 Crittenden Road to Grange Lakes pipe upgrades	$24,172,000	Y	-	D, P	$1,214,000 (in combination with Priority F1 and F5) Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 8 properties subject to above floor flooding)	L	Opportunity to incorporate WSUD
Medium	F5 Matheson Reserve underground tank	$18,960,000	Y	$2,000	D, P	$1,214,000 (in combination with Priority F1 and F4) Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 4 properties subject to above floor flooding)	L	Limited disturbance of open space
Medium	F6 Recreation Parade detention basin	$3,765,000	Y	$2,200	D, P, Q	$111,000 (in combination with Priority F7) Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 2 properties subject to above floor flooding) Significant reduction (~200 mm) in flood depths within the road corridor in the 20% AEP event	L	Possibility for landscaping for improved amenity and biodiversity
Medium	F7 Sansom Road pipe upgrades	$6,640,000	Y	-	D, P	$111,000 (in combination with Priority F6) Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 4 properties subject to above floor flooding)	-	-
Medium	F8 Golfers Avenue pipe and pump upgrades	$3,197,000	Y	-	D, Q	$648,000 (in combination with Priority F3 and F9) Improvements to flooding in roadways (particularly Frederick Road and Lily Avenue) in the 20% AEP event	-	-
Low	F9 Frank Mitchell Reserve underground tank	$15,049,000	Y	$2,000	D, Q	$648,000 (in combination with Priority F3 and F8) Significant reductions (~300 mm) in flood depth within the road corridor in the 20% AEP event	L	Limited disturbance of open space
Low	F10 Market Corner pipe upgrades	$392,000	N	-	D, Q	$111,000 (in combination with Priority F7) Minor reductions in flood depth within the road corridor	-	-

Priority	Project / Activity Title	Budget estimate	SMA Funding Eligible	Recurrent Cost ($ / annum)	Flood Mitigation Benefit		Other Benefits	
					Measure used? (D) – AAD Reduction (P) – Properties Affected (Q) – Qualitative	Quantification or Description of Benefit	Rating (H) – High (M) – Med (L) – Low	Qualitative Description of Benefit
High	F11 Education and awareness	$70,000	N	$10,000	Q	Likely to reduce flood impacts on community	M	Public can better respond to flooding. Better community resilience to flooding.
High	F12 Flood mapping outputs	$20,000	N	-	Q	Provide up to date information of flooding within the catchment	-	-
High	Bower Road Culvert Upgrade	N/A	N/A			Identified by the Western Regions Climate Adaption Plan. Will be required around 2050. Work to be undertaken by DIT.		

7 Water quality

This section provides a summary of the modelling undertaken to determine the existing water quality within the study area. An overview of the existing water reuse schemes within the study area is also provided.

7.1 Water quality modelling

The West Lakes catchment is heavily developed, with residential dwellings representing the greatest land use type. The primary pollutants associated with runoff from an urban landscape include sediments (total suspended solids (TSS)), nutrients (total phosphorus (TP) and total nitrogen (TN)), pathogens, oxygen demanding substances and gross pollutants (GP).

The water quality of runoff from the catchment was modelled using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC). In the absence of official guidelines for the application of MUSIC in South Australia at the time of modelling, the modelling is based on the recommendations made by the Goyder Institute following a review of guidelines for the application of MUSIC in other regions (Myers, Cook, Pezzaniti, Kemp, & Newland, 2015).

The model is based on the long-term (2070) state of development within the catchment and has been used to assess the spatial variability of water quality within the study area, as well as determining pollutant loads at the outlets from each sub-catchment into the Lake.

7.1.1 Model set-up

Development of a MUSIC model requires inputs of meteorological data, catchment data, drainage links and water quality improvement measures. The inputs used in the model are described below.

7.1.1.1 Meteorological data

Rainfall data used in the model were obtained from the Bureau of Meteorology (BoM). Rainfall totals at six-minute intervals for the period from 1967-2010 were available from the Adelaide Airport weather station (station number 023034), located approximately 6 km from the study area. Average monthly areal potential evapotranspiration (PET) data were also obtained from the BoM. The PET data used in the model are summarised in Table 7.1.

Table 7.1 Monthly areal potential evapotranspiration data (mm/month)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
260	229	190	121	70	41	50	74	113	167	209	231

7.1.1.2 Catchment data

The definition of MUSIC catchment areas and imperviousness was based on the sub-catchments used to define the hydrology for the floodplain mapping. The floodplain mapping utilised hydrological inputs from almost 5,000 sub-catchments; these sub-catchments were lumped together based on location to form 17 MUSIC catchments with areas typically in the order of 100-200 ha.

The pollutant load parameters applied to each MUSIC catchment are based on the predominant land use within each catchment (typically urban residential) and are consistent with the recommendations in Myers et al. (2015) for lumped catchment modelling for South Australian stormwater management plans. The adopted water quality parameters are summarised in Table 7.2.

Table 7.2 Water quality parameters for lumped catchment modelling

Land use		TSS $\log_{10}$ values		TP $\log_{10}$ values		TN $\log_{10}$ values	
		Mean	SD	Mean	SD	Mean	SD
Urban residential	Baseflow	1.00	0.34	-0.97	0.31	0.20	0.20
	Stormflow	2.18	0.39	-0.47	0.32	0.26	0.23
Commercial	Baseflow	0.78	0.39	-0.60	0.50	0.32	0.30
	Stormflow	2.16	0.38	-0.39	0.34	0.37	0.34

7.1.1.3 Drainage links

The drainage links within the MUSIC model were defined based on the existing drainage pathways, with all catchments ultimately discharging to the Lake. No routing was applied. This is considered conservative and is consistent with the recommendation of Myers et al. (2015) which states "routing is not required in South Australian MUSIC modelling undertaken for compliance with water quality targets to ensure results are conservative".

7.1.1.4 Rainfall-runoff parameters

The parameters relating to the rainfall runoff processes adopted in the model are summarised in Table 7.3. These parameters are consistent with those used in the SMP.

Table 7.3 Rainfall-runoff parameters

Parameter	Value
Impervious area properties	
Rainfall threshold (mm/day)	1
Pervious area properties	
Soil storage capacity (mm)	40
Initial storage (% of capacity)	30
Field capacity (mm)	30

7.1.1.5 Existing water quality improvement features

A schematic showing the layout of the MUSIC model is shown in Figure 7.1. Given the scale of the model, only water quality improvement measures that are considered to have a significant impact on the water quality at the downstream end of the catchment are included in the model. Small scale water quality improvement features such as soakage pits and rain gardens which will not have a measurable impact on downstream water quality (even when lumped together) due to the small volumes of flow treated are not included in the model. The location of the downstream receiving node is located such that it receives all flows that would discharge to the Lake.

The water quality improvement features included within the MUSIC model for the base case scenario include:

- Gross pollutant traps at catchment outlets discharging to the Lake.
- Royal Adelaide Golf Club wetland.
- Grange Golf Club wetland.

- Detention basin within Gleneagles Reserve.
- Sedimentation within Grange Lakes.

The bathymetry of the water quality improvement features was estimated based on review of the DEM. The operational regimes of the wetlands were based on design drawings and information provided by Council. The depth of the sedimentation area within Grange Lakes was based on a review of available survey and invert levels of the downstream culverts.

The model has been configured to allow interrogation of pollutant concentrations and loads at key points.

7.1.2 Water quality modelling results – validation

The MUSIC model was run to understand the patterns of flow and pollutant generation within the catchment. The model was run initially using the existing level of development. This allowed comparison of the modelling results with the water quality gauge located downstream of the Kirkcaldy wetland. The results of the modelling are summarised in Table 7.4, with a comparison to the recorded flows and pollutant loads. As would be expected, the recorded water quality parameters are highly variable. The maximum and minimum values for the period with records available (2013 to 2018) are provided as well as the value for 2017, which is considered to be an average rainfall year with 414 mm of rainfall recorded at the Adelaide Airport gauge (compared to the average annual rainfall of 437 mm).

Table 7.4 Modelled annual loads at Kirkcaldy wetland (existing level of development)

Parameter	Loads at gauge	Recorded range 2017 value (max min)
Flow (ML/a)	739	753 (306-1572)
TSS (kg/a)	61,400	35,900 (11,200 – 136,800)
TP (kg/a)	178	140 (50 – 330)
TN (kg/a)	1,310	1,200 (350 – 2,700)
GP (kg/a)	8	Not recorded

Acknowledging the highly variable nature of water quality, and the relatively simplistic approach used in building a MUISC model, with catchment loading based on limited available data, it is considered that there is good agreeance between the modelled results and the data recorded at the gauged site (refer Table 2.4).

As such it is considered that the parameters adopted within the modelling are appropriate for assessing the relative improvement provided by the proposed water quality improvement scenarios.

0 1,000 2,000 3,000 m

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WEST LAKES STORMWATER MANAGEMENT PLAN
MUSIC MODEL CONFIGURATION

Figure 7.1

7.1.3 Water quality modelling results – long-term development

The MUSIC model was then run for the entire catchment (long-term development scenario), incorporating the existing water quality improvement measures. The results of the modelling at the downstream receiving node are summarised in Table 7.5. The source loads represent the pollutant generation within the catchment area, while the residual loads are the loads that arrive at West Lakes (i.e. with the existing water quality improvement measures in place). These results form the baseline against which the effectiveness of proposed water quality improvement measures have been assessed.

Table 7.5 Modelled annual loads at downstream receiving node (long-term development scenario)

Parameter	Sources	Residual load	Reduction (%)
Flow (ML/a)	4,840	4,550	6.1
TSS (kg/a)	1,040,000	698,000	32.6
TP (kg/a)	2,110	1,520	28.2
TN (kg/a)	10,200	7,730	24.0
GP (kg/a)	228,000	105,000	54.1

A breakdown of the estimated pollutant loads at the downstream end of each major sub-catchment is provided in Table 7.6.

Table 7.6 MUSIC base case model – annual loads by sub-catchment

Catchment	Flow (ML/a)	TSS (kg/a)	TP (kg/a)	TN (kg/a)	GP (kg/a)
Henley Grange	957	179,000	372	1,790	33,100
Meakin	706	135,000	278	1,400	29,200
Trimmer Parade	870	188,000	378	1,810	41,100
West Lakes Central	138	29,600	60	288	6,550
West Lakes East	468	102,000	204	977	22,000
West Lakes North East	80	16,300	33	164	3,490
West Lakes Shopping Centre	88	18,600	49	277	3,750
West Lakes South	178	23,400	52	260	2,450
West Lakes West	649	112,000	238	1,130	17,200

7.2 Water quality improvement strategies

Opportunities for improving the water quality of runoff within the catchment, thereby decreasing the export of pollutants into West Lakes and subsequently the Port River, have been considered as part of the development of stormwater management strategies within the SMP.

The recommended measures for areas of existing development have been developed in the context of the heavily developed nature of the catchment, with limited 'free' open space available for the implementation of WSUD. The measures, which comprise both structural and non-structural measures are also consistent with Council's Biodiversity Action Plan for Water and Aquatic.

Where there are large scale new developments (land division creating 20 or more residential allotments), consistent with the requirements under the State's new Planning and Design Code, Council should require developers to produce a stormwater management plan which demonstrates mitigation of peak flows to pre-development levels and the incorporation of measures to achieve the specified water quality improvement targets.

7.2.1 Additional gross pollutant traps

There are a number of gross pollutant traps (GPTs) installed within the study area, including on the main discharge points into West Lakes. However, review of the existing infrastructure identifies that not all discharge points have a GPT installed.

The installation of additional GPTs at outlet points which are not currently treated is recommended to further reduce the residual load of gross pollutants that are discharged into the Lake, thereby addressing Goal WQ1. Locations where there are Council owned pipes discharging into the Lake, and where there is currently no GPT are summarised in Table 7.7. The locations of the proposed GPTs are shown in Figure 7.2.

Actual placement of each GPT would be subject to further design development which would need to consider issues such as access for maintenance and the hydraulic impacts on the upstream stormwater network.

The theoretical maximum removal of gross pollutants, as listed in Table 7.7, is based on high-flow GPT units with all pipe flows being directed to the GPT. The assumed pollutant removal efficiencies are based on manufacturer's specifications. The actual reduction in gross pollutants achieved will be dependent on the GPT model selected for each location, the maximum treatable flow rate and maintenance of the units.

Table 7.7 Recommended locations for the installation of GPTs

GPT	Location	Maximum GP removal* (kg/year)
GPT1	Opposite Hoylake Crescent	750
GPT2	Opposite Hallam Terrace	290
GPT3	Near Libby Court	680
GPT4	Annie Watt Circuit	335
GPT5	West Lakes Boulevard bridge	780
GPT6	West Lakes Boulevard bridge	105
GPT7	Near Hayman Court	985
GPT8	Hawaii Court	1,175
GPT9	Between Nareeda Way and Capri Close	835

* Based on 100% of flows in pipe going through the GPT, with 99% removal of GP as per typical manufacturer's specification

7.2.2 Street scale infiltration measures

Street scale infiltration measures promote the beneficial reuse of stormwater via passive irrigation (addressing Goal RU2). Designed to capture low flows, either directly from roof areas or from surface areas, street scale infiltration measures reduce the volumes of flows and associated loads of sediments and nutrients discharged to receiving waters (addressing Goal WQ1). They also contribute to urban greening with associated improved aesthetics and offsetting of urban heat island effects. The magnitude of the benefits of each infiltration system will be heavily dependent on the size and configuration of the system in addition to the size and characteristics of the contributing catchment.

Street scale infiltration measures can be implemented in a range of forms including:

- simple openings in kerbs
- infiltration pits and wells
- tree pits (with and without connection to the stormwater network)
- infiltration trenches.

Water Sensitive SA have case studies demonstrating the application of a range of infiltration measures that have been implemented by councils across metropolitan Adelaide. Further details on some of the measures that have been implemented are provided in the following sections. When considering which type of system is best suited to application in the West Lakes SMP study area considerations should include contributing catchment, geotechnical conditions, available space, species of vegetation and existing stormwater infrastructure.

City of Burnside B-Pods

As part of the City of Burnside's commitment to water sensitive urban design, they have trialled a number of small-scale, subsurface retention systems to capture and retain water from roof runoff. The water is then allowed to infiltrate, providing passive irrigation to roadside vegetation. In addition to promoting urban greening, the pods also contribute to a reduction in the flow rates and volumes of stormwater being discharged to the receiving environments. Photos of Burnside's B-Pods are provided in Figure 7.3.

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Figure 7.3 **Burnside Council's B**-Pods (watersensitivesa.com)

Tree pits and infiltration trenches

Tree pits divert gutter flows to an infiltration storage to provide passive irrigation of vegetation, whilst also reducing stormwater discharges to the receiving environments. A variety of tree pits have successfully been adopted by metropolitan councils in South Australia. TREENET pits have been used to promote street tree health across the City of Mitcham. City of Adelaide have installed tree pits at over 100 locations to sustain tree health. Photos showing examples of tree pits are provided in Figure 7.4. Where space permits, water may be diverted to infiltration trenches (refer Figure 7.5).

Figure 7.4 TREENET Pit inlet and infiltration pit (City of Mitcham, watersensitivesa.com) and City of Holdfast Bay (https://www.yourholdfast.com/wsud)

Figure 7.5 Infiltration trench, supporting roadside vegetation in Colonel Light Gardens (watersensitivesa.com)

7.2.3 Street scale biofiltration (raingardens)

Raingardens are shallow, planted depressions that provide water quality improvement benefits via biofiltration mechanisms. Raingardens can be implemented at a range of scales from individual residential blocks up to the treatment of whole of catchment flows. Similar to tree pits and infiltration trenches, raingardens reduce flow rates and volumes (particularly during frequent flow events) and also contribute to a reduction in the quantity of sediment and nutrients exported to receiving waters (thereby addressing goals WQ1 and RU2). Secondary benefits are associated with increase greening, improved aesthetics and urban cooling.

Typically constructed within verges or roads, streetscape raingardens receive gutter flows via gaps in the kerbing. Flows are then allowed to pond and infiltrate. A high-level overflow may be provided to discharge flows exceeding the storage capacity of the raingarden into the underground drainage network. Depending on the local soil conditions, raingardens may also include a slotted pipe to collect filtered flows and discharge them into the underground drainage network.

Raingardens are best suited to areas that have relatively flat grades and wide streets, making them well suited to some of the residential areas within the West Lakes SMP study area. Council has already installed a number of rain gardens across their Council area, including in Flinders Park. Raingardens can be retrofitted into existing roads and can be incorporated into road upgrades and traffic calming measures. A typical layout for a streetscape raingarden is illustrated in Figure 7.6.

DesignFlow (2016) estimated that the area of a raingarden required to achieve the State Government’s stormwater treatment targets can be approximated as 0.7% of the impervious area of the contributing catchment. Raingardens of a smaller size will still provide some water quality treatment.

Figure 7.6 Typical layout of a raingarden (Water Sensitive SA)

To test the potential effectiveness of streetscape raingardens within the West Lakes catchment, additional MUSIC modelling was undertaken, incorporating raingardens within a single test catchment (West Lakes West). This catchment has a directly connected impervious area of approximately 165 ha, and hence the work of DesignFlow (2016) estimates that raingardens with a total area of 1.2 ha would be required to achieve the State water quality targets. A single bioretention node at the downstream extent of the West Lakes West catchment was incorporated in the modelling. The modelled treatment effectiveness of the raingardens is summarised in Table 7.8. It can be seen that the construction of 1.2 ha of raingardens results in a significant reduction in pollutants discharged from the catchment, although the raingardens alone do not achieve the specified targets.

Table 7.8 Modelled treatment effectiveness of raingardens for West Lakes West catchment

	Inflow	Outflow	% reduction
Flow (ML/yr)	933	908	2.7
Total Suspended Solids (kg/yr)	206,000	116,000	43.6
Total Phosphorus (kg/yr)	413	281	32.0
Total Nitrogen (kg/yr)	1,950	1,390	28.8
Gross Pollutants (kg/yr)	42,200	22,000	47.8

Consistent with Council's Biodiversity Action Plan (2017), it is recommended that Council implements a policy that requires all planned capital work upgrades to consider opportunities for incorporating raingardens and other WSUD elements into the works. This will provide water quality benefits in addition to greater urban greening across the study area. The level of water quality improvement achieved will be dependent on the size of the raingarden relative to the upstream catchment.

During the detailed design phase, it will be necessary to consider additional site constraints, including:

- Traffic considerations (sight distances, turning circles etc.)
- Impacts arising from the loss of parking spaces
- Property access

- Impacts on existing trees.

7.2.4 Incorporation of water sensitive urban design into reserve upgrades

There are a vast number of reserves across the study area. Many are irrigated and most are heavily utilised for both formal and informal recreational purposes.

While it is not recommended that reserves that are used for recreational purposes be replaced with water sensitive urban design features (such as large biofiltration systems or wetlands), a strategy of incorporating water sensitive urban design into planned reserve upgrades is recommended. As part of this strategy, Council should include consideration of small-scale, localised diversions of stormwater into the reserve for irrigation purposes in conjunction with identifying opportunities for the replacement of some areas of irrigated turf with native species which require minimal watering. There is the potential for these works to improve water quality (Goal WQ1), promote beneficial reuse of runoff (Goal RU2) and enhance the biodiversity and aesthetics of the reserve area (Goal RA3)

The opportunity for raising public awareness and/or community education via way of involving local groups and educational signage should also be considered.

7.2.4.1 Oval Corridor reserve

Collectively, Chambers Reserve, Don Ferguson Reserve and Colin Sellars Reserve are known as the 'Oval Corridor' reserve. These reserves, located within the Henley Fulham Catchment, have been identified as one area where there is the potential to incorporate water sensitive urban design into a reserve upgrade. It is a green corridor which runs from Henley Grange Memorial oval (in the south) to Grange Road, in the north. The width of the corridor varies from 30 to 60 metres.

The corridor currently comprises irrigated and non-irrigated areas, with numerous native trees of varying sizes scattered along the corridor. Recent plantings of native trees were observed at the southern end of the reserve (refer Figure 7.7 and Figure 7.8).

There are recreational facilities (such as sports courts) within the corridor and a shared use path extends along the northern section of the reserve. During a site visit, it was observed that the reserve was being heavily utilised by the community.

Figure 7.7 An irrigated section of the Oval corridor. The existing trees which line the reserve and the shared use path can be seen.

Figure 7.8 A non-irrigated section of the Oval corridor. Note an informal path and newly planted trees on the right-hand side.

WGA (2010) presented a preliminary concept for the incorporation of water sensitive design into the Ovals Reserve Corridor. The concept included the following components:

- Revegetation using species of local provenance to increase biodiversity and reduce irrigation demand.
- Creation of different planting zones along the corridor based on pre-European landscapes.
- Diversion of stormwater into the reserve to created mini wetlands, infiltration zones and dry land swale systems. The potential to 'break open' existing stormwater pipes that currently cross the reserve was identified. This would provide water quality improvement benefits, in addition to increasing biodiversity along the corridor.
- Extend the shared use path along the length of the corridor.
- Localised stormwater harvesting at Beck Street.
- The creation of zones where stormwater can pond, thereby providing flood attenuation benefits.

Subsequent geotechnical and environmental investigations along the corridor (Coffey, 2010) identified contamination within the upper layers of soil, that not only exceed the EPA's criteria for Waste Derived Fill, but also exceed the National Environmental Protection (Assessment of Site Contamination) Measure 1999 (NEPM) maximum recommended concentrations of Benzo(a)pyrene and Total PAH for a recreational park. The presence of contamination will need to be considered in future plans for upgrading the reserve.

Consistent with the recommendations for the incorporation of water sensitive urban design into reserve upgrades, it is recommended that Council consider the following for the Ovals Reserve Corridor:

- Revegetation of areas not used for recreational purposes with species of local provenance and low irrigation requirements.
- Localised diversion of surface runoff to support the areas of planting.

The works described above should aim to minimise impacts on the existing trees within the reserve and should be cognisant of the contamination which has been identified. Works should also be undertaken in a manner so as to not have any adverse hydraulic impacts on the upstream stormwater network.

7.2.5 Grange Lakes channel upgrades

The Grange Lakes system is an open channel stormwater drain which extends from Grange Road to Trimmer Parade and conveys flows from the Henley-Fulham catchment to West Lakes. The downstream sections of the channel are concrete lined, while the upstream reaches take on a more natural, meandering form with earth banks. The banks appear to have a steep drop-off into the channel and are lined with exotic grasses, with some reeds (refer Figure 7.9 and Figure 7.10). There is no vegetation within the channel. There are trash nets at the upstream end of the channel (refer Figure 7.11). The natural section of the channel also contains a wide basin like area which acts as a sedimentation zone (refer Figure 7.12). Council periodically removes the build-up of sediment from this basin.

Figure 7.9 The Grange Lakes natural section of channel – note the exotic grasses and erosion on the bank, with steep drop off into the water.

Figure 7.10 The Grange Lakes natural section of channel – note the tall reeds and exotic grasses.

Figure 7.11 Trash nets at the upstream end of the Grange Lakes channel

Figure 7.12 The basin area on Grange Lakes which acts as a sedimentation zone.

There is the potential to increase the water quality improvement, in addition to biodiversity, amenity and public safety, along the natural section of the Grange Lakes channel. In furthering the design of the works, careful consideration should be given to ensuring that the works do not adversely impact the hydraulic conveyance of the system, thereby resulting in upstream flooding.

It is recommended that (where space permits) the edges be regraded to provide a flat bench (nominally 1V:8H and 2.5 m wide). This flat bench can then be planted with aquatic species of local provenance. This will help to create habitat, improve biodiversity, improve public safety, improve amenity and provide some water quality benefits.

While it is recommended that the channel be maintained as an ephemeral watercourse, investigations should be undertaken to identify areas suitable for construction of deeper pools, which will provide continuity of habitat for water birds during extended dry periods.

Consideration should be given to increasing the volume of the sedimentation zone, and the construction of shallow macrophyte zones perpendicular to the flow path to provide increased water quality improvement.

These proposed works are generally consistent with the concept design developed by WGA (2010) and address Goals WQ1 and RA3 of this SMP.

The scope to undertake water quality improvement works along the downstream (concrete lined) section of the Grange Lakes channel is more limited as conversion of the concrete lined channel to a natural watercourse would impact the conveyance of the channel. WGA (2010) identified the option of terminating stormwater pipes which discharge into the drain further away from the channel, with conveyance of flows to the channel via open swale. This is recommended where space permits.

7.2.6 Permeable paving

Permeable paving, also known as porous paving, is a load bearing pavement structure which can be used on trafficable surfaces including roads with low traffic volumes, footpaths, carparks and pedestrian areas. It is best suited to areas that are relatively flat (DPLG, 2010).

Permeable paving typically comprises a permeable surface layer overlying an aggregate storage layer and provides many runoff management benefits including:

- Reduction in peak discharges and volumes.
- Increased groundwater recharge.
- Water quality improvement as a result of infiltration.

It is recommended that Council consider the use of permeable paving as part of capital works (e.g. construction/rehabilitation or carparks). An education campaign, informing the general public of the benefits of using permeable paving on their sites (e.g. driveways) should also be considered. This would align well with the requirements of the new Planning and Design Code, which contains provisions for permeable paving.

Installation of permeable paving addresses Goal WQ1.

7.3 Non-structural water quality improvement strategies

The structural water quality improvement strategies described above are aimed at treating water after it has been 'contaminated'. The principles of water sensitive urban design dictate that non-structural strategies, aimed at reducing the peak flow rates, volumes and contaminant concentrations of runoff, should be considered higher up in the hierarchy of controls.

Council's Biodiversity Action Plan includes a focus on education and citizen science (Action Area 4). It is recommended that the non-structural water quality improvement strategies be delivered within the framework of the Biodiversity Action Plan.

7.3.1 Microplastics investigation

Sampling undertaken as part of the AUSMAP program identified very high concentrations of microplastics on the beaches of West Lakes. A recording of 9,517 particles/m^2 at Towpath Reserve on the shores of West Lakes in 2019 is the highest recorded concentration within Australia. The source of the microplastics in West Lakes is not currently known.

It is recommended that Council work with the AUSMAP program to undertake further investigations to identify the source of the microplastics (including consideration of stormwater discharges) and to understand the patterns of export of the microplastics to the Port River environment.

This is considered a high priority and will be the first step in addressing Goal WQ2. The investigation could incorporate an element of community education and/or citizen science in conjunction with Council's Biodiversity Action Plan.

7.3.2 Sediment controls for development

While no information could be found in the literature, anecdotally high levels of development within a catchment significantly contribute to the sediment load discharged to receiving environments. There have been reports from the operators of managed aquifer recharge schemes that sediment loads as a result of development in the upstream catchment impact the schemes' harvestable volumes.

While effective sediment controls are often implemented during the construction of larger developments, small infill development does not always have the same levels of control. This results in visible sediment on the road network in the vicinity of the development (examples of which are shown in Figure 7.13). This sediment is then washed into the stormwater network, contributing to the sediment loads in the receiving environment.

It is recommended that Council implement and monitor tougher controls on all development within the catchment to reduce the sediment loads being discharged to the Coastal Waters via West Lakes. Given the recognised impact that sediment has on the coastal waters, this is considered a high priority action which addresses Goal WQ1 and could be undertaken by existing Council staff.

Figure 7.13 Examples of development sites, with visible sediment at the entrance to the site and on the downstream road network.

7.3.3 WSUD in the backyard

It is recommended that Council encourage 'WSUD in the backyard' both for existing residences, but more importantly for in-fill development. Examples of measures could include rainwater tanks (with effective reuse), permeable paving and small-scale raingardens. Potential benefits that could be achieved by a WSUD in the backyard approach include reduced peak flows and runoff volumes, beneficial reuse of runoff (Goal RU2) and improved water quality (Goal WQ1).

Implementation of WSUD in the backyard will require community buy-in. It will require a community awareness and education campaign, which aligns with key actions (Education and Citizen Science) identified by Council's Biodiversity Action Plan.

It is recommended that Council work with Water Sensitive SA (WSSA) in the roll out of the campaign. WSSA has a range of relevant online resources (refer Figure 7.14) and also runs a community training program. A WSUD in the Backyard campaign

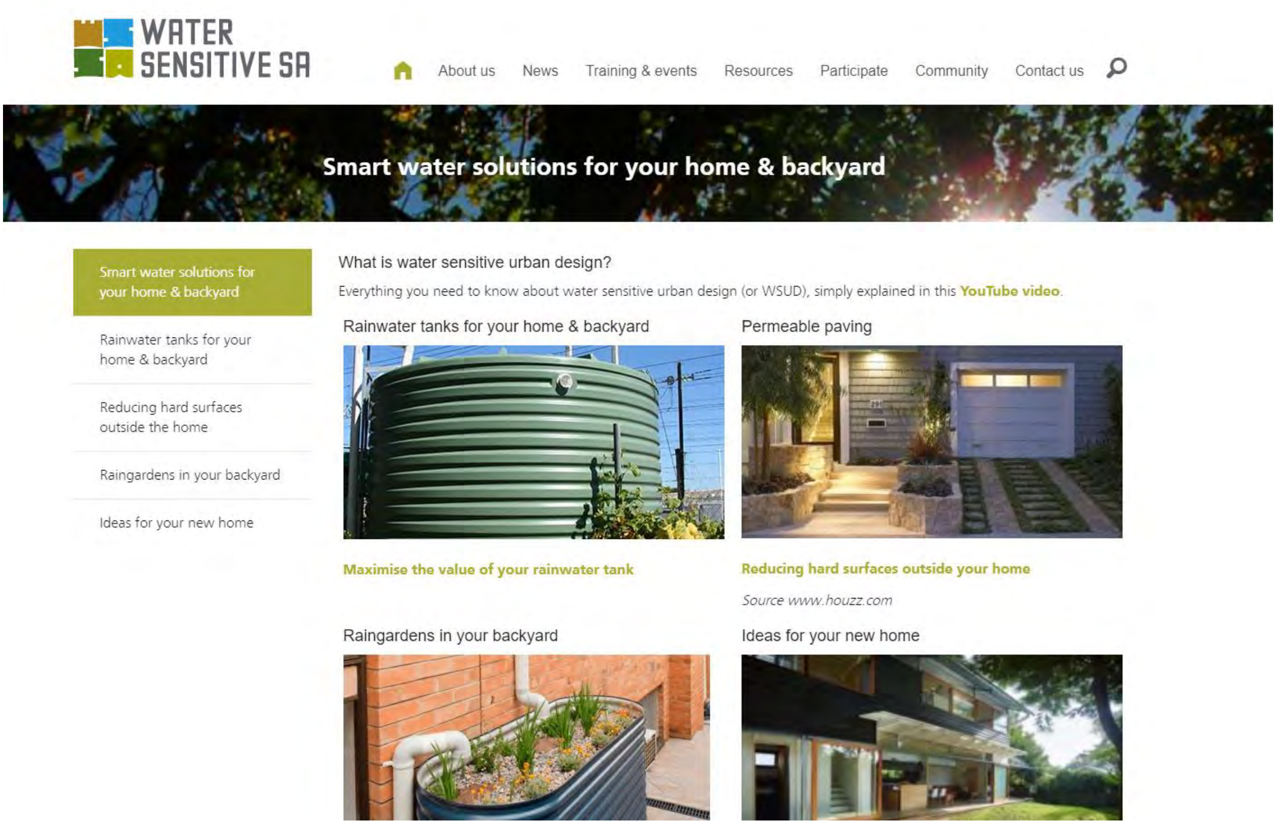

Figure 7.14 Online resources relating to WSUD in the backyard (Water Sensitive SA)

7.4 Summary of water quality actions

Table 7.9 contains a summary of the identified actions, a budget cost and priority.

Table 7.9 Summary of water quality improvement actions and priorities

Project ID	Description	Budget cost	Priority	Goal addressed
Q1	Gross pollutant traps	$300,000 each	High/Ongoing	WQ1
Q2	Street scale infiltration measures	$50,000 per year	High/Ongoing	WQ1, RU2
Q3	Street scale biofiltration (raingardens)	$25,000 each	High/Ongoing	WQ1, RU2
Q4	Oval Corridor reserve WSUD upgrades	$200,000	Low	WQ1, RU2, RA3
Q5	Grange Lakes channel upgrades	$500,000 with $5,000 annual cost	Medium	WQ1, RA3
Q6	Permeable paving	Part of capital works projects (no additional cost)	Ongoing	WQ1, RU2
Q7	Microplastics investigation	$20,000	High	WQ2
Q8	Sediment controls	$20,000 per year (nominal, assumed to be enforced by existing Council staff).	High	WQ1
Q9	WSUD in the backyard	$20,000 allowance each year	Medium	WQ1, RU2

8 Stormwater harvesting and reuse

The beneficial reuse of stormwater is one of the key objectives of the SMP (Goals RU1 and RU2). Not only does the reuse of stormwater reduce the volumes of water (and associated pollutant loads) being discharged into the receiving environment, but the use of fit-for-purpose water instead of mains water can also result in costs savings for Council.

8.1 Existing water reuse

There are number of existing water reuse schemes within the study area. These are described in the following sections. An overview of the existing recycled water network within the study area is shown in Figure 8.1.

8.1.1 Waterproofing the West

Council is the owner and operator of the Waterproofing the West (WPW) scheme, which includes a managed aquifer recharge (MAR) scheme within the study area, at Cooke Reserve. The Cooke Reserve site captures stormwater runoff from the urban catchment. Prior to injection into the aquifer, runoff is treated within biofiltration wetlands located along the edge of the West Lakes Golf Course, adjacent to Frederick Road.

WPW was commissioned to reduce Council's reliance on potable water, particularly for irrigation of reserves. The scheme incorporates a distribution network of approximately 53 km, which is now connected to a large number of reserves and recreation areas within the northern and central portion of the Council. The scheme was designed with an ultimate distribution network almost double this length connecting more Council reserves, schools and industrial premises. The scheme has a target design harvest volume of 2,400 ML/a, however only 15 of the planned 25 injection/extraction bores have been constructed to date (based on available budget at the time of construction), and Council estimates that the current maximum supply volume is in the order of 1,200 ML/a.

Council is currently reviewing the demand, supply, operational efficiencies and return on investment of the WPW scheme. As part of this, increasing the number of bores will be considered.

8.1.2 Grange Golf Club

The Grange Golf Club was the first golf club in Adelaide to adopt a water reuse scheme. The scheme was developed in order to supply an alternative source of irrigation for the golf course. The scheme began operating in 2009, diverting runoff from the City of Charles Sturt's stormwater network. Two diversion structures (located at Trimmer Parade and Brebner Drive) are used to pump stormwater to a series of wetlands adjacent to the eastern boundary of the course. Following treatment in the wetlands, the captured stormwater is injected into the T1 aquifer via two injection/extraction bores. Typical injection volumes within recent years are in the order of 50 ML/a, with limiting factors including catchment yield and artesian conditions.

8.1.3 Royal Adelaide Golf Club

As with the Grange Golf Club, the water harvesting scheme within the Royal Adelaide Golf Club sources stormwater runoff from the adjacent catchment. Harvested water is used for irrigation of lawns and gardens within the club. An injection volume of 150 ML was achieved in 2018/2019. This scheme is currently limited by aquifer conditions, with artesian conditions experienced in 2019.

8.2 Water reuse opportunities (managed aquifer recharge)

It is recommended that the assessment of opportunities associated with additional managed aquifer recharge schemes within the catchment focus on extending the existing schemes and/or increasing inflows to the existing schemes as opposed to the creation of new water reuse schemes.

Based on usage information provided by Council it is understood that the current demand for recycled water (based on existing connections) is approximately 510 ML/a. This is less than half of the existing supply volume of the WPW scheme (1,200 ML/a).

There are a large number of reserves within the West Lakes catchment that are not currently connected to the existing recycled water network. Work undertaken by Tonkin previously identified that extension of the existing alternative water supply network to additional reserves within the Council area could replace potable water usage by approximately 180 ML/a (Tonkin, 2020b). This estimate is based on irrigation demand information provided by Council. It is recommended that Council consider extending the WPW network to increase the reuse of stormwater runoff within the catchment. Consistent with the recommendations of Tonkin (2020b), Council should also liaise with Port Adelaide Enfield Council to identify opportunities for supply beyond the Council area.

While there may be opportunities for small scale harvest and reuse at some locations within the catchment (such as at the downstream end of Grange Lakes), it is not considered that the investment required to undertake the necessary investigations and then implement small (one or two well) managed aquifer recharge systems will stack up compared to augmentation of the existing system.

8.3 Water reuse opportunities (small-scale)

A number of the water quality improvement strategies will also provide opportunities for small-scale stormwater capture and beneficial reuse (Goal RU2). These include small-scale reuse opportunities such as rainwater tanks (with effective reuse) and passive reuse of water through WSUD features.

It is recommended that Council encourage these small-scale schemes through community awareness and education programs and consideration of grants to partially offset the costs of the rainwater tank installation.

Council should also implement an internal policy which requires opportunities for the incorporation of WSUD to be considered for all Council funded capital works across the whole of Council (Goal RA2).

8.4 Summary of stormwater harvesting and reuse actions

Action RU1: Opportunities to augment the existing WPW scheme to be documented through identification of increased demands . This is a medium priority action and addresses Goal RU1.

Action RU2: Council to develop community awareness and education campaign to promote rainwater tank uptake and implementation of WSUD at a lot-scale. This will promote the beneficial reuse of water within the study area. This is a high priority action, and addresses Goal RU2.

Action RU3. Council to implement a policy which requires opportunities for the incorporation of WSUD to be considered for all Council funded capital works across the whole of Council (Goal RA2). This is a high priority action.

9 Asset management

One of the objectives of the SMP is to ensure that sustainable management of stormwater infrastructure, including maintenance, is undertaken. The following sections provide guidance for the management of assets within the study area.

9.1 Existing infrastructure condition assessment

Council has a number of existing asset management plans, including a Water Assets Management Plan which has recently been subject to a periodic review. It is recommended that Council undertake a review of existing asset management plans relating to stormwater assets and identify where there are any gaps. Council should ensure that they have good information on the condition and likely remaining life of key infrastructure. Similarly Council should ensure that existing asset management plans consider the long-term sustainable management of infrastructure with respect to the projected changes in climate over the life of the asset.(Goal RA1). Detailed inspections of existing infrastructure, including CCTV and physical inspections, will enable an informed estimation of the residual design life for key components of the drainage system to be made. For underground drainage infrastructure, priority should be given to CCTV inspection of drains that have at least two of the characteristics described in Table 9.1.

Table 9.1 Criteria defining CCTV inspection priority

Drain characteristic	Discussion
Large drain size (larger than 750 mm diameter)	Large drains comprise the highest value component of Council's drainage assets and the unplanned replacement of a section of large drain would have a large impact on Council's financial resources.
Old drain	The older the drain the more likely that it will be nearing the end of its service life.
Prominent location	Some drains are located in prominent locations such as the centre of a commercial area or within an arterial road. Failure of these drains could result in major traffic disruptions and the potential for flood damages is highest.
Box culverts	Experience shows that box culverts can fail well before the end of their design life, increasing the need to understand their current condition.

9.2 Asset maintenance plan

A number of recommendations of this SMP include infrastructure that will require regular maintenance to ensure that it will continue to function as intended.

Council has recently undertaken a review of their Water Asset Management Plan (AMP). The intended purpose of the plan includes ensuring that the infrastructure functions correctly and has enough capacity for existing use and future demand.

It is recommended that Council review the AMP in the context of the findings of this SMP to identify any impacts the outcomes of the SMP have on the AMP. They should also develop a maintenance plan to cover the long-term management of their drainage assets, particularly the assets that have a high maintenance frequency (Goal RA2). The maintenance plans would be expected to align with Council's existing asset management plans, and would need to include the following key details:

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- The location and description of the asset.
- The likely frequency (or event trigger, such as a heavy rainfall event) that maintenance will be required.
- The type of maintenance that will be required (such as removal of silt, weeding).

Council will also need to allow for adequate resourcing and budgets to maintain the additional infrastructure that may be constructed as part of the implementation of the recommendations of this SMP.

9.3 Summary of asset management actions

Asset maintenance plans for all infrastructure, including WSUD, should be developed as infrastructure is built. It is therefore considered a high priority action.

The Water AMP should be reviewed against the outcomes of this SMP. The focus should be on identifying gaps in the existing AMP, and in particular knowledge about the state of key existing infrastructure and potential impacts of climate change on the sustainable management of assets. This is considered a high priority action.

10 Consultation

The objectives of stakeholder consultation for the SMP are to:

- Communicate the SMP and its aims to stakeholders.
- Obtain stakeholder input to the SMP, specifically the identification of key stormwater management issues and opportunities.
- Obtain stakeholder feedback on structural and non-structural stormwater management measures developed for the SMP.

The following key stakeholders have been identified:

- City of Charles Sturt (Council as well as the broader community)
- Stormwater Management Authority
- Green Adelaide
- Department for Infrastructure and Transport
- Environment Protection Authority South Australia

It is recommended that the following tasks be undertaken to inform the identified stakeholders about issues that may affect them:

- Media release published on Council’s website
- Display the draft SMP at Council’s libraries and office
- Letter to landholders that may be affected by proposed management actions, informing them of the recommendations of the SMP.
- Development of feedback forms.

10.1 Development of this draft SMP

This draft SMP has been developed in collaboration with a range of stakeholders within Council and has been reviewed by DIT, the SMA and Green Adelaide.

10.2 Community consultation

Community consultation for the draft SMP was undertaken over a 28 day period in February/March 2022. Details of this consultation are provided in Appendix G.

10.3 Council consultation

The SMP will be presented to Council’s executive management and elected members for Council endorsement in April 2022. Following this, any required changes to the plan will be made to produce a ‘final’ plan suitable for submission to the SMA.

11 Consolidated stormwater management plan

11.1 Summary of actions, costs, benefits and priorities

A summary of the recommended actions along with a recommended priority and associated costs and benefits is provided in Table 11.1.

The flood mitigation (structural and non-structural) measures presented in this SMP will not only reduce the magnitude of flooding but will also provide social benefits, including improved public safety and continuity of community services. The strategies presented in this SMP also consider opportunities to improve water quality (and therefore the receiving water environmental values), promote beneficial reuse of runoff, enhance biodiversity and promote a sustainable approach to asset management.

11.2 Timeframes for implementation

The actions detailed in this plan will be implemented over a period of many years, as budget and funding opportunities allow.

Highest priorities are for measures that have the greatest reduction in flood damages, with a greater weighting given to measures that can demonstrate other benefits.

It is recommended that the following target timeframes be adopted for the prioritised works:

- High priority – within 5 years
- Medium priority – 5-10 years
- Low priority – greater than 10 years.

A suggested 10-year capital works plan is provided in Table 11.3.

11.3 Responsibilities for implementation and maintenance

The implementation and maintenance of the structural measures identified in this SMP will generally be the responsibility of Council. The exception is works associated with the West Lakes outlet, which will be responsibility of DIT. The economic analyses undertaken as part of this SMP consider recurrent annual maintenance costs, which will be Council's responsibility. Annual maintenance costs will generally be associated with the maintenance of underground storage tanks, open basins and raingardens.

11.4 Potential funding contributions

Council will be responsible for funding the proposed works documented in this SMP and it is recommended that Council allocate funds for the high priority works within their long-term financial plans.

Stormwater management projects that are in accordance with an approved SMP and that have at least 40 ha of contributing catchment upstream of the location of the proposed works are eligible for SMA funding. The SMA may contribute up to 50% of capital costs. The eligibility of projects for SMA funding is provided Table 11.2. It should be noted that eligibility for SMA funding does not guarantee funding.

Other sources of potential funding may include Green Adelaide (particularly for works promoting WSUD within the community). The State and Commonwealth governments may also offer grants periodically to facilitate specific works such as flood disaster planning and relief and the incorporation of WSUD.

Table 11.1 Summary of recommended options

Priority	Project / Activity title	Budget estimate	SMA funding eligible	Flood mitigation benefit	Water quality benefit	Other benefits
High	F1 Gleneagles Reserve storage	$12,726,000 ($2,000 annually)	Y	Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot	Could consider infiltration during detailed design	Limited disturbance of open space Opportunities for localised infiltration/reuse Can be staged
Medium	F2 Nedford Reserve detention basin	$248,000 ($2,000 annually)	Y	Significant reduction (~180 mm) in flood depths within the road corridor in the 20% AEP event	High – landscape to provide water quality improvement	Possibility for landscaping for improved amenity and biodiversity
High	F3 Beatrice Avenue and Trimmer Parade pipe upgrades	$9,117,000	Y	Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 7 properties subject to above floor flooding)	Minimal	Opportunity to incorporate WSUD with inlets
High	F11 Education and awareness	$70,000	N	Likely to reduce flood impacts on community	-	Public can better respond to flooding. Better community resilience to flooding.
High	F12 Flood mapping outputs	$20,000	N	Provide up to date information of flooding within the catchment	-	Better planning outcomes. Public can better respond to flooding via greater preparedness.
High	Q7 Microplastics investigation	$20,000	N	-	Understanding of source of Microplastics so that the levels can be reduced	-
High	Q8 Enforce sediment controls for development	-	N	-	Lower TSS discharged to receiving environments	Low cost (developer responsibility). Will also improve aesthetics in areas of heavy development and may reduce required frequency of street sweeping.
High	Q1 Gross Pollutant Traps	$300,000 each ($20,000 annually)	N	-	Reduce loads of gross pollutants and sediments to receiving environment	-
High	Q2, Q3, RU1 Commence ongoing programs to promote incorporation of street scale infiltration and biofiltration into Council works	Low initial investment	N	-	Reduced loads of sediment and nutrients to the receiving environments	Aligns with the promotion of small scale projects promoting beneficial reuse of water. Reduced volumes of flows, improved amenity associated with urban greening and offset of the urban heat island effects.
High	AM1, AM2 Asset management – review of existing plans and plans for new assets	$40,000	N	-	Will help to ensure existing/proposed WSUD measures function as intended	Reduced costs associated with proactive (as opposed to reactive asset management). Ability to better plan for asset management.
High (2050)	Bower Road Causeway upgrade and Consideration of Pumps	N/A	Work to be undertaken by DIT	Required to lower lake levels as sea level rises	None	None

Priority	Project / Activity title	Budget estimate	SMA funding eligible	Flood mitigation benefit	Water quality benefit	Other benefits
Medium	F4 Crittenden Road to Grange Lakes pipe upgrades	$24,172,000	Y	Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 8 properties subject to above floor flooding)	Minimal	Opportunity to incorporate WSUD with inlets
Medium	F5 Matheson Reserve underground tank	$18,960,000 ($2,000 annually)	Y	Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 4 properties subject to above floor flooding)	Could consider infiltration during detailed design	Limited disturbance of open space Opportunities for localised infiltration/reuse Can be staged
Medium	F6 Recreation Parade detention basin	$3,765,000 ($2,200 annually)	Y	Eliminates above floor flooding of private property in the 20% AEP event in a known flooding hotspot (previously 2 properties subject to above floor flooding) Significant reduction (~200 mm) in flood depths within the road corridor in the 20% AEP event	Consider plant selection to provide water quality improvement	Possibility for landscaping for improved amenity and biodiversity
Medium	F7 Sansom Road pipe upgrades	$6,640,000	Y	Eliminates above floor flooding of private property in the 20% AEP event along the alignment of the upgrade (previously 4 properties subject to above floor flooding)	Minimal	Opportunity to incorporate WSUD with inlets
Medium	F8 Golfers Avenue pipe and pump upgrades	$3,197,000	Y	$648,000 (in combination with Priority F3 and F9) Improvements to flooding in roadways (particularly Frederick Road and Lily Avenue) in the 20% AEP event	Minimal	Opportunity to incorporate WSUD with inlets
Medium	Q5 Grange Lakes Channel Upgrades	$500,000 ($5,000 annually)	N	Minimal	Reduced loads of sediments and nutrients discharged to receiving waters	Improved biodiversity and visual amenity
Medium	Q9 WSUD in the backyard	$20,000 allowance each year	N	-	Reduced loads of sediments and nutrients discharged to receiving waters	Promotes beneficial reuse of water. Community education opportunities.
Medium	Additional connections to existing MAR schemes to increase water reuse	Variable	N	-	Reduced loads of sediments and nutrients discharged to receiving waters	Reduced volumes of water discharged to the receiving waters. May be financial gains from offsetting potable water with fit-for-purpose. Promote urban greening and offset head island effect.
Low	F9 Frank Mitchell Reserve underground tank	$15,049,000 ($2,000 annually)	Y	$648,000 (in combination with Priority F3 and F8) Significant reductions (~300 mm) in flood depth within the road corridor in the 20% AEP event	Low	Limited disturbance of open space
Low	F10 Market Corner pipe upgrades	$392,000	N	$111,000 (in combination with Priority F7) Minor reductions in flood depth within the road corridor	-	-
Low	Q4 Oval Corridor Reserve WSUD upgrades	Variable	N	-	-	Improved amenity and biodiversity. Opportunity to incorporate WSUD for small-scale beneficial reuse.

11.5 Achievement of stated SMP goals

An assessment of the level to which the proposed SMP objectives are attained by the recommended priorities described in the report is provided in Table 11.2.

Table 11.2 Attainment of objectives

Goal	Achieved	Discussion
Flood management		
F1a.	Partial	Over-floor flooding in a 1% AEP event reduced from 896 to 581 residential properties (2.4% of the study area). The SMP addresses the most pronounced areas of flooding. Residual areas of flooding are shown in the flood maps. Achieving a 1% AEP standard of protection across the entire SMP area is an aspirational target that can be worked towards over a long timeframe (not economically viable within a 10-year planning horizon).
F1b.	Partial	The strategies provide improvement to flood depths in the 20% AEP event in the most pronounced areas of flooding. There are very few areas remaining with flood depths in excess of 150 mm (i.e. above kerb height).
F1c.	Yes	The results of the flood mapping can be used to ensure a 1% AEP standard of protection for new developments.
F1d.	Yes	The modelling undertaken as part of the SMP development can be used to ensure new development have a stormwater network that provides a 20% AEP level of service.
F2	Yes	No private property is subject to high or extreme hazard (i.e. category H4 or higher) in a 1% AEP event.
F3	Yes	Community awareness and education is a recommended action.
Water quality improvement		
WQ1	Partial	Recommended measures will improve the water quality discharged to West Lakes. The achievement of the stated goals will depend on the extent to which the strategy is implemented.
WQ2	Partial	Investigation into the source of microplastics is identified as a high priority action. This will be the first step in achieving the targeted reduction. Once the source is known, a strategy to reduce the concentrations can be implemented.
Beneficial reuse of stormwater		
RU1	Yes	Opportunities to augment WPW scheme identified.
RU2	Yes	Direct recommendation to consider small-scale implementation.
Desirable planning outcomes		

Goal	Achieved	Discussion
RA1	Yes	Flood maps have been prepared and can be incorporated into the Planning and Design Code.
RA2	Yes	Recommendation for Council policy to require consideration of WSUD opportunities in the planning phase of all capital projects.
RA3	Yes	Recommended works in Grange Lakes.
Asset management		
AM1	Yes	Recommended that all existing stormwater assets be identified and recorded.
AM2	Yes	Details of asset maintenance plans provided.

Table 11.3 Indicative 10-year capital works plan (values in millions)

Priority	Works	21/ 22	22/ 23	23/ 24	24/ 25	25/ 26	26/ 27	27/ 28	28/ 29	29/30	31/32	Total per project
F1	Gleneagles Reserve storage (Stage 1)	5.0										5.0
F2	Nedford Reserve detention basin							0.25				0.25
F3	Beatrice Avenue and Trimmer Parade pipe upgrades		4.5	4.5								9.0
F4	Crittenden Road to Grange Lakes pipe upgrades				4.0	4.0	4.0	4.0	4.0	4.0		24.0
F6	Recreation Parade detention basin										3.8	3.8
F11, F12, Q8	Education, awareness, planning and enforcing sed controls	0.1	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.55
Q2/Q3/Q6	Street scale biofiltration measures and permeable pavement		0.2	0.2	0.2	0.2	0.2					1.0
Q7	Microplastics investigation	0.02										0.02
Q1	GPTs		0.3	0.3	0.3	0.3	0.3	0.3				1.8
Q5	Grange Lakes								0.25	0.25		0.5
	Total per year	5.12	5.05	5.05	4.55	4.55	4.55	4.60	4.30	4.30	3.85	45.9

12 References

ARR (2016): Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I (Editors), *Australian Rainfall and Runoff: A Guide to Flood Estimation*, Commonwealth of Australia (Geoscience Australia) 2016.

Australian Microplastic Assessment Project (AUSMAP) (2020), *Review of Microplastics across South Australia 2019.*

Australian Water Environments (AWE) (2002), *City of Port Adelaide Enfield and Charles Sturt - Initial Urban Stormwater Master Plans.*

City of Charles Sturt (2017), *Biodiversity Action Plan 2017-2030*, Prepared by Seed Consulting Services August 2017.

CoastAdapt (2019), *Sea-level rise and future climate information for coastal councils* <https://coastadapt.com.au/sea-level-rise-information-all-australian-coastal-councils#SA_CHARLES_STURT>.

Coffey (2010), *Henley Beach to Grange Corridor Preliminary Environmental and Geotechnical Assessment*, Ref: 06362AA-AB, prepared for City of Charles Sturt.

Commonwealth of Australia (2018), *Building Up & Moving Out – Inquiry into the Australian Government's role in the development of cities*, House of Representatives Standing Committee on Infrastructure, Transport and Cities, September 2018, Canberra.

Connell Wagner (2007), *Port Road Rejuvenation Stormwater Managment Plan (Ref: 23462-001-01),* Adelaide: Connell Wagner.

CSIRO and Bureau of Meteorology (2016), Climate Change in Australia, viewed 07 August 2019, <https://www.climatechangeinaustralia.gov.au/en/>.

CSIRO (2018), Climate change information for Australia, viewed 07 August 2019 <https://www.csiro.au/en/Research/OandA/Areas/Oceans-and-climate/Climate-change-information>.

Department of Environment, Water and Natural Resources (DEWNR) (2013), *Water Sensitive Urban Design, Creating more liveable and water sensitive cities in South Australia*. State of South Australia through the Department of Environment, Water and Natural Resources. August 2013.

Department of Natural Resources and Environment (DNRE) (2000), *Rapid Appraisal Method (RAM) for Floodplain Management*, Report prepared by Read Sturgess and Associates, Victoria.

Department of Planning and Local Government (DPLG) (2010), *Water Sensitive Urban Design Technical Manual for the Greater Adelaide Region*, Government of South Australia, Adelaide.

Department for Infrastructure and Transport (DIT) (2021), *Climate Change Adaptation Guideline for Asset Management*.

Design Flow (2016), *Tracey Avenue catchment raingardens*, Prepared for the City of Charles Sturt, May 2016, Reference 5197 V 1.1.

Engineers Australia (2006), *Australian Runoff Quality: A Guide to Water Sensitive Urban Design*, Engineers Media, NSW.

Environmental Protection Authority South Australia (EPA SA) (2007), *The Adelaide Coastal Waters Study*, Vol. 1 Summary of Findings, CSIRO, South Australia.

Environmental Protection Authority South Australia (EPA SA) (2013), *Adelaide Coastal Water Quality Improvement Plan*, Australian Government and Government of South Australia.

Fox, D.R., Batley, G.E., Blackburn, D., Bone, Y., Bryars, S., Cheshire, A., Collings, G., Ellis, D., Fairweather, P., Fallowfield, H., Harris, G., Henderson, B., Kämpf, J., Nayar, S., Pattiaratchi, C., Petrusevics, P., Townsend, M., Westphalen, G., Wilkinson, J. (2007). *Adelaide Coastal Waters Study: Final Report, Volume 1 Summary of Study Findings.* Prepared for the South Australian Environment Protection Authority.

Gerges, N. (2006), *Overview of the hydrogeology of the Adelaide metropolitan area (Report DWLBC 2006/10),* Department of Water, Land and Biodiversity Conservation.

Green Adelaide (2021), *Draft Regional Landscape Plan 2021-2026.*

Greenhill (2018). *Trimmer Parade Stormwater Drainage Plan, Drawing No. 17-1572-004.*

Kretschmer, P. (2017). *Managed aquifer recharge schemes in the Adelaide Metropolitan Area - DEWNR Technical Report 2017/22,* Adelaide: Department of Environment, Water and Natural Resources.

Myers, B., Cook, S., Pezzaniti, D., Kemp, D., Newland, P (2015), *Implementing Water Sensitive Urban Design in Stormwater Management Plans*, Goyder Institute for Water Research Technical Report Series No. 16/7, ISSN: 1839-2725, Adelaide.

NatureMaps. Accessed 19 July 2021 at [http://spatialwebapps.environment.sa.gov.au/naturemaps].

New Zealand National Asset Management Steering Group (NZNAMSG) (2004), *Optimised decision making guidelines: A sustainable approach to managing infrastructure*, 1st Edition, Thames, New Zealand.

Pfennig, P (2008), *Port Waterways Water Quality Improvement Plan.* Report prepared for the EPA of South Australia, May 2008.

Smith, G, Davey E and Cox R (2014), *Flood hazard*, Technical report 2014/07, Water Research Laboratory, University of New South Wales, Sydney.

SouthFront (2019), *Port River East Stormwater Management Plan. Final Report.* Reference 17008-4. Prepared for the City of Port Adelaide Enfield, August 2019.

Stormwater Management Authority (SMA) (2020), Stormwater Management Planning Guidelines (Draft for Consultation), Government of South Australia.

Taylor, J. K., Thomson, B. P. & Shepherd, R. G. (1974), *The Soils and Geology of the Adelaide Area: Bulletin (Geological Survey of South Australia) no. 46.* Department of Mines.

Tonkin Consulting (2003a), *Trimmer Parade Catchment: Initial Urban Stormwater Master Plan (20020277RA4).* Prepared for City of Charles Sturt, March 2003.

Tonkin Consulting (2003b), *Meakin Terrace Catchment - Initial Urban Stormwater Master Plan (20020277RA5).* Prepared for City of Charles Sturt, March 2003.

Tonkin Consulting (2005), *Henley Fulham Catchment - Initial Urban Stormwater Master Plan (20040581RA1).* Prepared for City of Charles Sturt, May 2005.

Tonkin Consulting (2009), *West Lakes TUFLOW Floodplain Modelling (20060049RA1).* Prepared for City of Charles Sturt. September 2009.

Tonkin Consulting (2012), *Flood Inundation Mapping Report HEP, Torrens East, Western Coastal and Patawalonga Catchments (20111158RA1).*, *June 2012.*

Tonkin Consulting (2014). *Duncan Street Diversion Drain and Detention Basin (20140345FL1A).* Prepared for City of Charles Sturt.

Tonkin Consulting (2015), *Western Adelaide Region Climate Change Adaptation Plan: Coastal and Inundation Modelling Phase 1 Report.* Ref 20140329R1. Prepared for City of Charles Sturt, City of Port Adelaide Enfield and City of West Torrens. May 2015.

Tonkin Consulting (2016), *Charles Sturt Local Stormwater Upgrades – Option Analysis and Concept Design*. Ref: 20160734R001A. Prepared for City of Charles Sturt

Tonkin Consulting (2017), *Gluyas Avenue Drainage Investigation*, Ref: 2017.0764L001B.

Tonkin Consulting (2018), *Western Adelaide Region Climate Change Adaptation Plan - Coastal and Inundation Modelling Phase 3 Report (20140329R3C).* Prepared for City of Charles Sturt, City of Port Adelaide Enfield and City of West Torrens. February 2018.

Tonkin (2020a), *West Lakes Catchment Stormwater Management Plan – Stage 3 Report – Decision Making Framework*, Ref: 20190818R003RevC.

Tonkin (2020b), *Stormwater Capture and Reuse Efficiency Measures, Stage 2 – Option Development*, Ref: 20191197.01 R002 Rev0, prepared for Department of Environment and Water.

URPS (2016). *AdaptWest Western Adelaide Region Climate Change Adaptation Plan. 2014-045R008.* Prepared for AdadptWest 11 October 2016.

URPS (2019), *West Lakes catchment development potential,* Adelaide: URPS.

Wallbridge and Gilbert (WGA) (2010), *Henley Fulham Catchment and Ovals Corridor – Stormwater Harvesting and WSUD Study*, Ref: C081181, Prepared for City of Charles Sturt.

Water Sensitive SA 2016, *A guide to raingarden plant selection and placement – fact sheet*, viewed 20 June 2019 <https://www.watersensitivesa.com/raingarden-plant-selection-and-placement-fact-sheet/>.

Water Data Services (2019), *Kirkcaldy Wetland @ Nash Street East Grange - A5041016*. <https://amlr.waterdata.com.au/WaterQualitySummary.aspx?sno=A5041016>.

Appendix A – Assessment of development potential

MEMO

To	Olivia Oliver, Tonkin
From	Simon Channon, Anna Pannell
Date	14 October 2019
Project Number	19ADL-0214
Regarding	West Lakes catchment development potential

This memo summarises the findings of an investigation to determine development potential in the West Lakes catchment to inform the development of the West Lakes Stormwater Management Plan.

2070 is a long development horizon. To predict what may change within the catchment over this time requires making numerous assumptions. The assumptions described in the following sections have been made with regard to the planning context provided in the current Development Plan and 30 Year Plan for Greater Adelaide.

1. Assumptions regarding future development in the catchment by 2070

1. There will be no substantial changes to zone boundaries.
2. Future land use will be consistent with current zone intent.
3. Non-residential zones are unlikely to see any increase in permeable areas.
4. Recreation, open space and education land uses will not change.
5. No change in land use will occur within Residential Character Zones
6. Within existing Residential Zone, all residential, commercial, retail and industrial land uses could be developed (with the exception of existing aged care, flats and townhouses); if not by redevelopment at higher densities, through alterations and additions or other increases in impervious areas (i.e. new structures/paved areas)
7. No heritage places or Residential Character Zone properties will be developed

Residential zone development assumptions

8. 3 development scenarios have been used aligning with permeability provisions identified in the Planning and Design Code (P&DC):
    1. Low density development – only sites greater than 900m^2 are developed
    2. Medium density – only sites greater than 600m^2 are developed
    3. High density – sites greater than 400m^2 are developed.

The related P&DC provisions are described below: (draft Phase 3, 1 October 2019)

DTS / DPF 21.1

Residential development incorporates areas for soft landscaping with a minimum dimension of 0.5 metres provided in accordance with the following:

(a)

Dwelling site area (or in the case of residential flat or group average site area) (square metres)	% of site
<200	15%
201 - 450	20%
>450	25%

9. Given the development timeframe to 2070, it is assumed that all sites will be developed by 2070.

Even if land is not divided to create additional dwellings. It is assumed that the impervious area could increase through activities such as dwelling additions, new verandahs or other outbuildings and by an increase in paved/hard surfaces. New buildings will typically trigger a development application and therefore the above soft landscaping (permeable area) requirements will apply.

2. Other considerations for future development

Tree canopy will increase in line with 30-Year Plan target and City of Charles Sturt strategic plan priorities and strategies. The Draft Phase 3 P&DC also identifies tree planting requirements (refer page 2241).

3. Development zone permeability assumptions

Table 1 describes the zones that intersect the West Lakes stormwater catchments. Existing development plan provisions regarding permeability are described and where no guidance is provided, assumptions on the permeability of land within the zone are provided.

Table 1 Current land development zones and associated permeability guidance

Zone	Observations	Development Plan Site Coverage/Impervious Area Guidelines	Assumptions
Coastal Open Space Zone	Small portion in catchment. Largely open space but including a caravan park. Also expect footpaths/cycling trails.	No site coverage or permeability guidelines in the Development Plan but Zone intended to retain coastal landscape character.	Assume little if any development and therefore low impervious area and accommodating existing land uses and hard surfaces (30%)
District Centre Zone	The land is almost entirely developed and hard surfaced (roofs and car parks). There are some scattered trees in the car parks.	No site coverage or permeability guidelines in the Development Plan	Assume very high impervious area (~100%)
Education Zone	This Zone covers a school – more open space than built form.	No site coverage or permeability guidelines in the Development Plan	Assume medium level impervious area (~50%)

Zone	Observations	Development Plan Site Coverage/Impervious Area Guidelines	Assumptions
Home Industry Zone	Zone mainly contains dwellings and big sheds. Relatively high impervious areas.	No site coverage or permeability guidelines in the Development Plan.	Assume very high impervious area (~90%)
Local Centre Zone	The land is almost entirely developed and hard surfaced (roofs and car parks). There are some scattered trees in the car parks.	No site coverage or permeability guidelines in the Development Plan	Assume very high impervious area (~100%)
Mixed Use Zone	The land is almost entirely developed and hard surfaced (roofs and car parks). There are some scattered trees in the car parks.	Site coverage guideline that development should be limited to 60%. Landscaping should be a minimum of 10% of site area.	Assume very high impervious area (~100%)
MOSS/OS Zone	Zone runs along the River Torrens – generally no development in this area. No change to be expected.	No site coverage or permeability guidelines in the Development Plan.	Assume little if any development and therefore low impervious area (20%)
Neighbourhood Centre Zone	The land is almost entirely developed and hard surfaced (roofs and car parks). There are some scattered trees in the car parks.	No site coverage or permeability guidelines in the Development Plan	Assume very high impervious area (~100%)
Residential Character Zone	Low density area typically comprising larger homes on larger sites with lots of landscaping. Unlikely to be material infill development in the Zone given the desire to retain as is.	No site coverage or permeability guidelines in the Development Plan.	Assume high level impervious area (~80%)
Residential Zone	Residential area largely developed with infill development occurring throughout the zone (average of 1000 dwelling approvals per year over the past 10 years).	No site coverage or permeability guidelines in the Development Plan. Nearly all of the Zone is located in the area where the Residential Code applies that	Assume increase as per draft Planning and Design Code guidelines.

Zone	Observations	Development Plan Site Coverage/Impervious Area Guidelines	Assumptions
		permits up to 60% site coverage (roofed area).	
Special Uses Zone	Largely open space including schools and golf clubs. High proportion of open space.	No site coverage or permeability guidelines in the Development Plan.	Assume medium level impervious area (~50%)
Stadium Zone	Specific Zone covering the basketball stadium only – approximately 40% of site developed and the remaining open. Could be further developed.	No site coverage or permeability guidelines in the Development Plan.	Assume development potential will lead to higher impervious area (~85%)
Suburban Activity Node Zone	A predominantly residential zone that will have a mix of land uses. Very small area within the catchment.	No site coverage or permeability guidelines in the Development Plan.	Assume high impervious area (~85%)
Urban Core Zone	Zone set aside for intense urban development. Largely developed but will be developed to greater heights/densities.	No site coverage or permeability guidelines in the Development Plan.	Assume very high impervious area (~100%)
Urban Employment Zone	Typically developed industry zones. Covers a substantial area but generally hard surfaced already with buildings/car parks.	No site coverage or permeability guidelines in the Development Plan.	Assume very high impervious area (~100%)

4. Current sub catchment zoning

Table 2 summarises the sub catchment zoning for each of the 10 sub catchments which is assumed will not change by 2070.

Table 2 Sub catchments and current zoning

Sub catchments and zones	Area of sub catchment in each zone	% of sub catchment
Henley Grange sub catchment	**6021546**	
District Centre	62139	1.0%
Education	94604	1.6%
Local Centre	36468	0.6%
Metropolitan Open Space System	1	0.0%

Sub catchments and zones	Area of sub catchment in each zone	% of sub catchment
Mixed Use	42019	0.7%
Neighbourhood Centre	6295	0.1%
Residential	5546737	92.1%
Residential Character	227063	3.8%
Special Use	6222	0.1%
Meakin sub catchment	**4430446**	
Local Centre	19516	0.4%
Mixed Use	89237	2.0%
Neighbourhood Centre	10308	0.2%
Residential	3664029	82.7%
Special Use	336129	7.6%
Stadium	79355	1.8%
Suburban Activity Node	9159	0.2%
Urban Employment	222713	5.0%
Port Road sub catchment	**6611668**	
Commercial	6954	0.1%
District Centre	304180	4.6%
Home Industry	13989	0.2%
Industry	5822	0.1%
Local Centre	24312	0.4%
Mixed Use	331188	5.0%
Neighbourhood Centre	61877	0.9%
Recreation	1	0.0%
Residential	2162472	32.7%
Residential Character	1442416	21.8%
Special Use	578937	8.8%
Urban Core	77444	1.2%
Urban Employment	1602076	24.2%
Torrens East sub catchment	**5934740**	
District Centre	196247	3.3%
Industry	4564	0.1%
Local Centre	33611	0.6%
Metropolitan Open Space System	316378	5.3%
Mixed Use	452532	7.6%
Neighbourhood Centre	40586	0.7%
Open Space	53228	0.9%
Residential	3785958	63.8%
Residential Character	223862	3.8%
Special Use	60490	1.0%
Urban Corridor	1831	0.0%
Urban Employment	765451	12.9%
Trimmer Parade sub catchment	**4636999**	
District Centre	130710	2.8%

Sub catchments and zones	Area of sub catchment in each zone	% of sub catchment
Local Centre	4810	0.1%
Mixed Use	7382	0.2%
Neighbourhood Centre	62573	1.3%
Residential	3763063	81.2%
Residential Character	145677	3.1%
Special Use	381376	8.2%
Suburban Activity Node	43120	0.9%
Urban Employment	98286	2.1%
West Lakes Central sub catchment	**1039614**	
Local Centre	1785	0.2%
Residential	1037828	99.8%
West Lakes East sub catchment	**3466885**	
District Centre	5904	0.2%
Local Centre	13995	0.4%
Mixed Use	14871	0.4%
Neighbourhood Centre	28186	0.8%
Residential	2757109	79.5%
Special Use	49559	1.4%
Urban Core	269637	7.8%
Urban Employment	327624	9.5%
West Lakes North East sub catchment	**791230**	
Residential	260472	32.9%
Special Use	515828	65.2%
Urban Employment	14930	1.9%
West Lakes South sub catchment	**1687411**	
District Centre	268275	15.9%
Local Centre	1810	0.1%
Residential	400679	23.7%
Special Use	1011806	60.0%
Urban Core	4841	0.3%
West Lakes West sub catchment	**3305918**	
Coastal Open Space	152672	4.6%
Local Centre	32129	1.0%
Recreation	29	0.0%
Residential	3113948	94.2%
Special Use	7140	0.2%
Grand Total	**37926455**	**100.0%**

5. Current and future catchment conditions

Table 3 describes the current proportions of major land uses to inform catchment permeability considerations. This table has been prepared considering current zoning and land use.

Table 3 Current catchment conditions (2019)

Sub catchment	Total area m^2	Land area in cadastre m2	Land not in cadastre (ie road) m^2	% of subcat not in cadastre	Area open space or rec m^2	% open space or rec	Area residential land use in Res zone m^2	% residential	Area Res Character m^2	% Res Character	Area education land uses m^2	% education	% other land uses*
Henley Grange	6021550	4731794	1289756	21.4%	585521	9.7%	3187112	52.9%	148432	2.5%	261605	4.3%	9.1%
Meakin	4430450	3596487	833963	18.8%	514131	11.6%	2382494	53.8%			130467	2.9%	12.9%
Port Road	6611670	4671219	1940451	29.3%	88483	1.3%	1214823	18.4%	1019275	15.4%	83907	1.3%	34.3%
Torrens East	5934740	4707593	1227147	20.7%	429844	7.2%	2551013	43.0%	141149	2.4%	132122	2.2%	24.5%
Trimmer Parade	4637000	3719190	917810	19.8%	502220	10.8%	2436518	52.5%	119561	2.6%	70284	1.5%	12.7%
West Lakes Central	1039610	777395	262215	25.2%	73636	7.1%	576619	55.5%					12.2%
West Lakes East	3466890	2676971	789919	22.8%	217756	6.3%	1689707	48.7%			85021	2.5%	19.7%
West Lakes North East	791230	728340	62890	7.9%	336774	42.6%	163929	20.7%					28.8%
West Lakes South	1687410	1582748	104662	6.2%	1063927	63.1%	205550	12.2%			5577	0.3%	18.2%
West Lakes West	3305920	2542710	763210	23.1%	436649	13.2%	1668408	50.5%			61084	1.8%	11.4%

* Other land uses are predominantly in non-Residential zones.

Table 4 shows the potential increase in allotments by 2070 for three scenarios:

1. Low density development – only sites greater than 900m^2 are developed
2. Medium density – only sites greater than 600m^2 are developed
3. High density – sites greater than 400m^2 are developed.

Table 4 Future residential density calculations

Sub catchment	Current residential allotments	2070 high density scenario – allotments	2070 medium density scenario – allotments	2070 low density scenario – allotments
Henley Grange	4,927	12,533	8,152	5,310
Meakin	3,792	9,276	6,126	4,046
Port Road	2,024	4,694	3,047	2,162
Torrens East	4,030	10,057	6,544	4,309
Trimmer Parade	3,885	9,491	6,199	4,255
West Lakes Central	843	2,263	1,414	882
West Lakes East	3,017	6,253	4,238	3,122
West Lakes North East	246	677	435	256
West Lakes South	261	785	504	290
West Lakes West	2,606	6,127	4,041	2,730
TOTAL	25,631	62,156	40,700	27,362

For the high density scenario, there is potential for 62,156 allotments with an average area of 200m^2. Assuming 15% permeable this would mean the area of permeable cover on residential allotments across the whole catchment would equal 1,864,680m^2 (186ha).

For the medium density scenario, there is potential for 40,700 allotments with an average area of 300m^2. Assuming 20% permeable this would provide 2,442,000m^2 (244 ha) permeable cover on residential properties.

For the low density scenario there is potential for an additional 1,731 allotments (above current conditions). Assuming 25% permeable this would provide 2,736,200m^2 (274 ha).

The current allotments are assumed to have an average of 40% impervious. The average current allotment size across the catchment is 590m2. Based on these figures current residential properties provide 4,100,960m^2 (410ha) of permeable cover.

This assessment suggests that the area of permeable cover on residential properties could be expected to significantly reduce considering future likely development conditions.

Appendix B – Summary of hydrologic and hydraulic modelling

Introduction

The approach to the hydrologic and hydraulic modelling that underpins the development of the West Lakes Stormwater Management Plan is summarised in the following.

The modelling is based on the modelling that was undertaken as part of the Western Adelaide Region Climate Change Adaptation Plan (Tonkin 2015), which in turn was based on the hydrologic and hydraulic modelling that was undertaken for the West Lakes TUFLOW Floodplain Modelling Project (Tonkin 2006).

Scope of modelling

Development of the flood modelling involved the following:

- Hydrological modelling of contributing catchments, including within and external to the study area.
- Obtaining details of the hydraulic structures, including pipes, culverts, pumps and areas of storage.
- Preparing a combined linked 1D−2D hydrodynamic flood model (using existing models prepared by Tonkin previously as a basis) to assess the extent of surface flooding within the study area for the predicted levels of development.
- Analysing the resultant flooding for the following storm events, assuming a 10% increase in rainfall intensity (climate change) with the 2070 level of development:
  - 63% AEP storm event (1 exceedance per year (EY))
  - 39% AEP storm event (0.5 EY)
  - 20% AEP storm event
  - 10% AEP storm event
  - 5% AEP storm event
  - 2% AEP storm event
  - 1% AEP storm event
  - 0.2% AEP storm event

Hydrological modelling

Modelling of runoff within the urban area was undertaken using the ILSAX hydrological model (in DRAINS). The ILSAX model requires the catchment to be divided into smaller sub-catchments, each of which is assigned a directly connected impervious area percentage, an indirectly connected impervious area percentage and a remaining pervious area.

The directly connected impervious area represents paved and roof areas within the catchment from which runoff is discharged directly to the street drainage system. The indirectly connected impervious area represents paved and roof areas within a catchment that are not directly connected to the street drainage system but may travel overland across a pervious surface before reaching the street. The pervious area largely represents the remaining grass and gardens areas.

For each sub-catchment, the model requires input of travel times, which when convolved with rainfall enables the generation of a runoff hydrograph using the time-area method.

A description of the parameters used to undertake the modelling within each of these models is provided in the following sections of this report.

Sub-catchment boundary delineation

Sub-catchment boundary delineation was performed for the study area using the digital elevation model. A single sub-catchment was delineated for each inlet to the urban drain system. The sub-catchments defined for the previous modelling were used as a starting point, with changes made to reflect the new DEM and changes to the drainage network since the previous modelling was undertaken.

Catchment imperviousness

Impervious area percentages were assigned to each allotment depending on land use.

The predominant land use within the Study Area is residential. A single scenario representative of the projected 2070 levels of development was modelled. Following review of development and the likely impacts of development on the impervious areas within the study area, it was assumed that all residential properties (excluding those in residential character zones) would be 80% impervious, comprising 65% directly connected areas and 15% indirectly connected areas.

The adopted percentages are shown in Table 12.1.

Table 12.1 Adopted impervious area percentages

Land Use	Directly Connected Impervious (%)	Indirectly Connected Impervious (%)
Residential	65	15
Driveways /Carparks	100	0
Commercial and Industrial	85	5
Schools	20	18
Public Institutions	70	10
Road Reserves	100	0
Public Reserves	1	5

Times of concentration

Times of concentration were calculated for each sub-catchment by summing together gutter flow and roof to gutter times. Gutter flow times were determined based on:

- The length of the travel path to the pit from the furthest upstream point in the catchment; and
- The slope of the travel path.

Slopes were calculated from the DEM. Overland flow charts (IEAust, 1977) were utilised where runoff within a sub-catchment would not travel to a pit via a gutter. A time of five minutes was allowed for the roof to gutter time of concentration for residential housing whilst ten minutes was used for large commercial/industrial buildings.

The golf courses within the catchment were split into a number of sub-catchments around low points within each golf course. The maximum travel time to the low point was calculated and used as the time of concentration for each sub-catchment, with the inflow hydrograph being applied at the low point of each sub-catchment.

Rainfall estimation

Consistent with the previous investigations undertaken within the study area, the hydrological modelling for the West Lakes SMP uses 1987 patterns of rainfall, and 1987 Intensity Frequency Duration (IFD) depths.

The rainfall intensities were increased by 10% to account for projections of likely future climate change.

Loss model

Runoff was estimated using an Initial Loss – Continuing Loss model. This model supposes an initial catchment wetting phase which absorbs rainfall (the initial loss) followed by a continuing, steady infiltration of rain over the pervious areas for the remainder of the event (the continuing loss). The initial and continuing losses are surface type dependent. The adopted loss parameters are presented in Error! Reference source not found.. The values listed are consistent with those used for modelling a range of urban catchments across Adelaide.

Table 12.2 Loss parameters used for urban catchments

Parameter	Value
Directly connected impervious area initial loss	1 mm
Indirectly connected impervious area initial loss	1 mm
Pervious area initial loss	45 mm
Pervious area continuing loss	3 mm/hr

Hydrograph generation

Hydrographs were generated using the industry standard DRAINS model. For each AEP event storm durations ranging from 15 minutes to 24 hours were run.

The hydrographs were then exported and used as a key input in the TUFLOW model.

Hydraulic modelling

Hydraulic modelling uses the outputs of the hydrological modelling to determine the extent, depth and behaviour of floodwater. The resulting outputs provide an estimate of areas subject to flooding.

A detailed flood model was created for the study area, which included both one and two dimensional components. The model was run to simulate storm events within the study area and generate flood inundation maps.

The model includes the external catchments which were identified as likley to influence flooding within the study area (Port Road and a section of the Torrens East catchment as identified in Section 2 of the SMP).

Modelling software

The hydraulic modelling was carried out using the TUFLOW modelling software. The software simulates depth averaged, two-dimensional free surface flows such as those that occur during floods. TUFLOW has the ability to dynamically link to the ESTRY one-dimensional (1D) model (if needed), which enables the creation of models containing both 1D and 2D domains.

For this study the TUFLOW HPC solver has been used to solve the full 2D shallow water flow equations. The HPC solver is a fixed grid 2D hydrodynamic solver that uses an explicit finite volume solution scheme that is 2nd order in space and 4th order in time. The solution scheme includes viscosity and sub-grid turbulence terms that other solution schemes do not. Consequently, the HPC solver is well suited to reproducing accurate flood behaviour.

The HPC solver is designed for efficient computation using Graphics Processing Units (GPUs); substantially reducing simulation time. This is advantageous when running large numbers of simulations due to the number of temporal patterns, AEPs or climate scenarios being considered.

Digital elevation model

A digital elevation model (DEM) of the study area was prepared using data from LiDAR survey undertaken in early 2019. LiDAR is a remote sensing method that uses laser pulses to measure the distance to features in the terrain. The laser pulses are obtained and processed to create a 3D model of the landscape. Tonkin reviewed the DEM to ensure it was free of major errors.

The lake was assumed to have an invert of -2 mAHD in the absence of accurate lake bathymetry. This invert is based on the level of the outlet gates. The assumed invert will have no impact on projected flood levels as the initial water level determines the Lake's capacity to store stormwater runoff.

Model setup

Determining an appropriate cell size for the computation grid used by TUFLOW requires a compromise between the resolution of flood mapping and the simulation time and memory required to run the models. Smaller 2D cell sizes more accurately reproduce detailed topography and the hydraulic behaviour, but significantly increase the amount of memory and computational power required to run the model. An understanding of the specific requirements for each study is needed in order to select an appropriate 2D cell size.

A cell size of 4 m was adopted for the modelling. A reivew of the preliminary modelling results was undertaken to confirm that this cell size provides sufficient definition to adequately define the patterns of flooding within the study area.

The selection of an appropriate time step for the numerical solution scheme is critically important to the accuracy of the model output. Time steps that are too large may result in overestimation of the derivatives within the model which decreases the numerical accuracy of the computations. The choice of a smaller time step helps prevent numerical diffusion but increases the simulation time of models. An appropriate time step will balance simulation time with the model's stability and numerical accuracy.

For this study, use of the TUFLOW HPC solver meant that the timestep was adaptively selected by the solver as the simulation progressed.

Boundary and initial conditions

The adopted initial conditions and boundary conditions were the same as was used for the 2070 scenario that was modelled for the Western Adelaide Region Climate Adaptation Plan.

The downstream boundary condition at the outlet of West Lakes was set using a Mean High Water Springs tide cycle (based on recorded tide data) with a 0.5 m sea level rise added. Modelling of each flood event was undertaken such that the tide was timed to rise with the rising water level in the Lake system. This simulates the situation where the beginning of the main storm outflow coincides with the rise of the first high tide, a situation which is most likely to result in the highest flood level in the lake.

The initial water level in the lake was set to -0.34 mAHD. This was on the basis of water balance modelling that was undertaken as part of the Western Adelaide Region Climate Adaptation Plan.

The inflow hydrographs generated in DRAINS were applied at each inlet pit within the study area.

Surface Roughness

Within TUFLOW a land use (materials) layer is utilised to import surface roughness information into the model. A materials layer for the catchment was constructed by utilising cadastre data in conjunction with aerial photography. The following Manning's 'n' values were used:

- 0.2 (Houses/ residential areas);
- 0.3 (Medium density residential and commercial/Industrial);
- 0.03 (Roads/ carparks);
- 0.035 (Grassed areas and bare ground);
- 0.045 (Parklands, scattered trees);
- 0.014 (Concrete lined open channels)

1D Drainage network preparation

The drainage network consists mostly of underground pipes and culverts with an open channel section along Grange Lakes.

The 1D network from the previous TUFLOW modelling was used as a basis for the West Lakes SMP model. During the model development phase, the pipe sizes and locations in the previously modelled network were compared to Council provided GIS data of the current stormwater network (conduits and inlet structures). The 1D network in the TUFLOW model was updated to reflect the information provided by Council.

Inlet pits were modelled using head-flow relationships to provide a good estimate of the inlet capacity of each pit. Different curves were created for single, double and triple side entry pits (SEPs) as well as 600×600 and 450×450 grated inlet pits (GIPs). This allowed the inflows to pass directly into the drainage network until the pit or pipe capacity was exceeded, with the excess spilling into the street network (2D floodplain).

Due to the broad scale objective of this flood study, no specific allowance has been made to account for pit blockages. Given that the capacity of the pipes is limiting across the study area, it is not considered that this will impact the results of the floodplain mapping and associated recommendations.

Limitations of the modelling

While every care has been taken with the preparation of the models and the choice of the adopted parameters, all hydrological and hydraulic modelling has an inherent level of uncertainty. This is due to a number of factors including the following:

- The accuracy and resolution of the DEM used and the interpretation of this information by the hydraulic model.
- Uncertainty in the rainfall pattern and catchment conditions prior to a flood. Actual flood events are dependent on the antecedent moisture conditions prior to rainfall, initial detention storage levels at the beginning of rainfall runoff and the intensity and uniformity of the rainfall event itself. The floods modelled by this study are based on design storm bursts which attempt to reproduce the expected average temporal pattern of a storm burst within specified rainfall zones (see AR&R for greater explanation). As such, individual rainfall events may exhibit a differing temporal pattern than those modelled.
- Estimation of input parameters to the model (such as runoff coefficients, times of concentration, Manning's roughness, entry and exit losses).
- Lack of gauging data available for calibration of the hydrologic and hydraulic models.
- Availability and quality of drainage infrastructure data.

The aforementioned limitations are considered typical of limitations associated with flood modelling and mapping, and in computer simulation of complex natural processes. It is not considered that these limitations will impact on the resultant flood mapping and recommendations for works.

Validation of the modelling

In the absence of recorded flow data to calibrate the model, the results of the initial floodplain mapping were compared with Council records of historical flooding complaints and Council staff's knowledge of flooding 'hotspots'. Reflecting the fact that the modelling considers an increased state of development relative to the existing catchment, the results of the modelling for the more frequent events (e.g. 0.5 EY) were considered.

In collaboration with Council, the modelling (in particular the pit and pipe network) was refined during the process of validation. The resultant floodplain maps are considered to provide an accurate representation of flooding issues within the catchment.

Floodplain map generation

During each model run, the peak flood depth and hazard category was recorded across the 2D model domain. Once modelling was complete, the results from each duration were spliced together to create a maximum depth and hazard envelope for each flood event.

Flood inundation and hazard maps were produced so that the impact of flooding could be visually analysed. The flood depth data was classified into discrete intervals to allow for easy discrimination of flood depths. Flooding less than 25 mm deep is not shown as it is not considered relevant to the wider flood map.

Appendix C – Flood inundation and hazard maps

Disclaimer

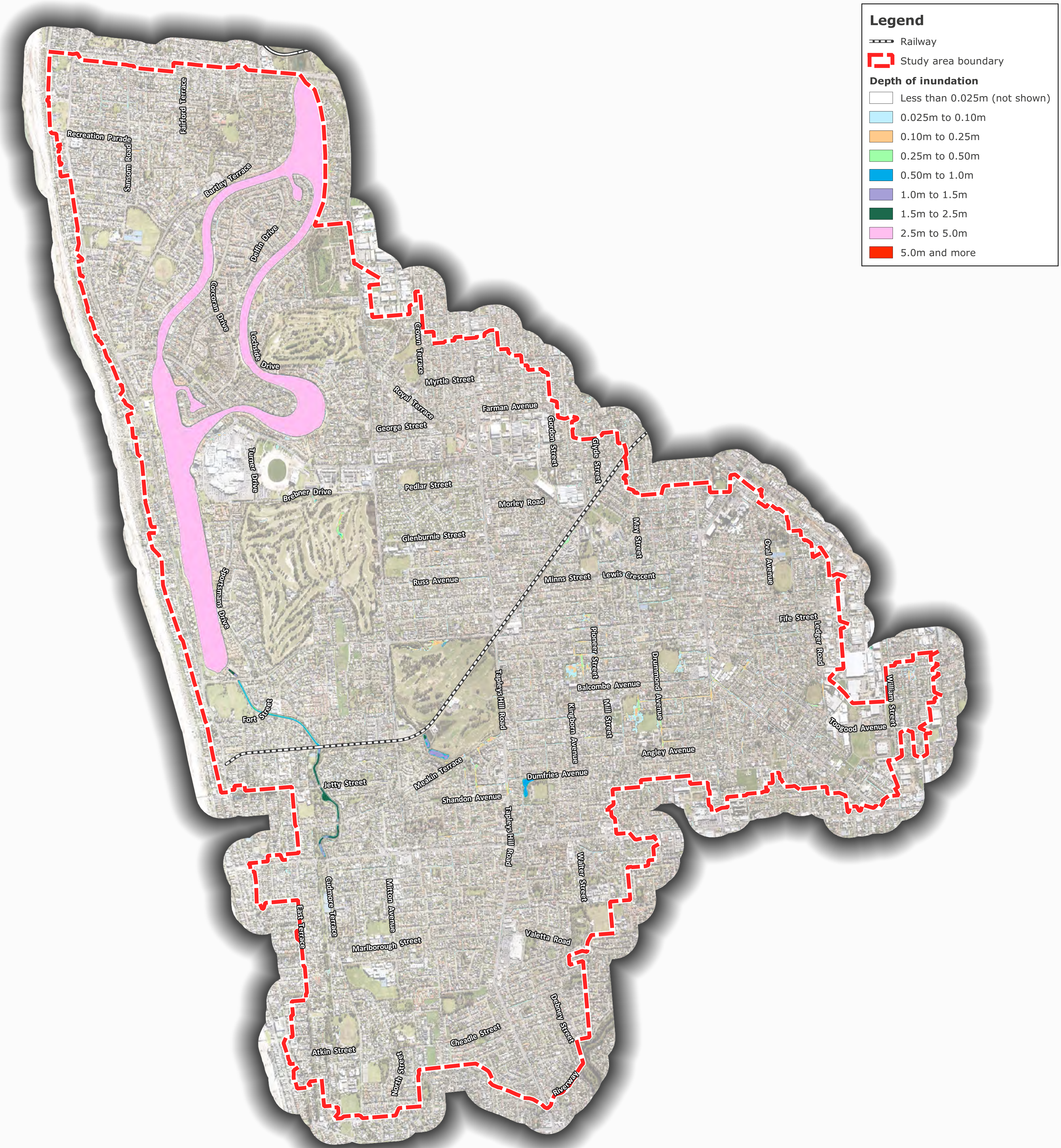
This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown on this map is not a boundary between flood prone and flood free land. Land outside the flood extent shown on this map could be affected by:

- Floods with a different Annual Exceedence Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damage alleged to be suffered by anyone as a result of the publication of the map, and the notations on it, or as a result of the use or misuse of the information provided herein.

More detail can be found in the report associated with this study.



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Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
63% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 1

Disclaimer

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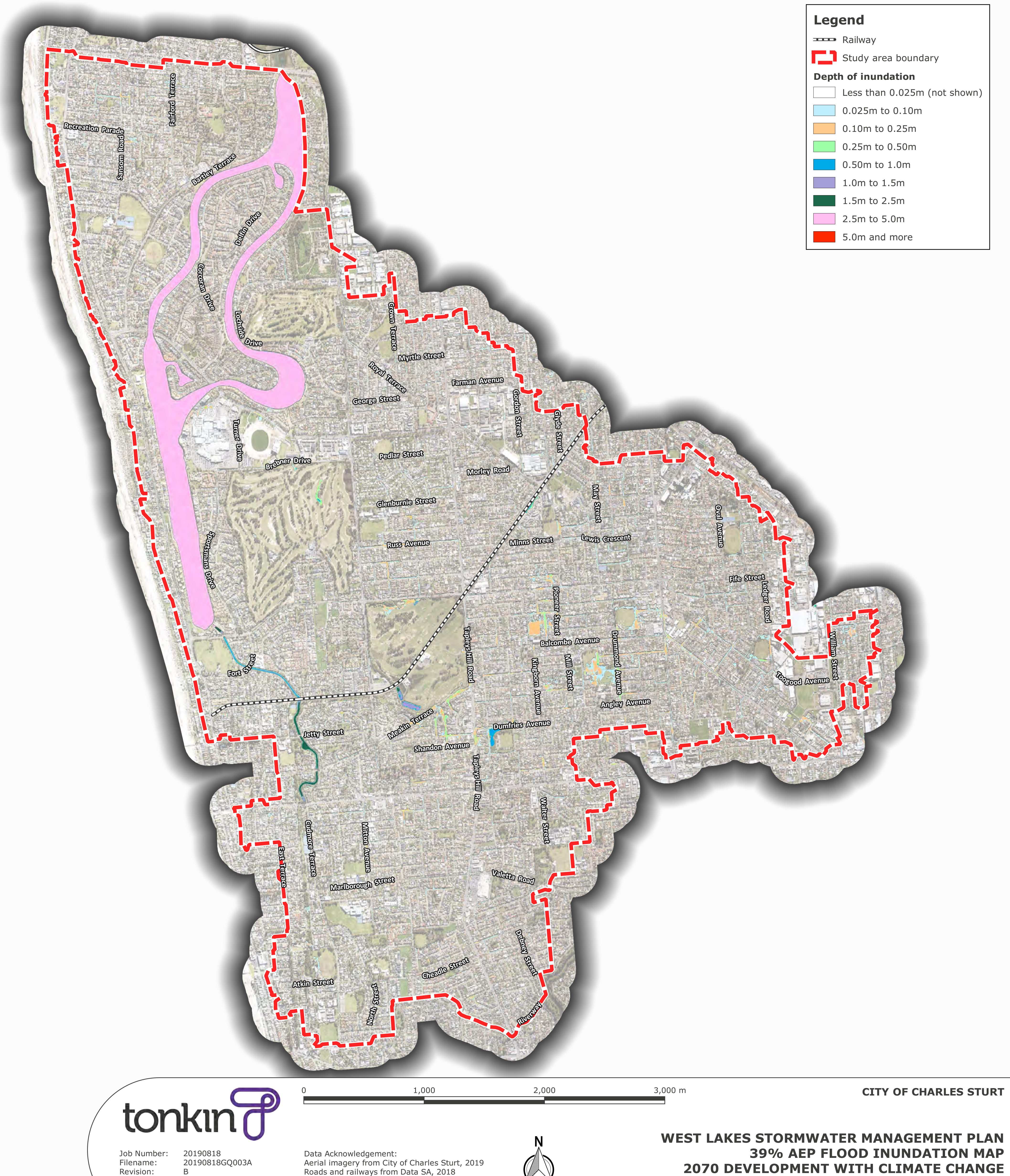

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
39% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 2

Disclaimer

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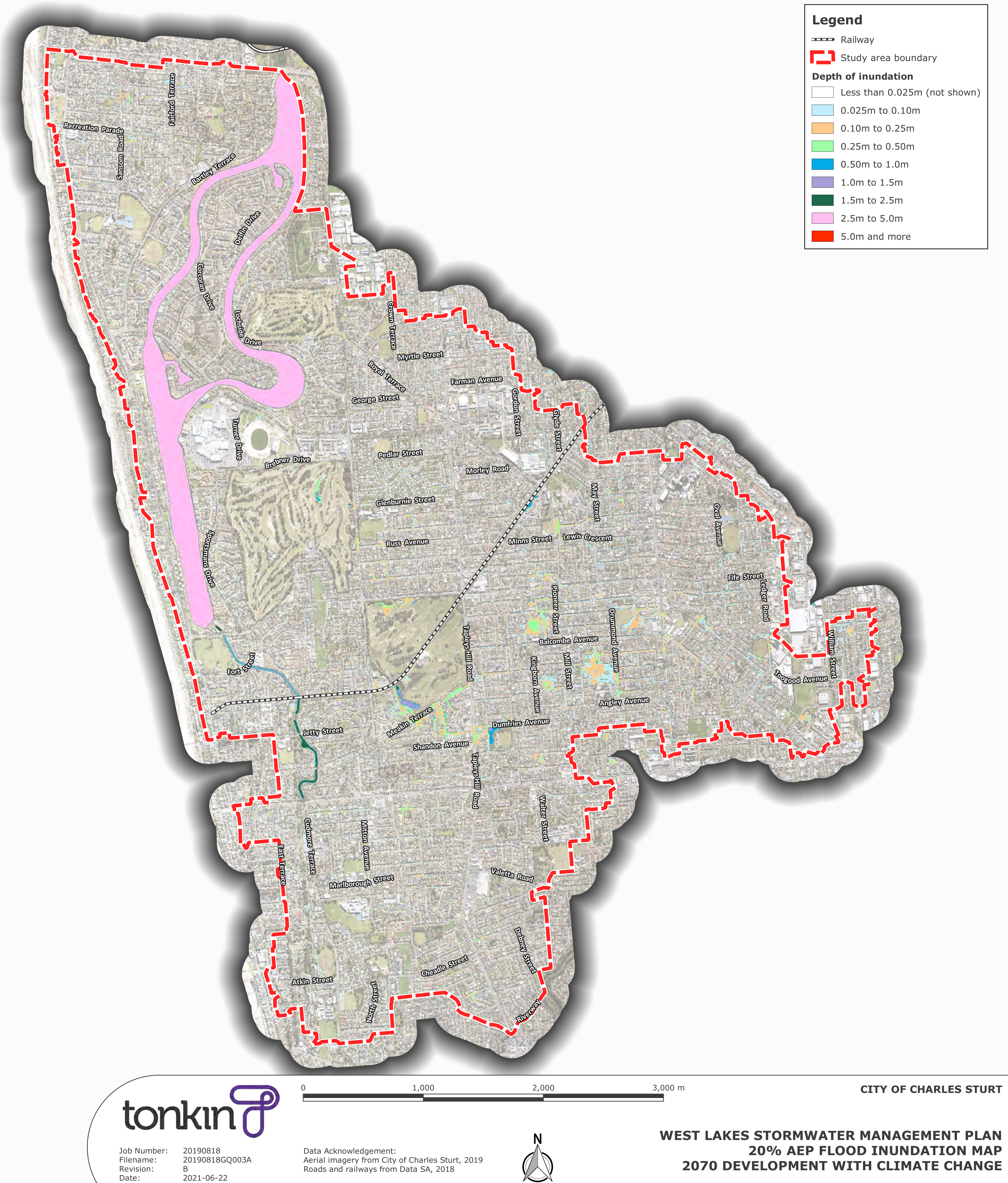

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
20% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 3

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown on this map is not a boundary between flood prone and flood free land. Land outside the flood extent shown on this map could be affected by:

- Floods with a different Annual Exceedence Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
10% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 4

Disclaimer

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- Floods with a different Annual Exceedence Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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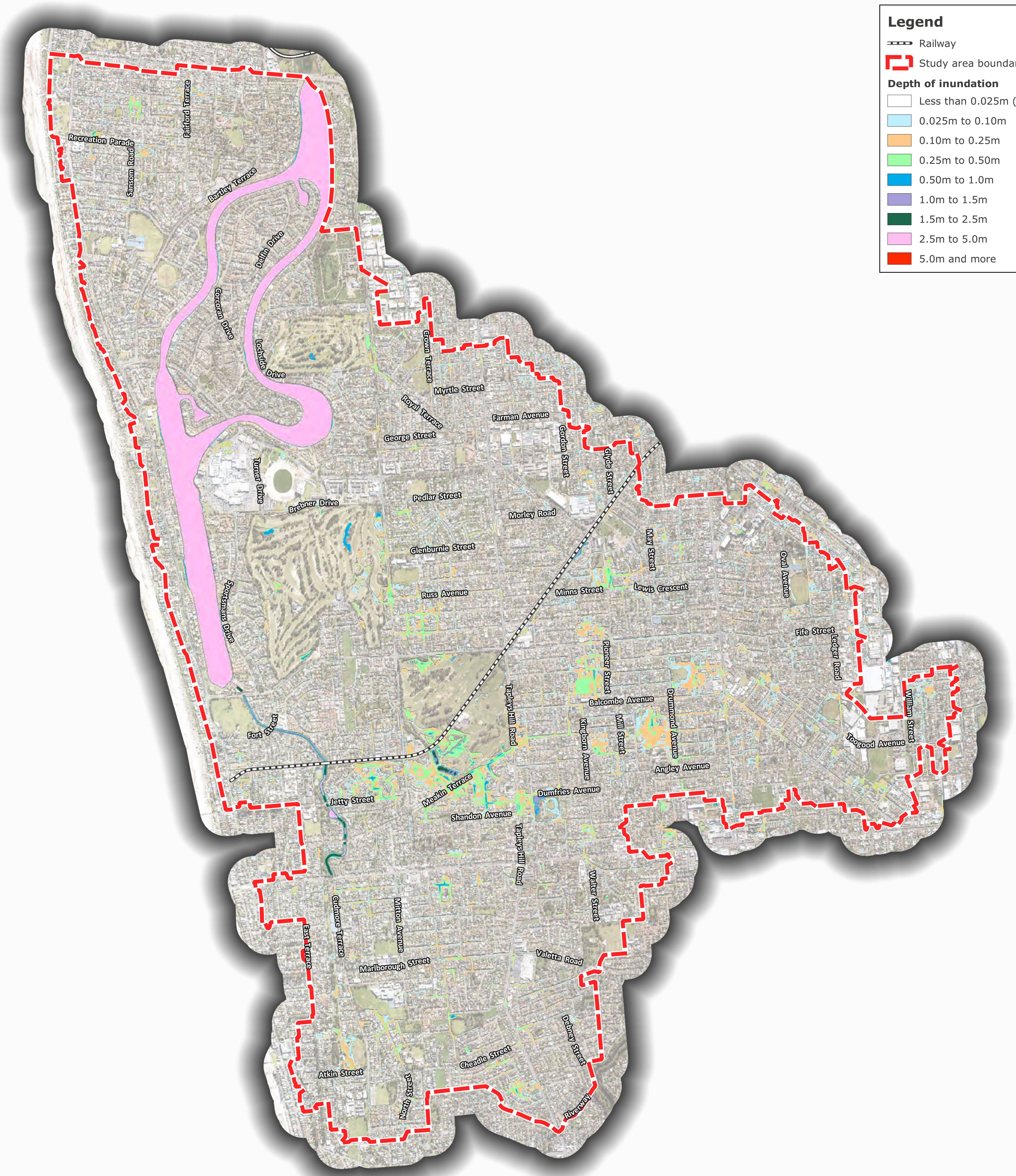

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

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Roads and railways from Data SA, 2018

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
5% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown on this map is not a boundary between flood prone and flood free land. Land outside the flood extent shown on this map could be affected by:

- Floods with a different Annual Exceedence Probability (AEP).
- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

The flood extents shown are a prediction of land subject to a specific level of flood risk and do not necessarily indicate a threat to buildings located on that land. Confidence in the prediction is reduced in areas affected by flood depths less than 0.1 m, due to the effects of fences, walls, buildings and landscaping which affect the flow of floodwaters. Such effects, which require detailed modelling, are beyond the capabilities of the modelling process. Flood assessment for particular sites will require more detailed interpretation, survey and analysis by qualified and experienced persons.

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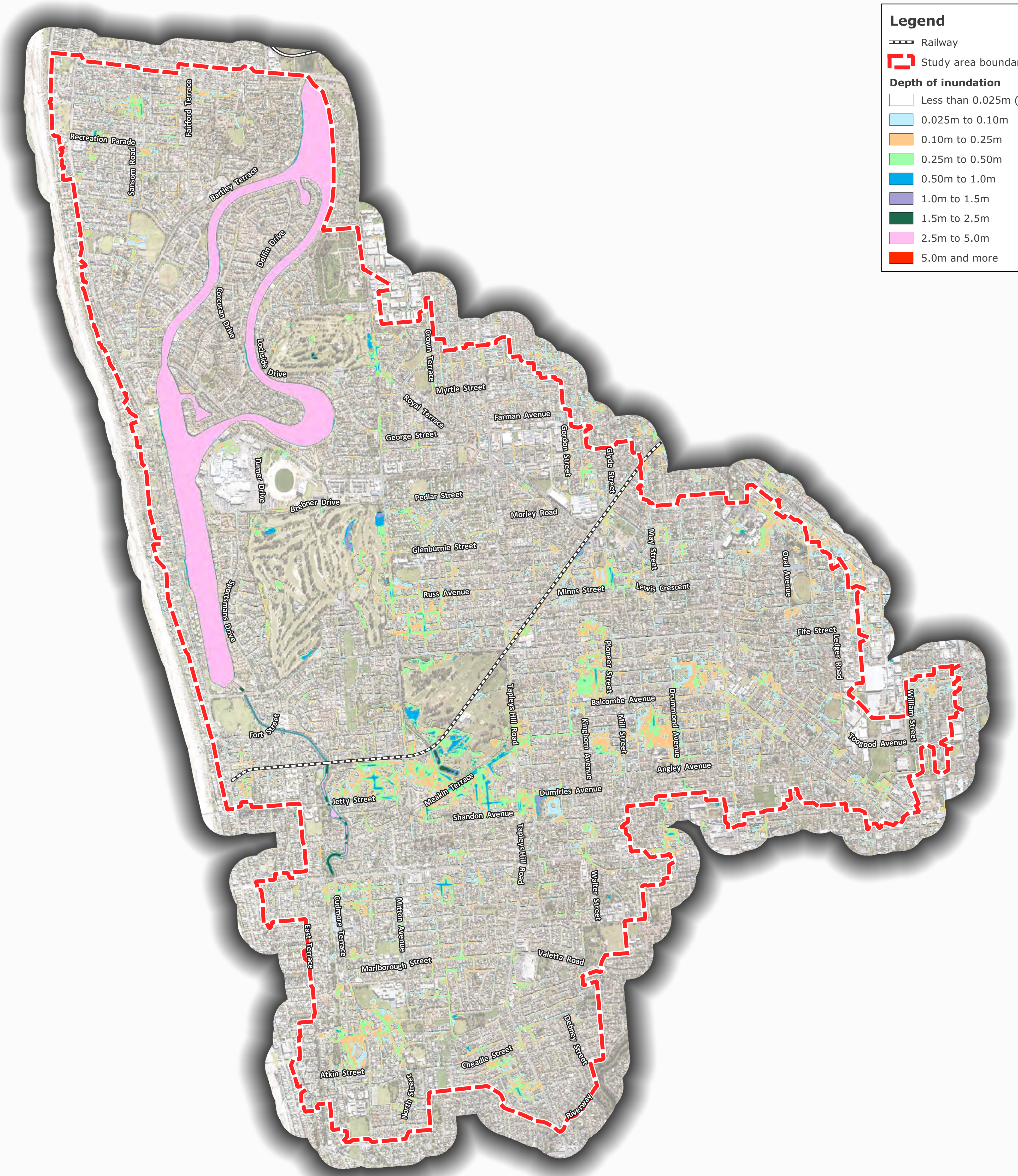

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 1,000 2,000 3,000 m

tonkin

Job Number: 20190818
Filename: 20190818GQ003A
Revision: B
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
2% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 6

Disclaimer

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- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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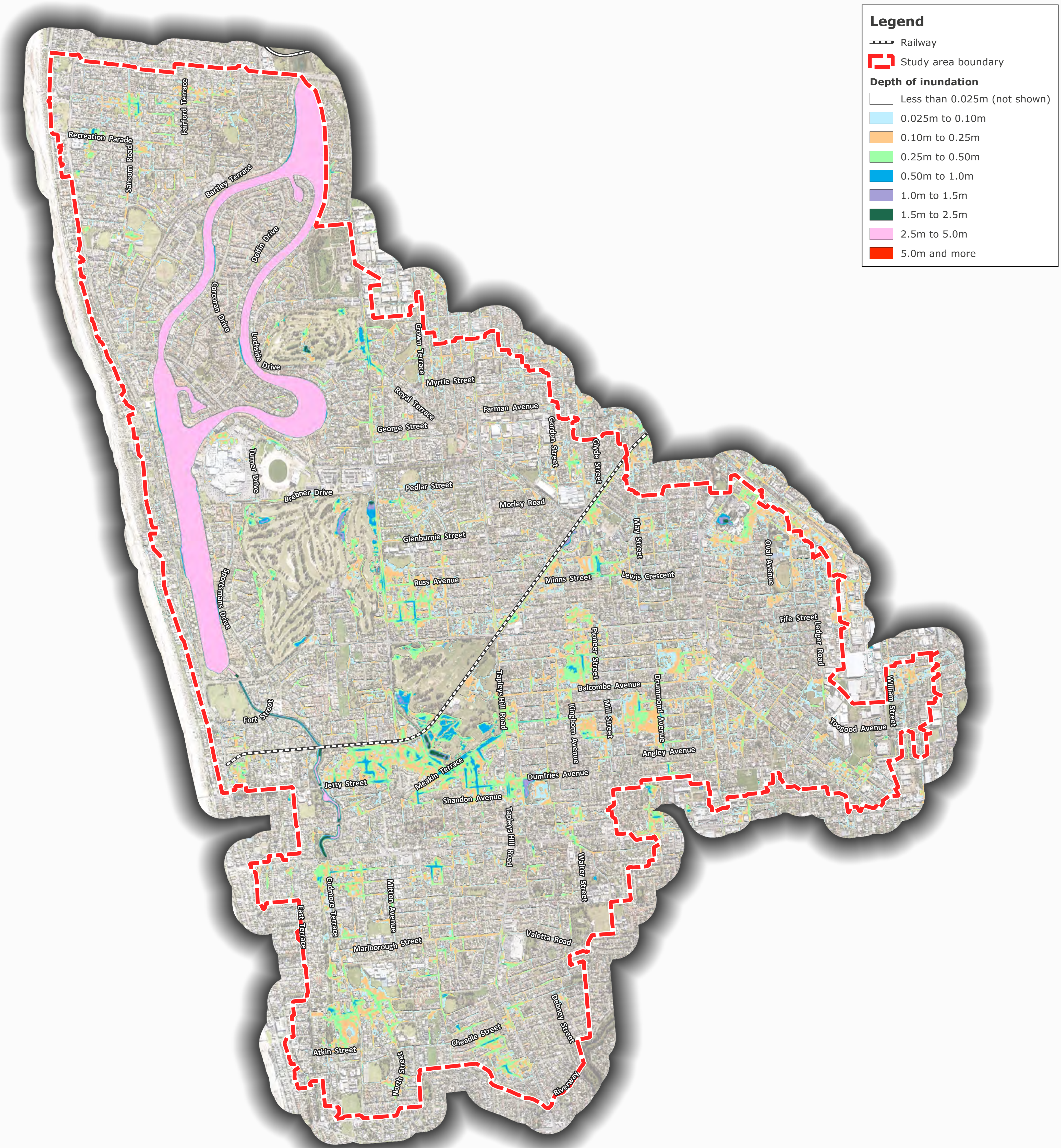

0 1,000 2,000 3,000 m

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Job Number:	20190818
Filename:	20190818GQ003A
Revision:	B
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

N

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
1% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 7

Disclaimer

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- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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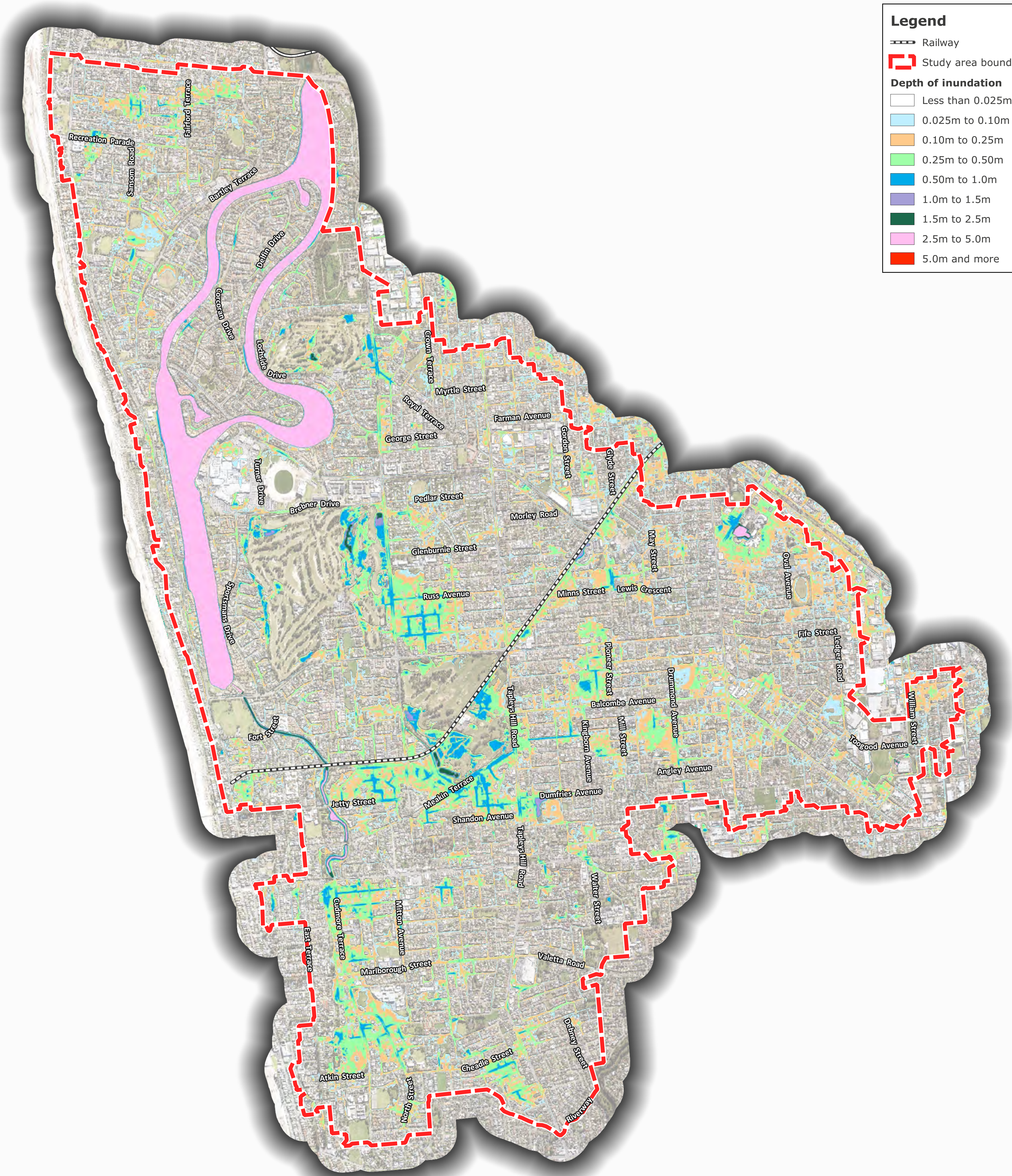

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 1,000 2,000 3,000 m

CITY OF CHARLES STURT

Job Number:	20190818
Filename:	20190818GQ003A
Revision:	B
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

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WEST LAKES STORMWATER MANAGEMENT PLAN
0.2% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 8

Disclaimer

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- Blockage in drainage systems, creeks or culverts caused by vegetation or other debris carried by floodwaters.
- Further development, earthworks and other changes to the catchment that alter the actual flood extents.

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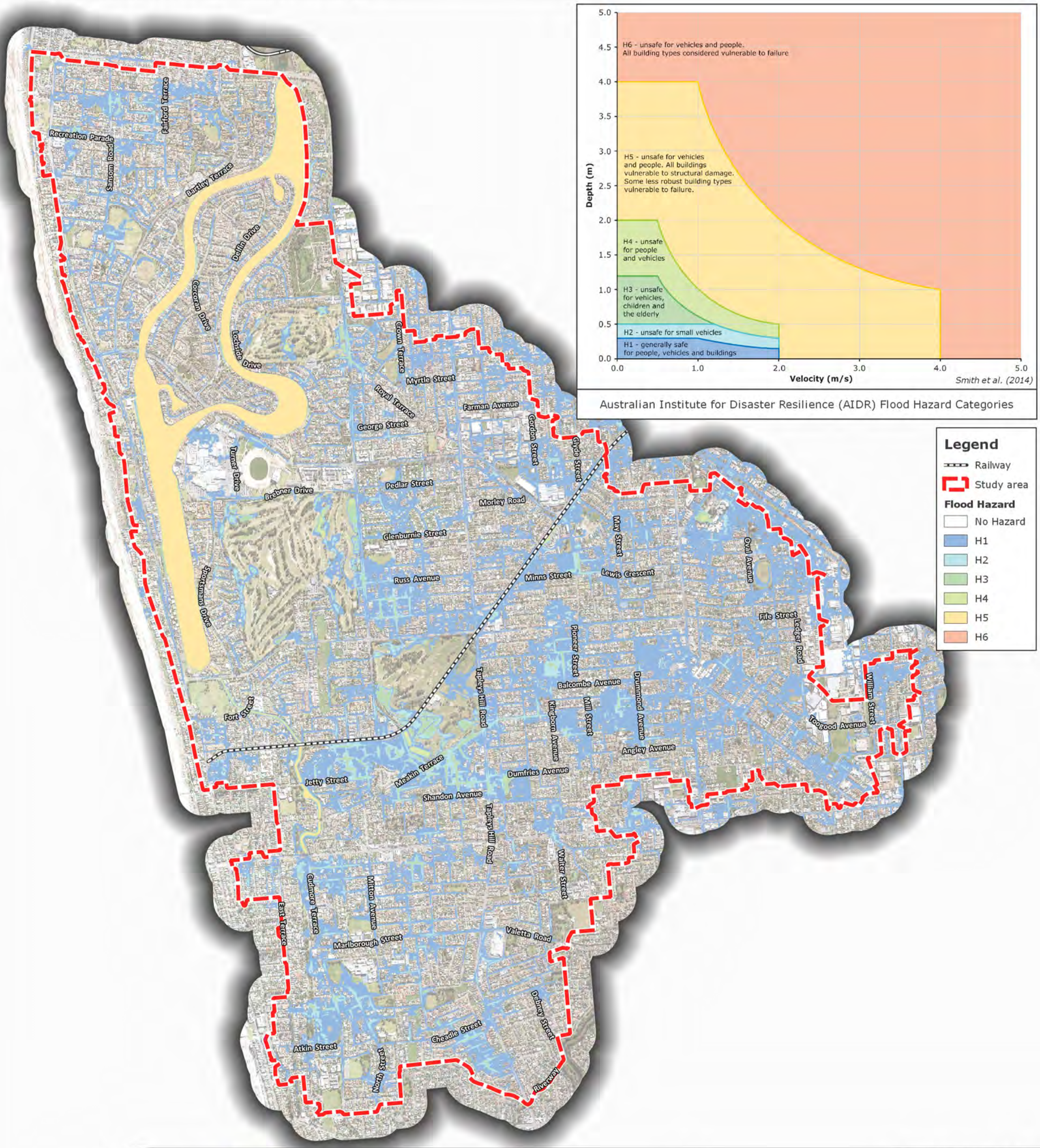

Australian Institute for Disaster Resilience (AIDR) Flood Hazard Categories

0 1,000 2,000 3,000 m

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Job Number: 20190818
Filename: 20190818GQ003A
Revision: B
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
1% AEP FLOOD HAZARD MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE

Map 9

Disclaimer

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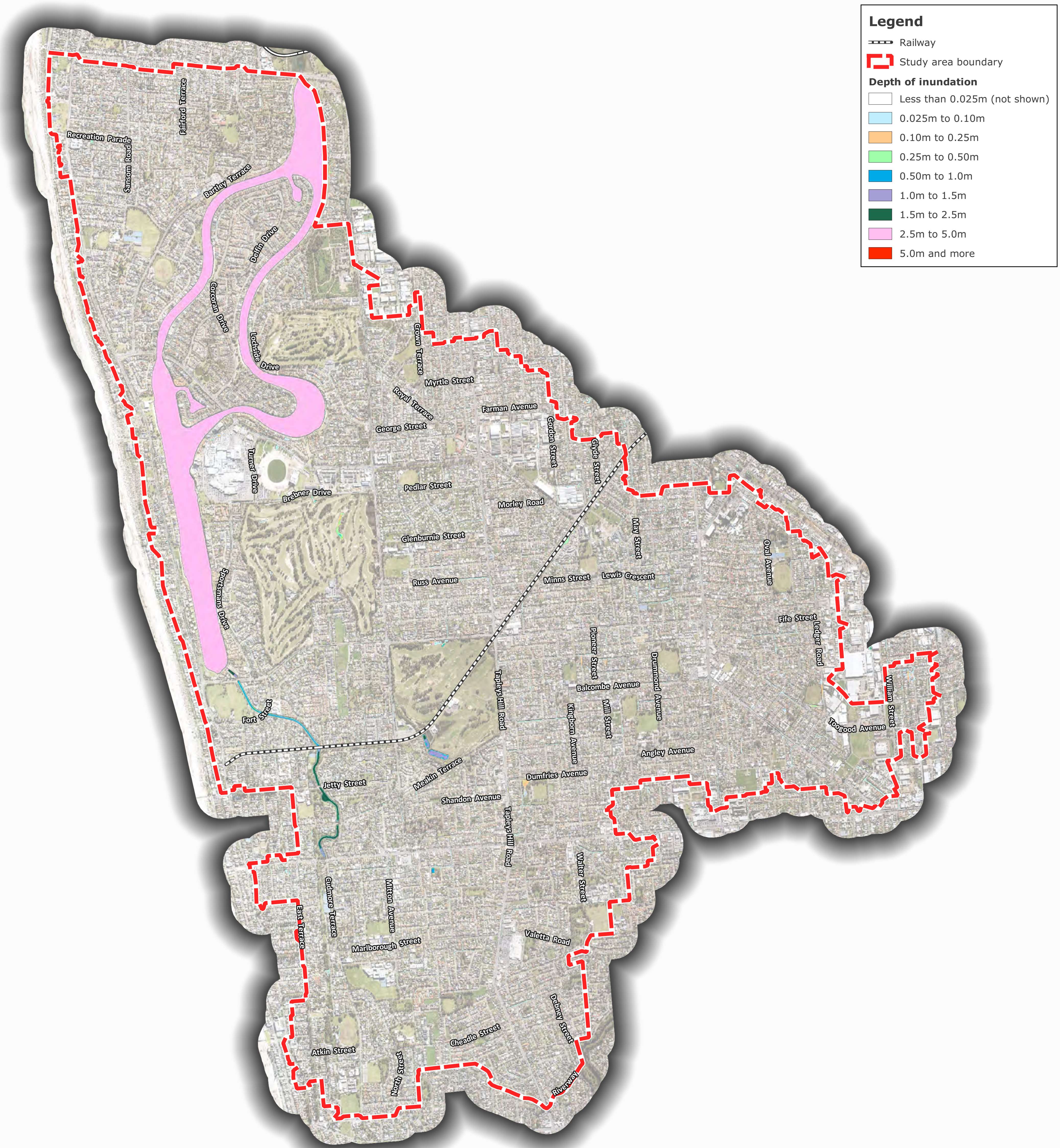

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Revision: A
Date: 2021-06-22
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Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
63% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 10

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown on this map is not a boundary between flood prone and flood free land. Land outside the flood extent shown on this map could be affected by:

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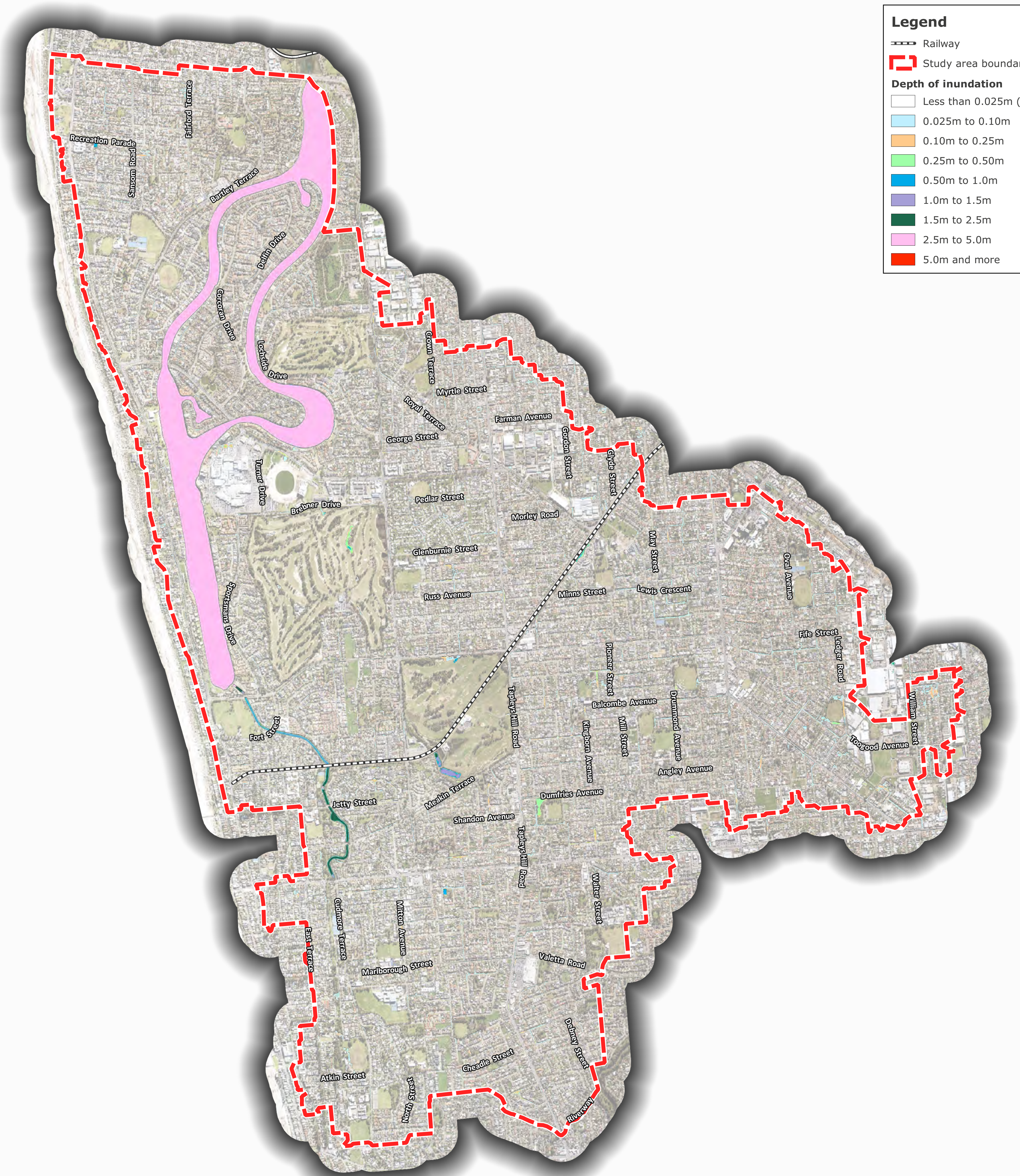

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 1,000 2,000 3,000 m

N

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Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
39% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 11

Disclaimer

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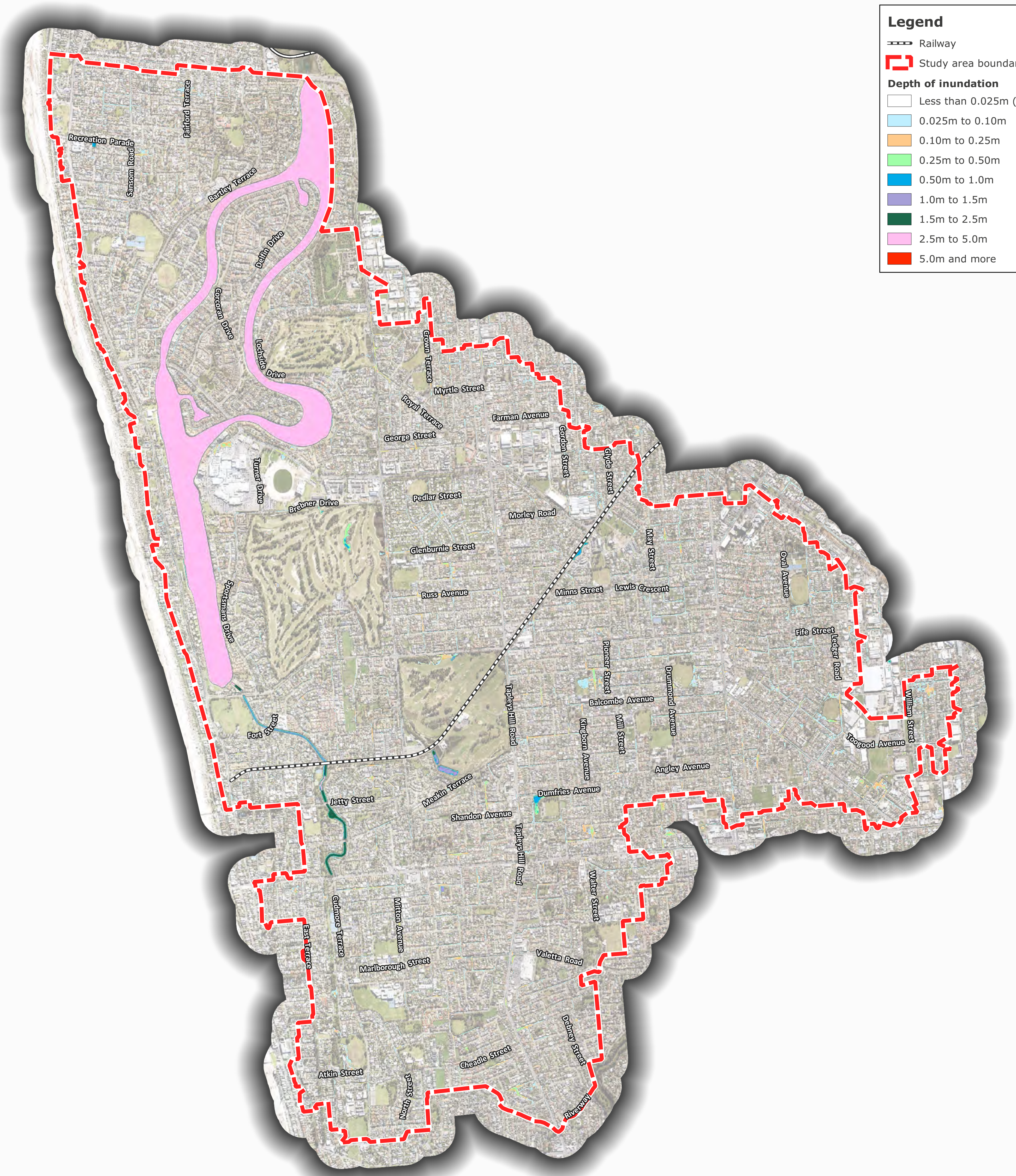

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

tonkin

Job Number:	20190818
Filename:	20190818GQ003A
Revision:	A
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Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
20% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 12

Disclaimer

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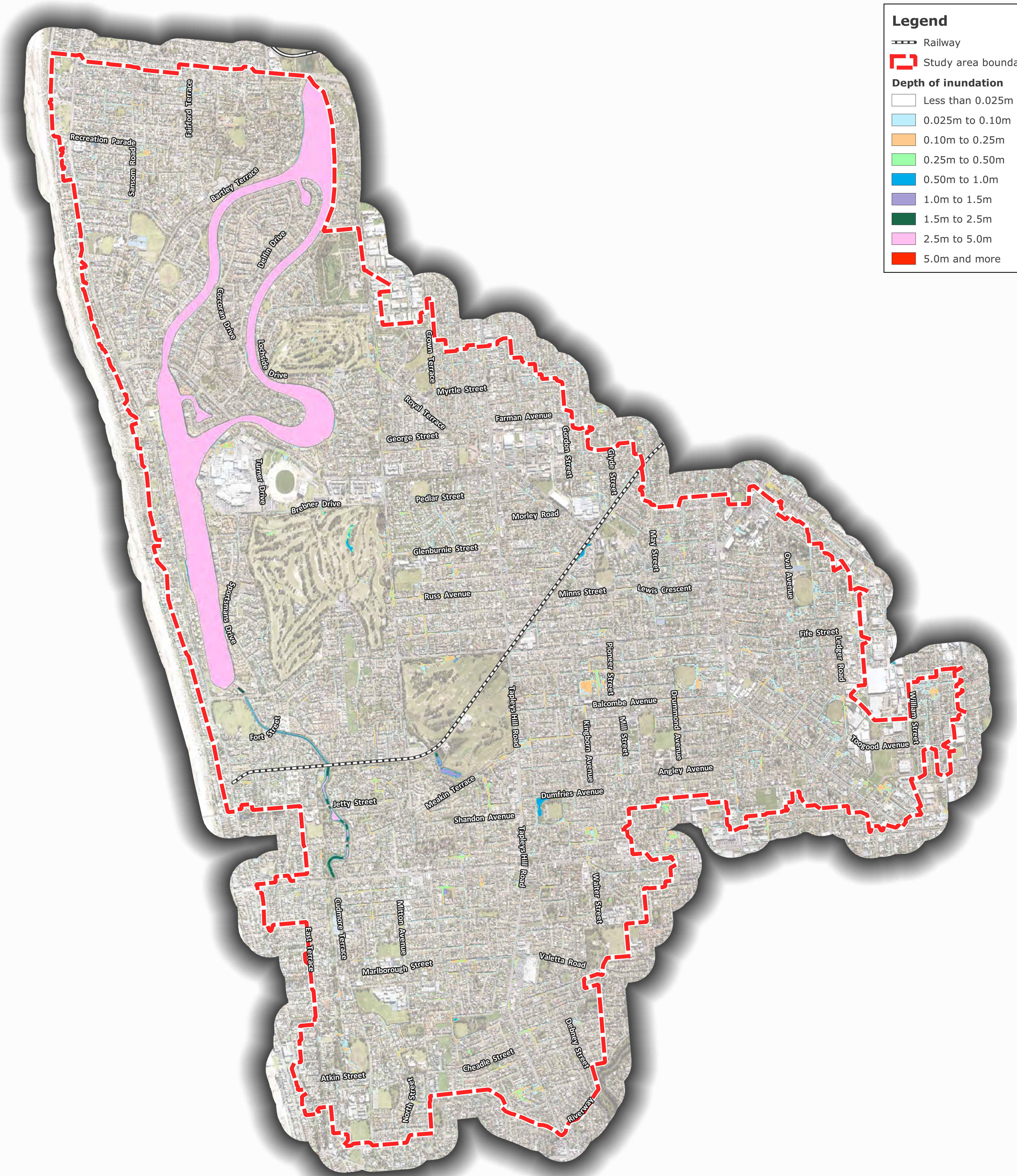

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

tonkin

Job Number:	20190818
Filename:	20190818GQ003A
Revision:	A
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
10% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 13

Disclaimer

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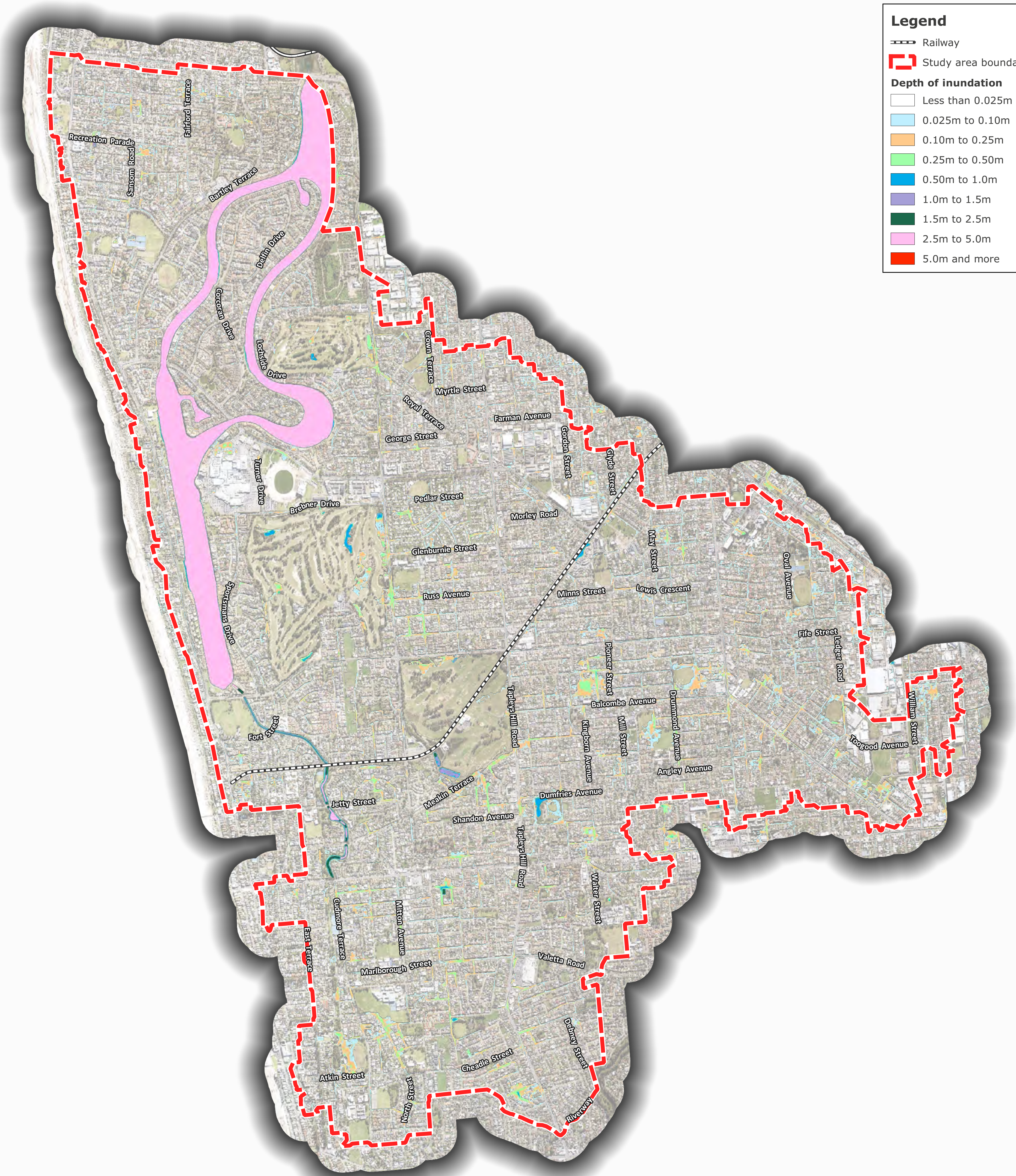

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 1,000 2,000 3,000 m

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Revision:	A
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Drawn:	MM

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Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
5% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 14

Disclaimer

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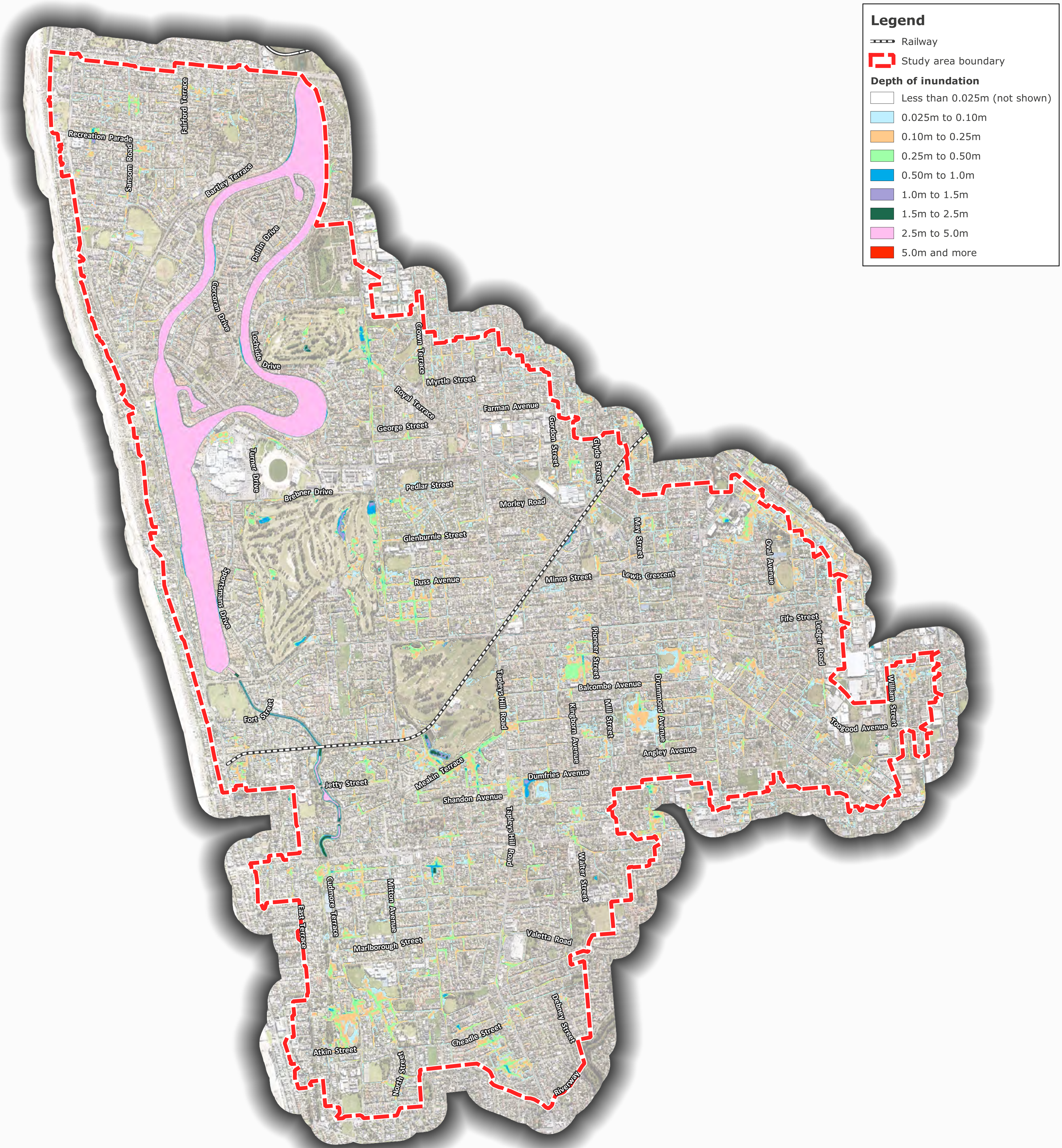

0 1,000 2,000 3,000 m

tonkin

Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

N

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
2% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 15

Disclaimer

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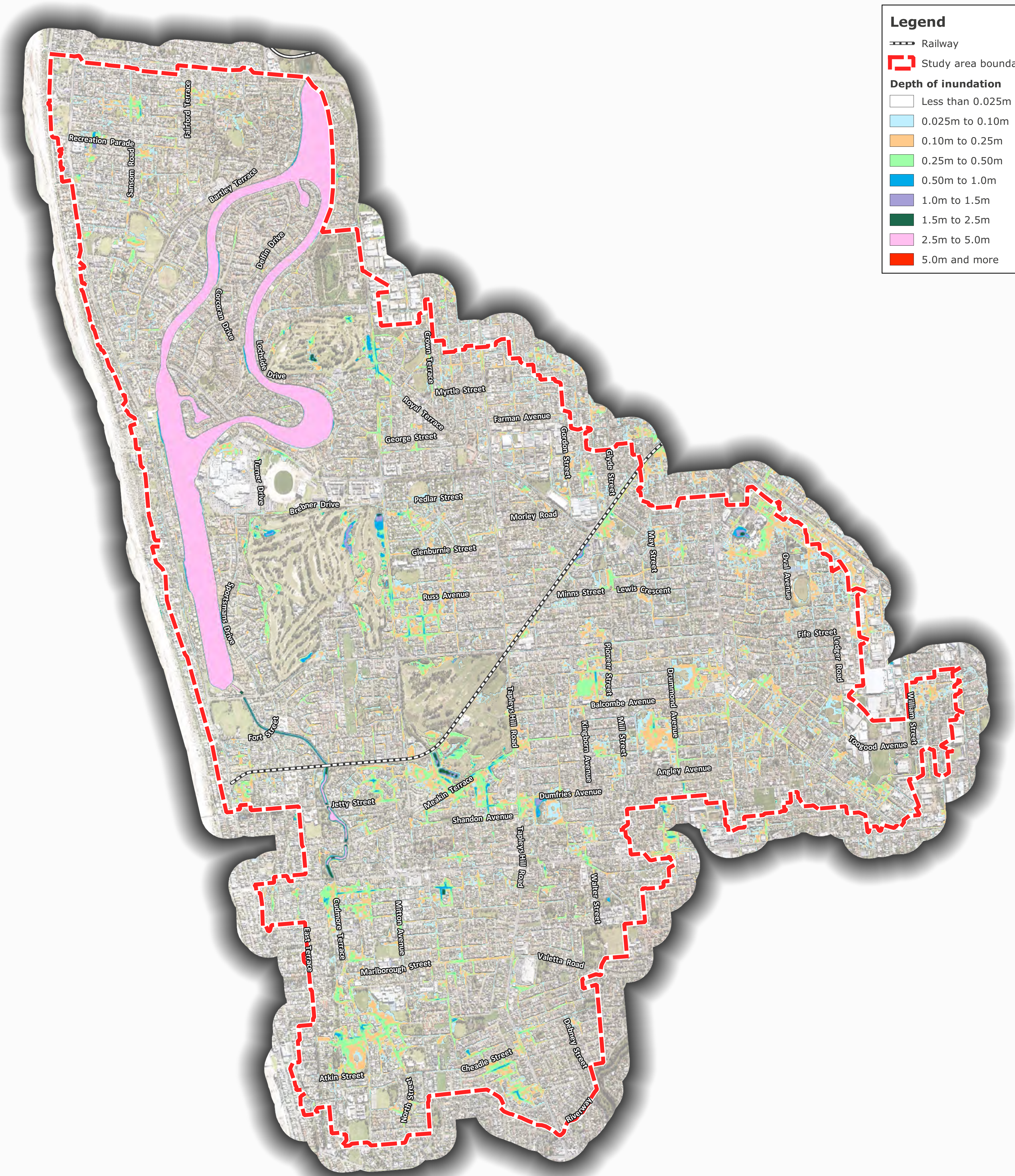

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

0 1,000 2,000 3,000 m

tonkin

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Filename: 20190818GQ003A
Revision: A
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Drawn: MM

Data Acknowledgement:
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Roads and railways from Data SA, 2018

N

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
1% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 16

Disclaimer

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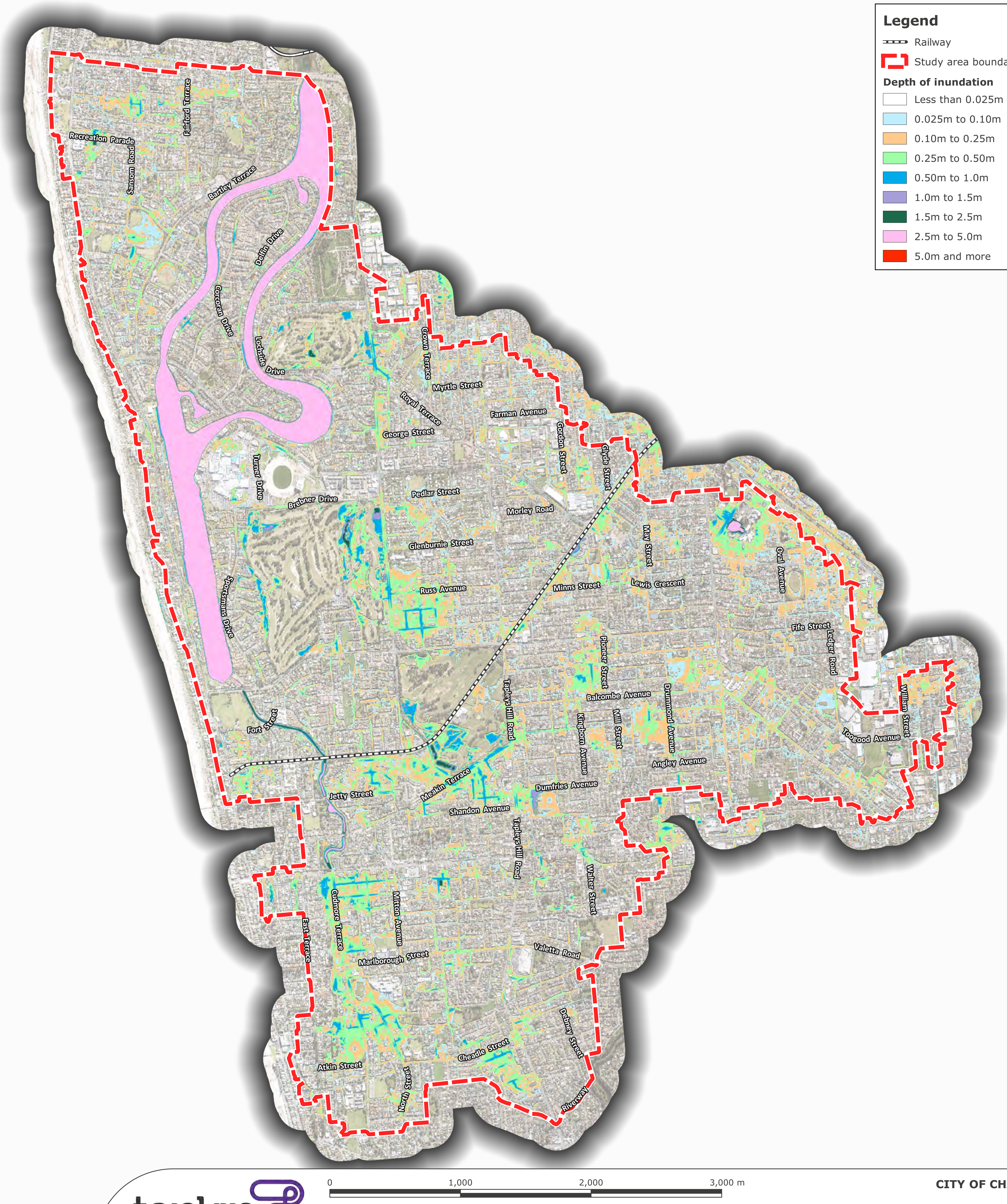

Legend

- Railway
- Study area boundary

Depth of inundation

- Less than 0.025m (not shown)
- 0.025m to 0.10m
- 0.10m to 0.25m
- 0.25m to 0.50m
- 0.50m to 1.0m
- 1.0m to 1.5m
- 1.5m to 2.5m
- 2.5m to 5.0m
- 5.0m and more

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Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
0.2% AEP FLOOD INUNDATION MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Disclaimer

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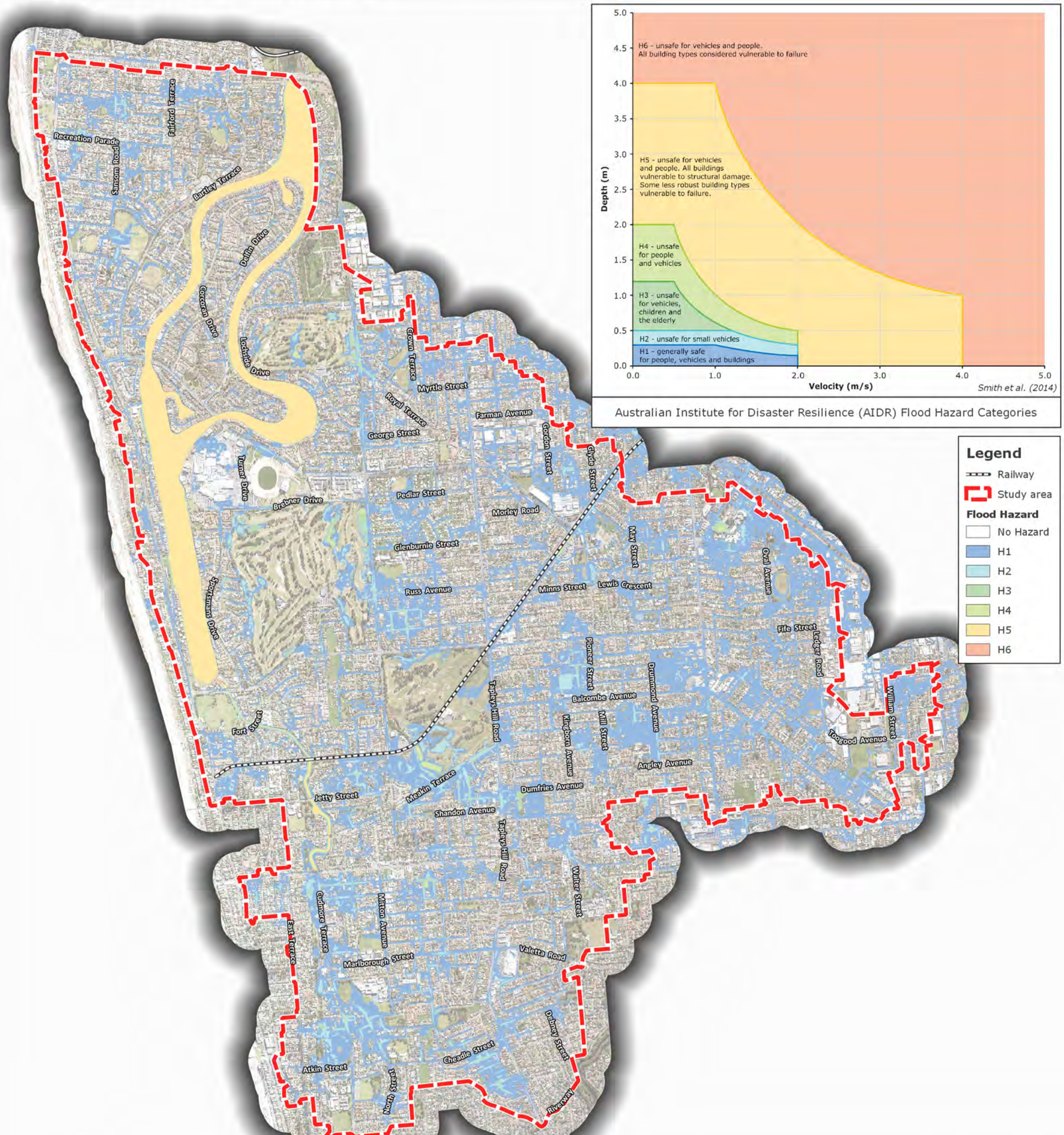

0 1,000 2,000 3,000 m

tonkin

Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
1% AEP FLOOD HAZARD MAP
2070 DEVELOPMENT WITH CLIMATE CHANGE
MITIGATION SCENARIO

Map 18

Disclaimer

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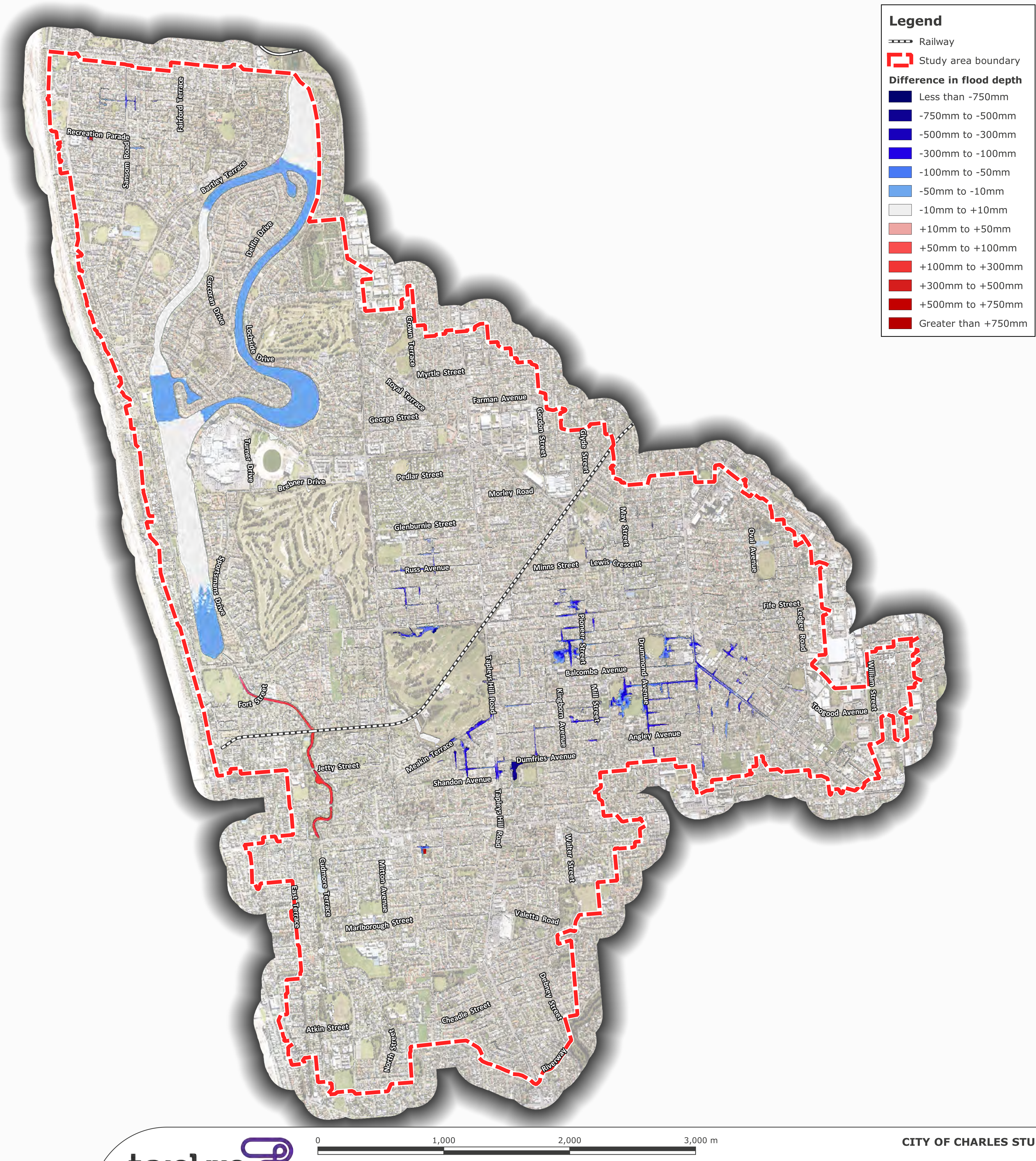

tonkin

Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
63% AEP FLOOD DEPTH DIFFERENCE MAP

Map 19

Disclaimer

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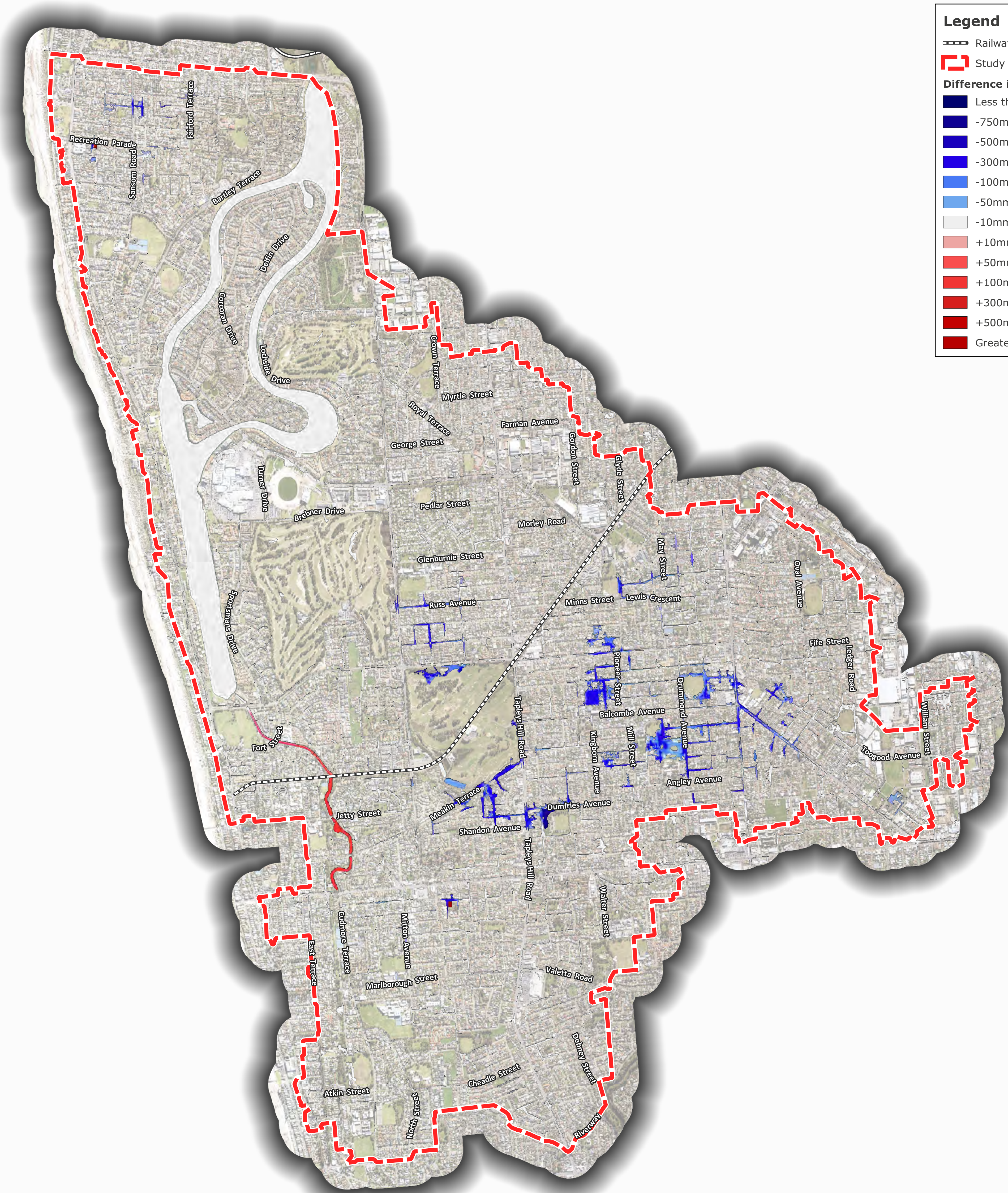

Legend

- Railway
- Study area boundary

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 1,000 2,000 3,000 m

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Job Number:	20190818
Filename:	20190818GQ003A
Revision:	A
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
39% AEP FLOOD DEPTH DIFFERENCE MAP

Disclaimer

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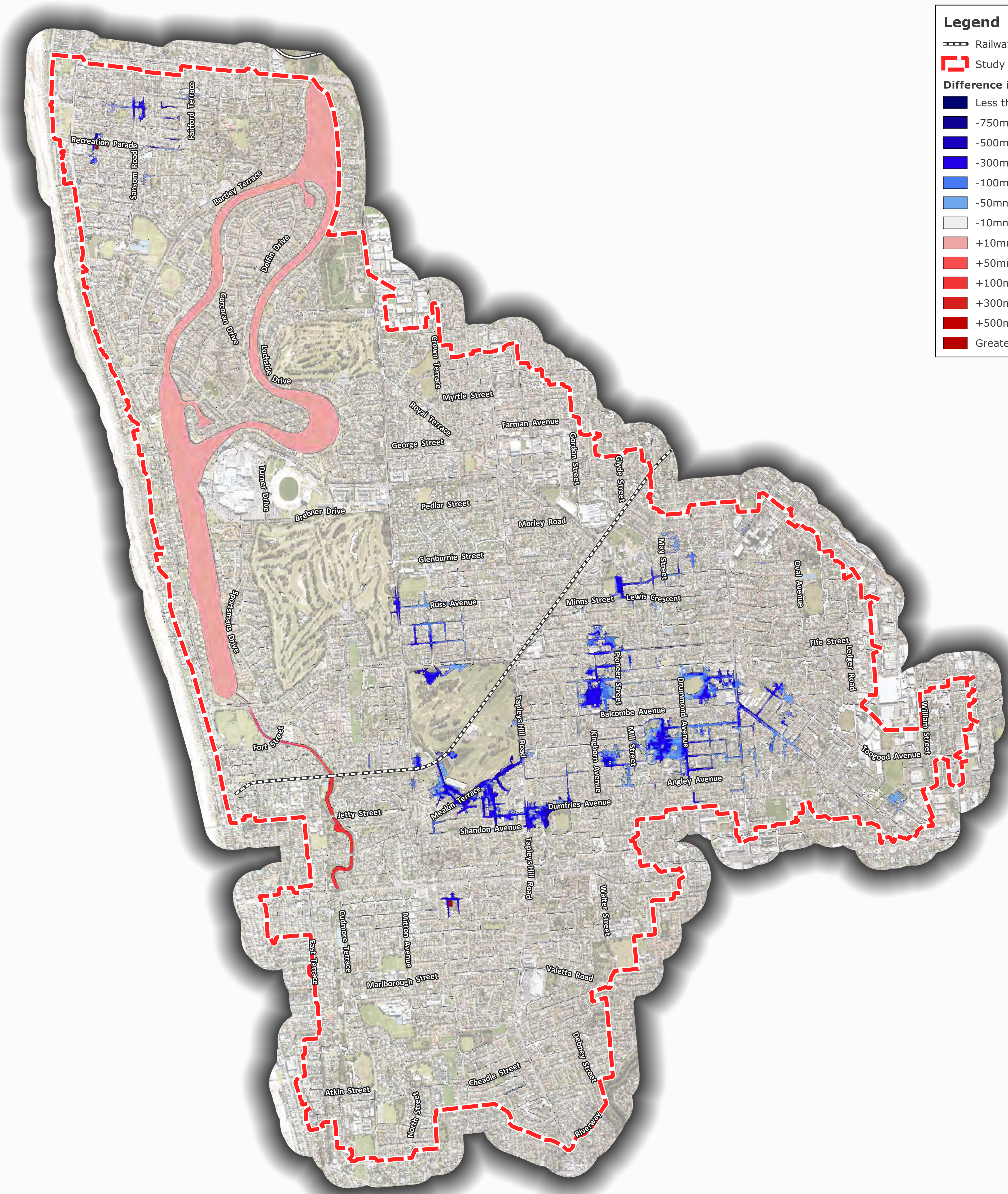

Legend

- Railway
- Study area boundary

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 1,000 2,000 3,000 m

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CITY OF CHARLES STURT

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WEST LAKES STORMWATER MANAGEMENT PLAN
20% AEP FLOOD DEPTH DIFFERENCE MAP

Job Number:	20190818
Filename:	20190818GQ003A
Revision:	A
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

Map 21

Disclaimer

This map has been prepared to a standard of accuracy sufficient for broad scale flood risk management and planning. The flood extents are not based on actual historical floods. The map does not increase the risk or affect the level of flooding over an area or property. The limit of flooding shown on this map is not a boundary between flood prone and flood free land. Land outside the flood extent shown on this map could be affected by:

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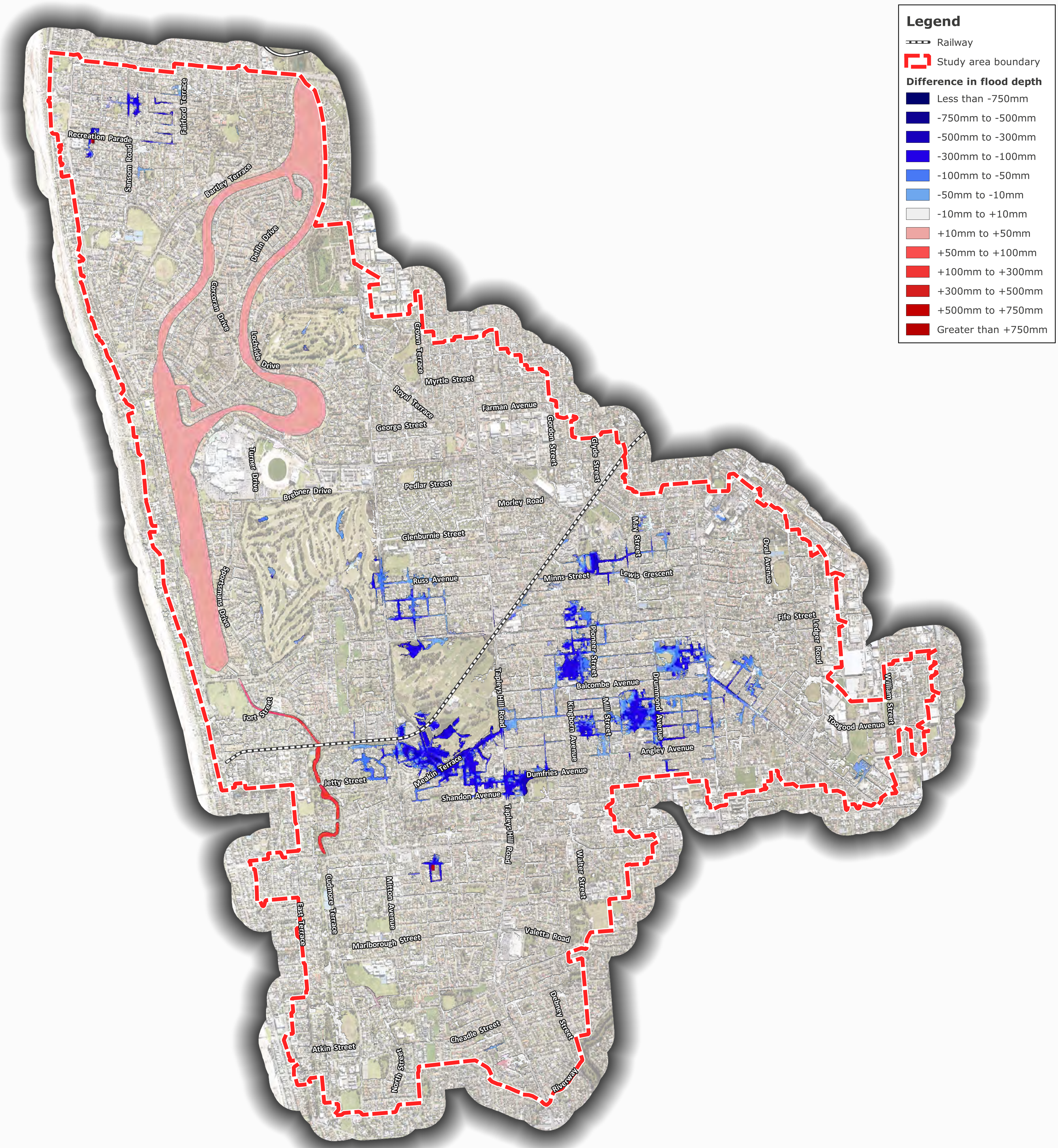

tonkin

Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
10% AEP FLOOD DEPTH DIFFERENCE MAP

Disclaimer

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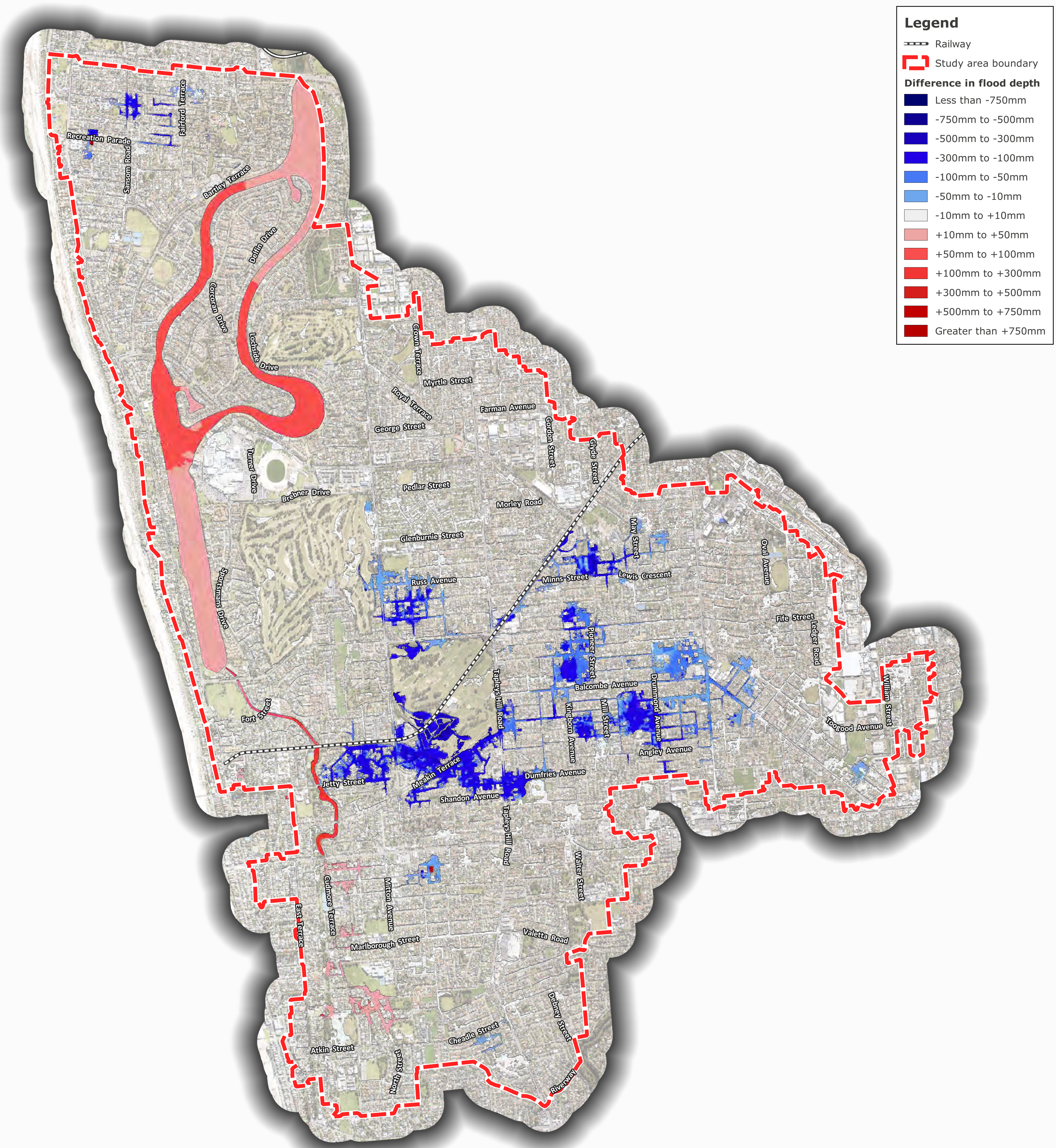

tonkin

Job Number: 20190818
Filename: 20190818GQ003A
Revision: A
Date: 2021-06-22
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
5% AEP FLOOD DEPTH DIFFERENCE MAP

Map 23

Disclaimer

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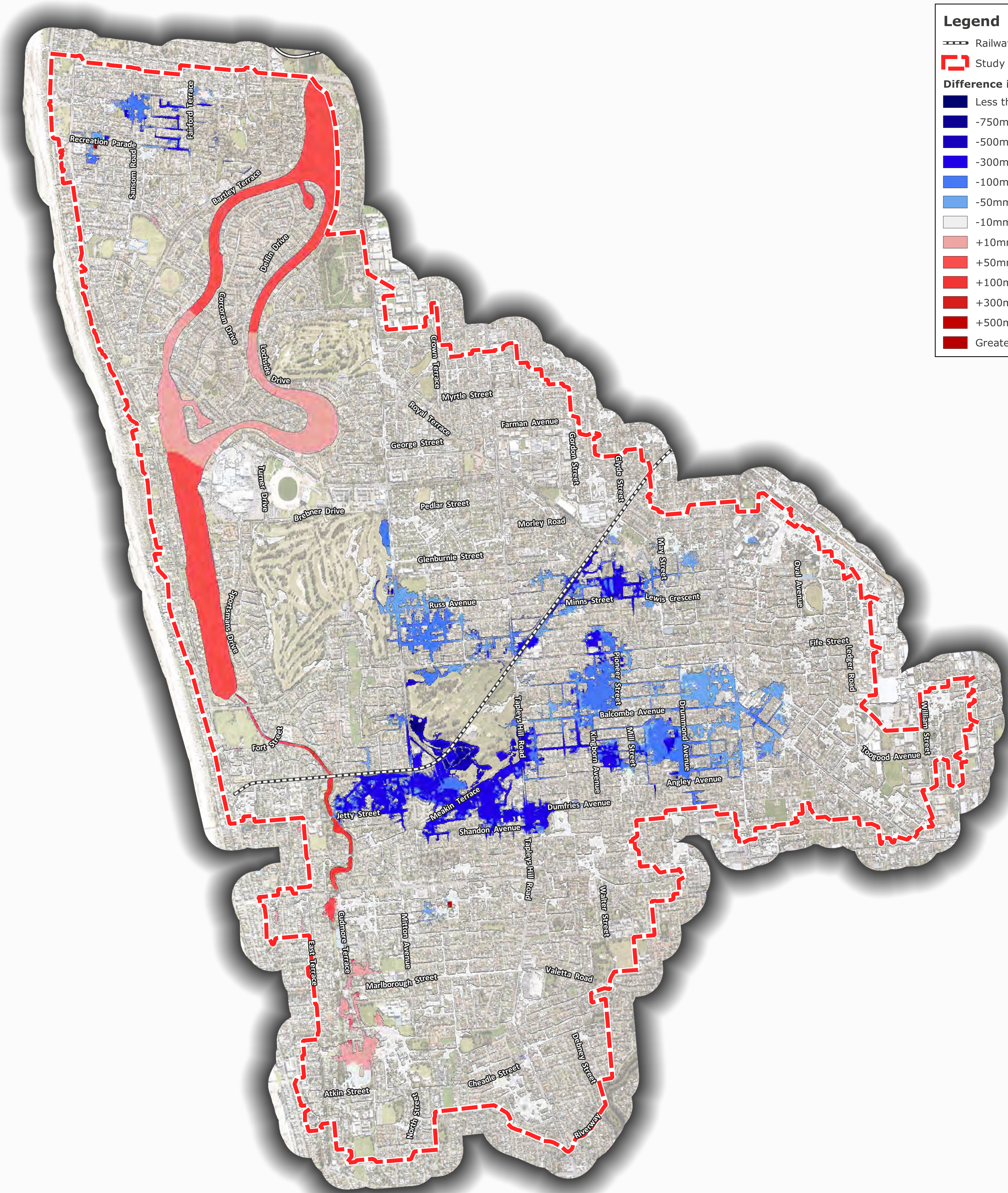

Legend

- Railway
- Study area boundary

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

0 1,000 2,000 3,000 m

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tonkin

Job Number:	20190818
Filename:	20190818GQ003A
Revision:	A
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
2% AEP FLOOD DEPTH DIFFERENCE MAP

Disclaimer

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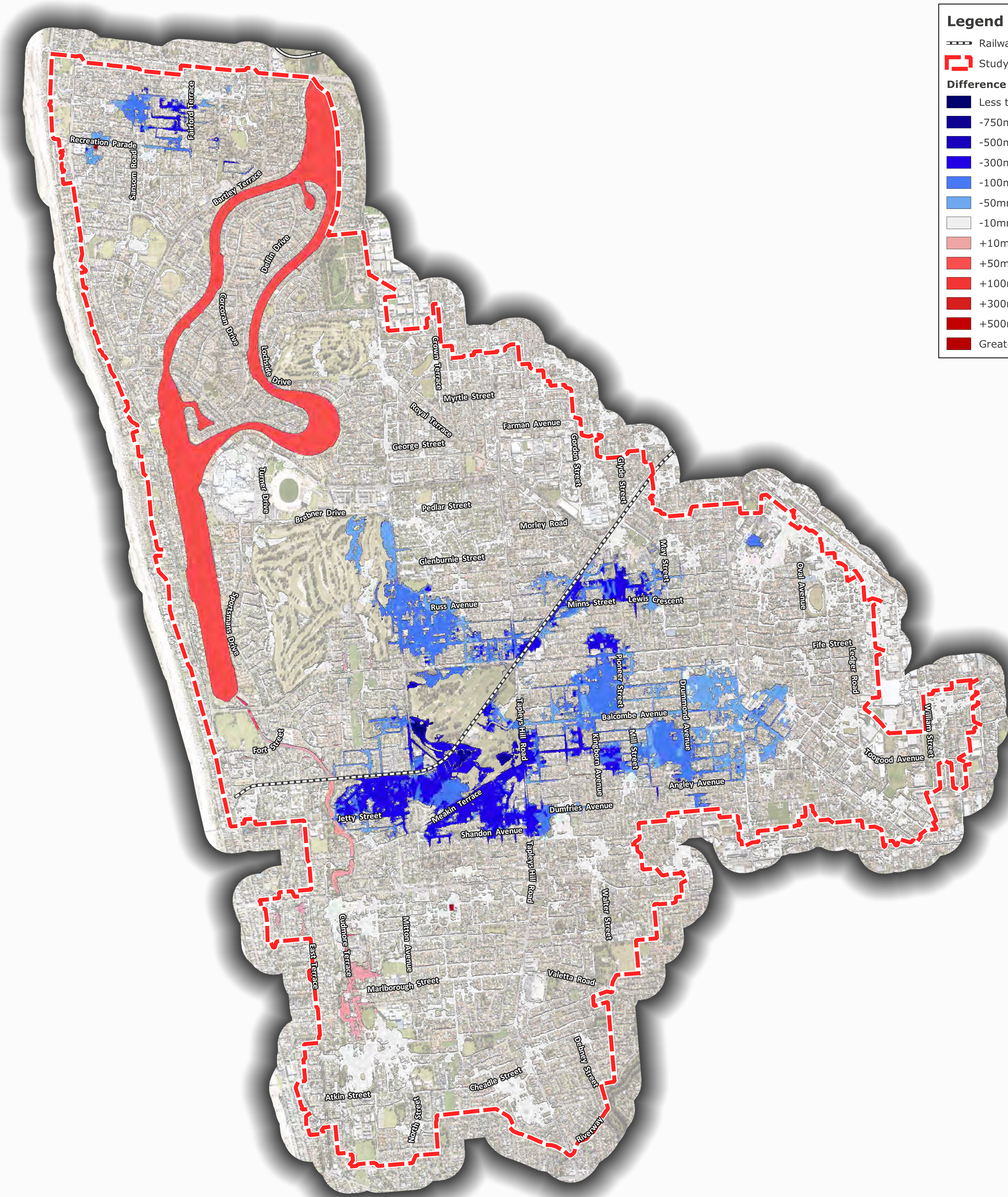

Legend

- Railway
- Study area boundary

Difference in flood depth

- Less than -750mm
- -750mm to -500mm
- -500mm to -300mm
- -300mm to -100mm
- -100mm to -50mm
- -50mm to -10mm
- -10mm to +10mm
- +10mm to +50mm
- +50mm to +100mm
- +100mm to +300mm
- +300mm to +500mm
- +500mm to +750mm
- Greater than +750mm

tonkin

Job Number:	20190818
Filename:	20190818GQ003A
Revision:	A
Date:	2021-06-22
Drawn:	MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2018

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
1% AEP FLOOD DEPTH DIFFERENCE MAP

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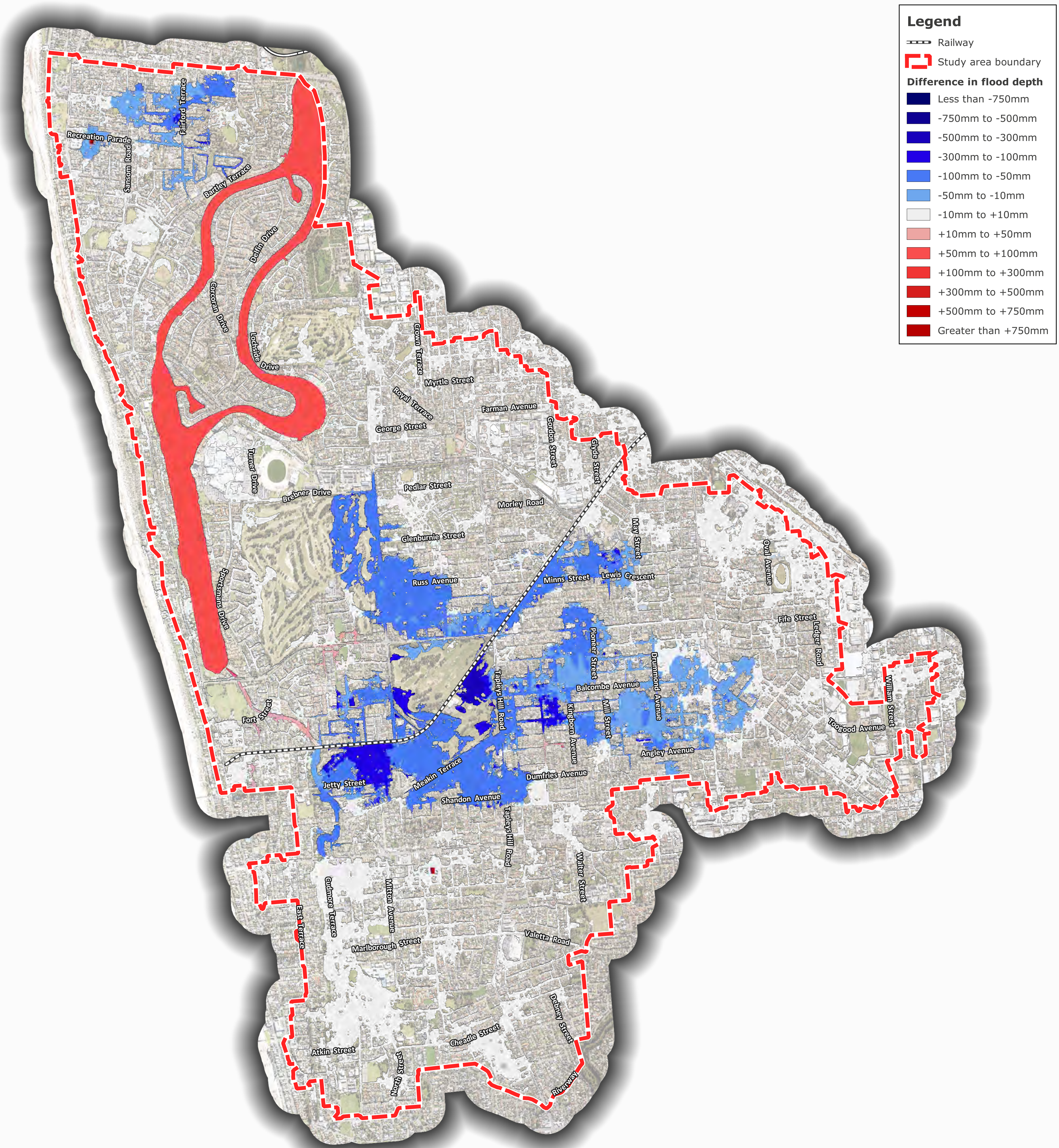

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Drawn: MM

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CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
0.2% AEP FLOOD DEPTH DIFFERENCE MAP

Map 26

Appendix D – Flood damages methodology

Flood damages have been estimated using the Rapid Appraisal Method (RAM) developed by the Victorian Department of Natural Resources and Environment (DNRE, 2000). This approach allows for a rapid and consistent evaluation of floodplain management measures in a cost-benefit analysis framework.

1.1 Methodology

The RAM relies primarily on geographic datasets, including the flood depth maps, cadastral data, land use types and property valuations. The general procedure for calculating the flood damages is detailed below:

- Process the cadastral dataset within the study area to include or exclude specific parcels, assign a category for calculations (residential or low, medium, high non-residential), and include valuation data for every parcel.
- Identify areas subject to inundation in a range of design flood events (63%, 39%, 20%, 10%, 5%, 2%, 1% and 0.2% AEP events).
- Use the flood depth maps to determine whether the building within a parcel is flooded for each of the design flood events. A building was considered flooded if the flood depth was above the adopted floor level for that type of building.
- Calculate the depth of flooding above floor level for residential buildings.
- Calculate the potential direct damage using stage-damage curves (for residential buildings) and areal damage rates for non-residential buildings.
- Factor in the community's preparedness to respond to a flood risk to convert potential direct damages to actual direct damages.
- Calculate the indirect damages as a percentage of the direct damages.
- Sum the actual direct and indirect damages to get the total damages for each design storm event and to produce a damage-probability relationship.
- Calculate the annual average damage (AAD) using the damage-probability relationship.

Damage to public infrastructure, such as roads, has not been included in the analysis as it has been assumed that these damages would be small.

1.2 Pre-processing the cadastral data

The cadastral dataset provided by Council was pre-processed to provide the property information on which the damage calculations were based. Some of the adjustments that were made to the cadastral datasets include:

- Above ground floors of multi-storey properties were removed.
- Private carparks and common areas within strata title properties were removed to avoid double counting clean-up costs for these areas.
- Parcels only containing areas unaffected by floodwaters, including private roads, reserves or watercourses, were removed.

1.3 Calculations

1.3.1 Potential direct damages

Residential allotments

In the absence of surveyed floor levels, it has been assumed that the floor level of residential buildings is 150 mm above ground level at the centroid of the allotment.

Where flood depths are above the floor level, the damages were calculated using a relationship between flood depth and residential property damage, developed by URS in 2002 as part of work undertaken for the City of Charles Sturt. This relationship has been adjusted to bring costs in line with present values and modified to adjust damages (either up or down) based on capital value. An additional $4,000 of damage has been included for damage to outbuildings and general external clean-up costs. The adopted relationship is shown in Equation 1.

$$\boldsymbol{Potential\ direct\ damage}\ (\$) = \mathbf{34{,}000} + \mathbf{30{,}000} \times \boldsymbol{d} \times \frac{\boldsymbol{CV}}{\boldsymbol{CV_{ave}}} \qquad \text{Equation 1}$$

Where, d $= flood\ depth\ above\ floor\ level\ (m)$

CV $= property\ valuation$

CV_{ave} $= average\ residential\ property\ valuation$

In the absence of valuation data, an average value of $750,000 has been adopted for all residential properties.

Where there is flooding at the centroid of the allotment less than 150 mm, a direct damage value of $2,000 has been applied.

Non-residential allotments

In the absence of surveyed floor levels, it has been assumed that the floor level of non-residential buildings is 100 mm above ground level. This is slightly lower than the adopted floor level for residential buildings as a portion of non-residential buildings are typically set lower, to allow for vehicular access.

The RAM describes the calculation of damages for non-residential buildings based on floor area. Small non-residential allotments (less than 1,500 m^2 in size) were considered flood-affected when the flood depth was above the floor level (100 mm). In the absence of building footprints, the affected floor area was calculated as 70% of the site area for smaller allotments and equal to the flooded area for larger allotments (greater than 1,500 m^2 in size).

The buildings were divided into either low, medium or high categories based on their likely value of contents. The damage rates for the floor area of flood-affected buildings were extracted from the RAM guidelines. Table 1 provides estimates of the mean potential damage and gives an indication of the typical land use types associated with each category.

Table 1 Adopted damages for non-residential buildings

Value of contents	Typical land use	Mean direct potential damage ($ / m^2)
Low	Offices, sporting pavilions, churches	71
Medium	Libraries, clothing retailers, caravan parks	126
High	Electronic retailers, printing	316

1.3.2 Actual direct damages

Damages that actually occur to a property (actual direct damages) are generally less than those that could occur if the landowners took no action to reduce damages during a flood (potential direct damage). Ratios to convert potential to actual damages were used as per the recommendations of RAM. For this study, a factor of 0.9 was used. This is representative of a community that is generally unaware of their flood risk and who have a warning time of less than 2 hours.

1.3.3 Indirect damages

Indirect damages refer to the costs incurred by a community during and after a flood occurs, including emergency response costs, disruptions to employment, commerce, transport and communication. These damages are in addition to the direct damages described above.

The RAM report suggests that these costs are approximately 30% of the actual direct damages and this was adopted to estimate the indirect damages for this study.

1.3.4 Annual average damage

The annual average damage (AAD) is an estimate of the average annual cost of flood damages (direct and indirect) over a long period of time. It balances small frequent flood damages with large but less frequent flood damages and provides a convenient way to compare different floodplain management measures. It is a probability-weighted mean of the actual flood damages and is equivalent to the area beneath the flood damage-probability curve.

AADs can be used to calculate the economic benefit of carrying out flood mitigation works, by taking the reduction in AAD brought about by the work and converting this, using an appropriate discount rate, to a net present value. The ratio of the net present value of saved damages to the cost of the works provides a benefit-cost ratio.

Appendix E – Cost estimates

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Gleneagles Reserve underground tank
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 5% of estimate				$ 481,604.81
	Sub-Total					**$ 481,604.81**
2.0	**Construction costs**					
2.1	Excavation and disposal of spoil		m^3	30,000	$ 38.00	$ 1,140,000.00
2.2	Topsoil stripping and stockpiling		m^2	15,000	$ 3.50	$ 52,500.00
2.3	Topsoil respreading		m^2	15,000	$ 5.00	$ 75,000.00
2.4	Tree removal		item	15	$ 250.00	$ 3,750.00
2.5	Undergound storage tank	Supply and installation of proprietary tank	m^3	30,000	$ 270.00	$ 8,100,000.00
2.6	Pipe capping	Concrete capping of bypassed pipe	item	2	$ 500.00	$ 1,000.00
2.7	375 mm diameter RCP	Outlet pipe	m	35	$ 280.00	$ 9,800.00
2.8	675mm diameter RCP	Inlet diversion pipe	m	105	$ 530.00	$ 55,650.00
2.9	1200 x 600 RCBC	Inlet diversion culvert	m	30	$ 1,735.00	$ 52,050.00
	Sub-Total					**$ 9,489,750.00**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 1.5% of construction cost	item			$ 142,346.25
	Sub-Total					**$ 142,346.25**
4.0	**Annual maintenance costs**					
4.1	Inspection and maintenance		item	1	$ 2,000.00	$ 2,000.00
	Sub-Total					**$ 2,000.00**

Sub-total		**$ 10,115,701.06**
Contingency	20%	$ 2,023,140.21
Grand Total		**$ 12,138,841.28**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.
Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Crittenden Road to Grange Lakes pipe upgrades
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 1,799,826.91
	Sub-Total					**$ 1,799,826.91**
2.0	**Construction costs**					
2.1	300 mm diameter RCP		m	865	$ 217.00	$ 187,705.00
2.2	375 mm diameter RCP		m	244	$ 280.00	$ 68,320.00
2.3	450 mm diameter RCP		m	638	$ 398.00	$ 253,924.00
2.4	900 mm diameter RCP		m	3,478	$ 904.00	$ 3,144,112.00
2.5	1050 mm diameter RCP		m	3,150	$ 1,302.00	$ 4,101,300.00
2.6	1200 x 900 RCBC		m	336	$ 2,299.00	$ 772,464.00
2.7	1800 x 900 RCBC		m	1,257	$ 4,500.00	$ 5,656,500.00
2.8	1350 x 675 RCBC		m	954	$ 1,930.00	$ 1,841,220.00
2.9	Side entry pit	Assumed to be double SEPs	item	138	$ 3,727.84	$ 514,441.92
2.10	Junction box	Assumed every 100 m	each	110	$ 9,130.00	$ 1,004,300.00
2.11	Outlet headwall upgrades		item	1	$ 15,000.00	$ 15,000.00
	Sub-Total					**$ 17,559,286.92**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 2.5% of construction cost	item			$ 438,982.17
	Sub-Total					**$ 438,982.17**

Sub-total		**$ 19,798,096.00**
Contingency	20%	$ 3,959,619.20
Grand Total		**$ 23,757,715.20**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered
- No allowance has been made for the relocation of services. This is likely to be an issue where there is duplication of large pipes within the road corridor.
- No allowance has been made for reinstatement of road pavement/footpaths

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Beatrice Avenue and Trimmer Parade pipe upgrades
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 688,185.27
	Sub-Total					**$ 688,185.27**
2.0	**Construction costs**					
2.1	300 mm diameter RCP		m	19	$ 217.00	$ 4,123.00
2.2	375 mm diameter RCP		m	1,517	$ 280.00	$ 424,760.00
2.3	450 mm diameter RCP		m	397	$ 398.00	$ 158,006.00
2.4	525 mm diameter RCP		m	352	$ 433.00	$ 152,416.00
2.5	1200 x 750 RCBC		m	730	$ 1,916.00	$ 1,398,680.00
2.6	1650 x 750 RCBC		m	460	$ 2,310.00	$ 1,062,600.00
2.7	1750 x 750 RCBC		m	199	$ 2,520.00	$ 501,480.00
2.8	1800 x 900 RCBC		m	539	$ 4,500.00	$ 2,425,500.00
2.9	Side entry pit	Assumed to be Double SEPs	item	52	$ 3,727.84	$ 193,847.68
2.10	Junction box	Assumed every 100 m	each	43	$ 9,130.00	$ 392,590.00
	Sub-Total					**$ 6,714,002.68**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 2.5% of construction cost	item			$ 167,850.07
	Sub-Total					**$ 167,850.07**

Sub-total		**$ 7,570,038.02**
Contingency	20%	$ 1,514,007.60
Grand Total		**$ 9,084,045.63**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered
- No allowance has been made for the relocation of services. This is likely to be an issue where there is duplication of large pipes within the road corridor.
- No allowance has been made for reinstatement of road pavement/footpaths

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.
Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Matheson Reserve underground tank
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 750,624.47
	Sub-Total					**$ 750,624.47**
2.0	**Construction costs**					
2.1	Excavation and disposal of spoil		m^3	45,000	$ 38.00	$ 1,710,000.00
2.2	Topsoil stripping and stockpiling		m^2	15,000	$ 3.50	$ 52,500.00
2.3	Topsoil respreading		m^2	15,000	$ 5.00	$ 75,000.00
2.4	Tree removal		item	5	$ 250.00	$ 1,250.00
2.5	Undergound storage tank	Supply and installation of proprietary tank	m^3	20,000	$ 270.00	$ 5,400,000.00
2.7	Drainage easement		m^2	1,420	$ 30.00	$ 42,600.00
2.8	300 mm diameter RCP	Inlet and outlet pipe	m	85	$ 217.00	$ 18,445.00
2.9	450 mm diameter RCP	Inlet pipe	m	240	$ 398.00	$ 95,520.00
	Sub-Total					**$ 7,395,315.00**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 1.5% of construction cost	item			$ 110,929.73
	Sub-Total					**$ 110,929.73**
4.0	**Annual maintenance costs**					
4.1	Inspection and maintenance		item	1	$ 2,000.00	$ 2,000.00
	Sub-Total					**$ 2,000.00**

Sub-total		**$ 8,258,869.20**
Contingency	20%	$ 1,651,773.84
Grand Total		**$ 9,910,643.04**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Frank Mitchell Reserve underground tank
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 1,140,043.13
	Sub-Total					**$ 1,140,043.13**
2.0	**Construction costs**					
2.1	Excavation and disposal of spoil		m^3	36,000	$ 38.00	$ 1,368,000.00
2.2	Topsoil stripping and stockpiling		m^2	12,000	$ 3.50	$ 42,000.00
2.3	Topsoil respreading		m^2	12,000	$ 5.00	$ 60,000.00
2.4	Undergound storage tank	Supply and installation of proprietary tank	m^3	36,000	$ 270.00	$ 9,720,000.00
2.6	Pipe capping	Concrete capping of bypassed pipe	item	2	$ 500.00	$ 1,000.00
2.7	300 mm diameter RCP	Outlet pipe	m	20	$ 217.00	$ 4,340.00
2.8	1350 mm diameter RCP	Inlet diversion pipe	m	18	$ 2,034.00	$ 36,612.00
	Sub-Total					**$ 11,231,952.00**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 1.5% of construction cost	item			$ 168,479.28
	Sub-Total					**$ 168,479.28**
4.0	**Annual maintenance costs**					
4.1	Inspection and maintenance		item	1	$ 2,000.00	$ 2,000.00
	Sub-Total					**$ 2,000.00**

Sub-total		**$ 12,540,474.41**
Contingency	20%	$ 2,508,094.88
Grand Total		**$ 15,048,569.29**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**
- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Nedford Reserve detention basin
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 18,211.69
	Sub-Total					**$ 18,211.69**
2.0	**Construction costs**					
2.1	Excavation and disposal of spoil		m^3	1,560	$ 38.00	$ 59,280.00
2.2	Tree removal		item	4	$ 250.00	$ 1,000.00
2.4	300 mm diameter RCP	Inlet diversion and outlet pipe	m	27	$ 217.00	$ 5,859.00
2.5	Pipe capping	Concrete capping for bypassed pipe	item	2	$ 500.00	$ 1,000.00
2.6	Headwall and connection to existing	375 mm RCP outlet headwall	item	1	$ 800.00	$ 800.00
2.7	Headwall and connection to existing	600 x 300 RCBC inlet headwall	item	1	$ 1,125.00	$ 1,125.00
2.8	Topsoil respreading		m^2	1,300	$ 5.00	$ 6,500.00
2.9	Topsoil strip and stockpiling		m^2	1,300	$ 3.50	$ 4,550.00
	Sub-Total					**$ 80,114.00**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 2.5% of construction cost	item			$ 2,002.85
3.2	Landscaping					$ 100,000.00
	Sub-Total					**$ 102,002.85**
4.0	**Annual maintenance costs**					
4.1	Basin maintenance	Mow and slash grass	m^2	1,300	$ 1.50	$ 1,950.00
	Sub-Total					**$ 1,950.00**

Sub-total		**$ 200,328.54**
Contingency	20%	$ 40,065.71
Grand Total		**$ 240,394.24**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

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Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Golfers Avenue pipe and pump upgrades
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 252,661.81
	Sub-Total					**$ 252,661.81**
2.0	**Construction costs**					
2.1	300 mm diameter RCP		m	377	$ 217.00	$ 81,809.00
2.2	375 mm diameter RCP		m	73	$ 280.00	$ 20,440.00
2.3	450 mm diameter RCP		m	742	$ 398.00	$ 295,316.00
2.4	525 mm diameter RCP		m	136	$ 433.00	$ 58,888.00
2.5	750 mm diameter RCP		m	175	$ 694.00	$ 121,450.00
2.6	900 mm diameter RCP		m	314	$ 904.00	$ 283,856.00
2.6	1050 mm diameter RCP		m	8	$ 1,302.00	$ 10,416.00
2.7	300 x 150 RCBC		m	2	$ 362.46	$ 724.92
2.8	450 x 225 RCBC		m	184	$ 552.66	$ 101,689.44
2.9	Pump station upgrades	Additional pumps to meet 750 L/s	item	1	$ 1,000,000.00	$ 1,000,000.00
2.10	Rising main infrastructure	Upsize the rising main to cater for increased flow	item	1	$100,000	$ 100,000.00
2.11	Side entry pit	Assumed to be double SEPs	item	40	$ 3,727.84	$ 149,113.60
2.12	Junction box	Assumed every 100 m	each	20	$ 9,130.00	$ 182,600.00
	Sub-Total					**$ 2,406,302.96**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 5% of construction cost	item			$ 120,315.15
	Sub-Total					**$ 120,315.15**

Sub-total		**$ 2,779,279.92**
Contingency	20%	$ 555,855.98
Grand Total		**$ 3,335,135.90**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**
- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.
Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Sansom Road pipe upgrades
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 502,994.96
	Sub-Total					**$ 502,994.96**
2.0	**Construction costs**					
2.1	300 mm diameter RCP		m	576	$ 217.00	$ 124,992.00
2.2	375 mm diameter RCP		m	494	$ 280.00	$ 138,320.00
2.3	450 mm diameter RCP		m	162	$ 415.00	$ 67,230.00
2.4	525 mm diameter RCP		m	531	$ 484.00	$ 257,004.00
2.5	600 mm diameter RCP		m	434	$ 544.00	$ 236,096.00
2.6	675 mm diameter RCP		m	39	$ 598.00	$ 23,322.00
2.6	750 mm diameter RCP		m	389	$ 694.00	$ 269,966.00
2.7	900 mm diameter RCP		m	421	$ 989.00	$ 416,369.00
2.8	1200 mm diameter RCP		m	1,116	$ 1,700.00	$ 1,897,200.00
2.9	1350 mm diameter RCP		m	440	$ 2,034.00	$ 894,960.00
2.10	300 x 225 RCBC		m	197	$ 380.32	$ 74,923.04
2.11	375 x 225 RCBC		m	203	$ 475.40	$ 96,506.20
2.12	600 x 225 RCBC		m	66	$ 552.65	$ 36,474.90
2.13	600 x 375 RCBC		m	12	$ 714.70	$ 8,576.40
2.14	Side entry pit	Assumed to be double SEPs	item	98	$ 3,727.84	$ 365,328.32
2.15	Junction box	Assumed every 100 m	each	51	$ 9,130.00	$ 465,630.00
	Sub-Total					**$ 4,907,267.86**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 2.5% of construction cost	item			$ 122,681.70
	Sub-Total					**$ 122,681.70**

Sub-total		**$ 5,532,944.51**
Contingency	20%	$ 1,106,588.90
Grand Total		**$ 6,639,533.41**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Recreation Parade detention basin
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of civil works estimate				$ 12,502.92
	Sub-Total					**$ 12,502.92**
2.0	**Construction costs**					
2.1	Property acquisition		each	4	$ 750,000.00	$ 3,000,000.00
2.2	Demolition of properties		m^2	930	$ 43.70	$ 40,641.00
2.3	Excavation and disposal of soil		m^3	1,560	$ 38.00	$ 59,280.00
2.4	375 mm diameter RCP	Outlet pipe	m	12	$ 280.00	$ 3,360.00
2.5	600 mm diameter RCP	Inlet diversion pipe	m	10	$ 544.00	$ 5,440.00
	Sub-Total					**$ 3,108,721.00**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 15% of construction cost	item			$ 16,308.15
	Sub-Total					**$ 16,308.15**
4.0	**Annual maintenance costs**					
4.1	Basin maintenance	Mow and slash grass	m^2	1,460	$ 1.50	$ 2,190.00
	Sub-Total					**$ 2,190.00**

Sub-total		**$ 3,137,532.07**
Contingency	20%	$ 627,506.41
Grand Total		**$ 3,765,038.48**

Note: **Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:**

- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

CONSTRUCTION COST ESTIMATE

Project: **West Lakes SMP**
Job No: 20190818
Date: 28/07/2021
Revision: A
Summary of works: Market Corner pipe upgrades
Estimated: BT
Review: BJT

Item No	Description	Comment	Unit	Qty	Rate	Cost
1.0	**Preliminaries**					
1.1	Preliminaries	Assumed to be 10% of estimate				$ 29,691.61
	Sub-Total					**$ 29,691.61**
2.0	**Construction costs**					
2.1	300 mm diameter RCP		m	180	$ 217.00	$ 39,060.00
2.2	375 mm diameter RCP		m	73	$ 280.00	$ 20,440.00
2.3	450 mm diameter RCP		m	262	$ 415.00	$ 108,730.00
2.4	600 mm diameter RCP		m	91	$ 544.00	$ 49,504.00
2.5	Side entry pit	Assumed to be double SEPs	item	14	$ 3,727.84	$ 52,189.76
2.6	Junction box	Assumed every 100 m	each	7	$ 6,570.00	$ 45,990.00
	Sub-Total					**$ 269,923.76**
3.0	**Other costs**					
3.1	Design cost	Assumed to be 10% of construction cost	item			$ 26,992.38
	Sub-Total					**$ 26,992.38**

Sub-total		**$ 326,607.75**
Contingency	20%	$ 65,321.55
Grand Total		**$ 391,929.30**

Note:

Cost estimates provided by Tonkin Consulting are based upon historic cost information and experience, and do not allow for:
- Latent conditions
- Changes in scope
- Market conditions (i.e. competition, escalation)
- No allowance for approvals for these works
- No allowance for site contamination and remediation or disposal of contaminated material
- No allowance for land acquisition
- No allowance has been made for the staging of these works
- No allowance has been made for landscaping works
- No allowance has been made for service depthing, liaison with service authorities, design of service relocations
- No allowance has been made for project delivery costs including project management
- Calculations assume clay soil and no rock will be encountered

These estimates are to be considered as indicative only, and are not purported to represent anything more than an indication of the cost of the scope of the work.

Tonkin Consulting recommend that an appropriately qualified quantity surveyor be consulted to provide detailed market cost inputs.

Appendix F – Decision-making framework

West Lakes Catchment Stormwater Management Plan

Stage 3 Report – Decision Making Framework

City of Charles Sturt

CCS045206
4 December 2020
Ref: 20190818R003RevC

Building exceptional outcomes together

Document History and Status

Rev	Description	Author	Reviewed	Approved	Date
A	For Council input of MCA framework	MM	OO	OO	30/10/20
B	For Council input of MCA framework (re-issue)	MM	OO	OO	04/11/20
C	For stakeholder comment	MM	OO	OO	04/12/20

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Client: City of Charles Sturt
Ref: 20190818R003RevC

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Appendices

1 Introduction

Tonkin has been engaged by the City of Charles Sturt (Council) to prepare a stormwater management plan (SMP) for the West Lakes catchment. Once developed, the SMP will provide the framework for a coordinated, multi-objective approach for the management of stormwater within the catchment area.

The Stage 1 report provided details of the investigations that have been undertaken to date, including a summary of relevant studies and a review of available data. It also provided a summary of existing and future catchment conditions, with a recommendation for the catchment and climatic factors to be used in the hydrologic and hydraulic modelling.

The Stage 2 report built upon the work undertaken in Stage 1, identifying stormwater management problems and opportunities for achieving outcomes for public and environmental benefit in the catchment.

This report (Stage 3) describes the development of a framework to provide decision-makers with a tool to assess and compare the net benefits of proposed strategies for the management of stormwater within the West Lakes catchment. The decision-making tool described in this report will be used to compare and select stormwater management strategies that address the stated objectives for stormwater management within the catchment. The multi-criteria analysis criteria and weightings contained in this report are suggestions only and are subject to confirmation by Council.

2 Optimised Decision-Making Methodology

2.1 Background

Our approach is generally consistent with the 'Optimised Decision Making Guidelines' (ODMG) (NZNAMSG, 2004). The guidelines were developed to *"allow the application of the very best management techniques and practices to ensure that the decisions made on maintaining, renewing and investing in new assets are both optimal and sustainable"*.

The development of the West Lakes Stormwater Management Plan (SMP) will require the selection of solutions to identified problems from a range of available measures. The ODMG process will be applied as a tool to support the decision-making process, considering a range of objectives, in the preparation of the SMP.

2.2 Process overview

The process to implement the ODMG is flexible, and in preparing the SMP will be implemented according to a four-step process, as described below.

Step 1 – Define the problem or opportunity

The definitions of problems or opportunities will relate to a particular problem (such as flooding) or desire to achieve a particular objective (such as a catchment water harvesting target). These problems and opportunities have been identified during the Stage 2 investigations.

Step 2 – Identify potential options to manage the problem or opportunity

This step requires the broad identification of all possible solutions. Alongside these, a list of non-negotiable criteria ('deal breakers' such as performance standards and use of valuable open space) would apply, some of which may emerge in response to the nature of the solutions put forward. The options list is then subsequently reduced to a shortlist of potential options according to these criteria.

Step 3 – Multi-criteria analysis of the potential options

The options are evaluated against a range of criteria that include economic, environmental and social considerations. All options are scored against each of the criteria which are given a weighting based on their (pre-agreed) relative importance.

Step 4 – Identify the optimal solution

This step generally involves selecting a solution that obtains the highest score in the evaluation process.

2.3 Stormwater management goals

The key issues to be addressed in the development of any plan for the management of stormwater runoff from an urban catchment include:

- flooding
- water quality
- water use
- environmental protection and enhancement
- asset management.

Catchment specific objectives are set based upon the problems and opportunities identified within the study area. The Stormwater Management Planning Guidelines (SMA 2007) state that, as a minimum, objectives are to set measurable goals for:

- An acceptable level of protection of the community and both private and public assets from flooding.

- Management of the quality of runoff and effect on the receiving waters, both terrestrial and marine where relevant.
- Extent of beneficial use of stormwater.
- Desirable end-state values for watercourses and riparian ecosystems.
- Desirable planning outcomes associated with new development, open space, recreation and amenity.
- Sustainable management of stormwater infrastructure, including maintenance.

These broad goals have been used as the basis for defining the components that feed into the multi-criteria analysis described below.

2.4 Multi-criteria analysis

Options for the management of stormwater within the study area will be developed as part of the SMP. As part of optimising the selection of strategies for implementation, a multi-criteria analysis will be undertaken. It is proposed to use six main evaluation criteria which broadly align with the goals defined for stormwater management. A number of sub-criteria will also be used. Each of the proposed criteria is described in more detail below.

2.4.1 Flood protection

Flooding has been identified as a key concern within the study area and as part of the Stage 2 work a number of areas throughout the study area have been identified as being flood prone.

The weighting assigned to this criterion is related to the likely improvement in flooding (and associated risk).

2.4.2 Runoff quality and impact on receiving environment

Runoff from urban areas should be at least of a quality that does not cause degradation of the receiving waters (in this case West Lakes), and ultimately does not further contribute to the degradation of Adelaide's coastal marine environment through inputs of nutrient rich, turbid and coloured water cause further the coastal marine environment. Microplastics have also been identified as a key water quality concern within the study area.

The water quality targets shown in Table 2.1 are consistent with the latest state-wide WSUD performance targets (DEWNR, 2013) and are expected to be consistent with the requirements of the new Planning and Design Code (Phase 3) when it is released..

Table 2.1 Water quality targets

Pollutant	Reduction target
Total suspended solids (TSS)	80% reduction of the untreated urban annual load
Total phosphorus (TP)	60% reduction of the untreated urban annual load
Total nitrogen (TN)	45% reduction of the untreated urban annual load
Gross pollutants (GP)	90% reduction of the untreated urban annual load

It is proposed to divide this criterion into four sub-criteria:

- Removal of gross pollutants (which can be modelled within the Model for Urban Stormwater Improvement Conceptualisation (MUSIC)).
- Removal of suspended solids (can be modelled using MUSIC).
- Removal of nutrients (can be modelled using MUSIC).
- Reduction in micro-plastics.

2.4.3 Beneficial use of stormwater

The reuse of stormwater provides a number of benefits – it reduces the flows (and hence pollutants) into the receiving environment, it can promote vegetation growth thereby reducing the urban heat island effect and improving amenity value and it can also reduce the reliance on mains water consumption resulting in economic and environmental benefits. Council places a high value on increasing tree canopy cover and biodiversity within the catchment.

The criterion associated with the beneficial use of stormwater will be split into two sub-criteria.

Passive reuse for urban greening

The passive infiltration of surface water into the underlying shallow aquifer and the irrigation of vegetated areas such that downstream flows mimic the predevelopment flow regime. Examples include infiltration areas, biofiltration zones and swales.

Storage and reuse

Stormwater harvesting for water reuse. A target for reuse would be to provide a noticeable reduction in mains water usage. Storage and reuse can occur on a range of scales from individual rainwater tanks through to new or supplemented managed aquifer recharge (MAR) schemes.

2.4.4 Social values

Given the heavily urbanised nature of a large portion of the study area, the social values associated with the management of stormwater are considered to be important. The social values will be considered using the following four sub-criteria:

Improved visual amenity

Beautify developed areas by landscaping drainage elements such as wetlands and other WSUD features. WSUD features also have the potential to improve visual amenity if they result in improved vegetative health through increased infiltration.

Improved safety

Reduce high flood hazard (i.e. deep and fast flowing water) for the public.

Additional useful open space

Improve the functionality and the services available within an area of open space that is currently unavailable for public use e.g. wetlands or green space/green trails within drainage corridors.

Disruption during construction

The construction of some items of new infrastructure may result in disruption to the public. This could include physical displacement and traffic disruptions during construction. Given the relatively short-term impacts of construction, this will be given a lower weighting.

2.4.5 Environmental protection and enhancement

The management of stormwater offers opportunities for environmental protection and enhancement through habitat creation and increased biodiversity. The greatest benefits are likely to be in the construction of regional scale measures (such as wetlands and basins).

2.4.6 Economics

The capital and maintenance costs feed into Council’s financial planning and asset management strategies. The cost criterion will be broken into the following three sub-criteria:

CAPITAL COST

The capital cost criteria relates to the upfront capital cost of the proposed works. This would be compared against what could reasonably be afforded by Council and the sources of financial support that may be available for each strategy.

ECONOMIC VIABILITY

The economic viability compares the capital cost of the works to the benefits derived from less flood damages to enable the derivation of a benefit to cost ratio. Due to the inability to quantify the benefits, the economic viability of non-structural works will be assessed qualitatively.

RECURRING / MAINTENANCE COST

Once established most new infrastructure will require some form of maintenance, therefore representing ongoing costs for Council. Consideration of ongoing costs is important when considering the affordability of the works.

Reflecting the importance of cost for the implementation of the works, the cost criterion has been assigned a relatively high weighting.

2.5 Criteria weightings

The weightings assigned to each of the criteria are subject to confirmation by Council. Table 2.2 and Table 2.3 show the suggested weightings for each of the criteria and sub-criteria. The weightings are not fixed and can be adjusted depending on the type of problem that is being assessed. For example, if the problem were focussed primarily on runoff quality, the flood protection weighting could be reduced to allow a higher importance to be placed on runoff quality.

It should be noted that the criteria/sub-criteria are not mutually exclusive; stormwater management options which result in the beneficial use of stormwater will most likely also result in improvements to runoff quality.

Table 2.2 Weighting of main criteria

Criteria	Weighting
Flood protection	30
Runoff quality and impact on receiving environment	25
Beneficial use of stormwater	10
Social values	5
Environmental benefit	5
Capital cost, maintenance cost and economic viability	25
TOTAL	100

Table 2.3 Weighting of sub-criteria

Criteria	Sub-Weighting
Flood protection of development	
Improved flood protection	100

Criteria	Sub-Weighting
Runoff quality and impact on receiving environment	
Reduction in gross pollutants	15
Reduction in suspended solids	40
Reduction in nutrients	30
Reduction in micro-plastics	15
Beneficial use of stormwater	
Storage and reuse	70
Passive reuse for urban greening	30
Social values	
Improved visual amenity	25
Improved public safety	40
Additional useful open space	25
Disruption during construction	10
Environmental benefit	
Habitat creation	50
Increased biodiversity	50
Capital and maintenance cost	
Capital cost	45
Economic viability	45
Maintenance cost	10

Each of the identified stormwater management options will be given a rating against each criterion. The ratings used for each criterion range from 0 through to 4. A description of the rating criteria is provided in Table 2.4.

Table 2.4 Criterion weighting guide

Rating	Flood protection of development
0	No improvement to existing flood risk.
1	Low level of improvement to flood risk.
2	Moderate improvement to flood risk.
3	Large improvement to flood risk. Flood protection during 10%–2% AEP event.
4	Large improvement to flood risk. Flood protection during 1% AEP event, the maximum level that can reasonably be expected.

Rating	Runoff quality and impact on receiving environment
0	No improvement in water quality.
1	Low level of improvement in downstream water quality.
2	Moderate improvement in downstream water quality.
3	Large improvement in downstream water quality.
4	Significant improvement in downstream water quality. Maximum level of improvement that could reasonably be achieved.

Rating	Beneficial use of stormwater
0	No beneficial use of stormwater.
1	Low level of beneficial use of stormwater.
2	Moderate beneficial use of stormwater.
3	Large beneficial use of stormwater.
4	Significant beneficial use of stormwater. Maximum level of improvement that could reasonably be achieved.

Table 2.4 Criterion weighting guide (continued)

Rating	Social values
0	No improvement in social values.
1	Low level of improvement in social values.
2	Moderate improvement in social values.
3	Large improvement in social values.
4	Significant improvement in social values. Maximum level of improvement that could reasonably be achieved.

Rating	Environmental benefit
0	No environmental benefit.
1	Low level of environmental benefit.
2	Moderate environmental benefit.
3	Large environmental benefit.
4	Significant environmental benefit. Maximum level of improvement that could reasonably be achieved.

Rating	Capital, economic viability and maintenance cost
0	Significant costs incurred. Major Council expenditure. Would require significant forward financial planning. Benefit/cost ratio significantly lower than other options and below 1.0.
1	Large costs incurred. Large Council expenditure. Likely to require changes to Council financial planning. Benefit/cost ratio moderately lower than other options.
2	Moderate cost option. Likely to be accommodated based on existing Council budgets. Benefit/cost ratio similar to other options.
3	Low cost option. Benefit/cost ratio moderately higher than other options.
4	Insignificant cost option. Benefit/cost ratio significantly higher than other options and above 1.0.

3 Worked examples

The following examples illustrate how the proposed process would be applied in deciding how to manage stormwater within the catchment. The matrices provided in Appendix A show how the examples would be evaluated.

3.1 Example 1 – flood risk

3.1.1 Step 1: Define the problem

The problem to be addressed is defined as follows: "Reduce the flood risk in the vicinity of Meakin Terrace."

Flooding within the area surrounding Meakin Terrace for the 20% AEP event is shown in Figure 3.1. The legend showing the depth of inundation is provided in Figure 3.2.

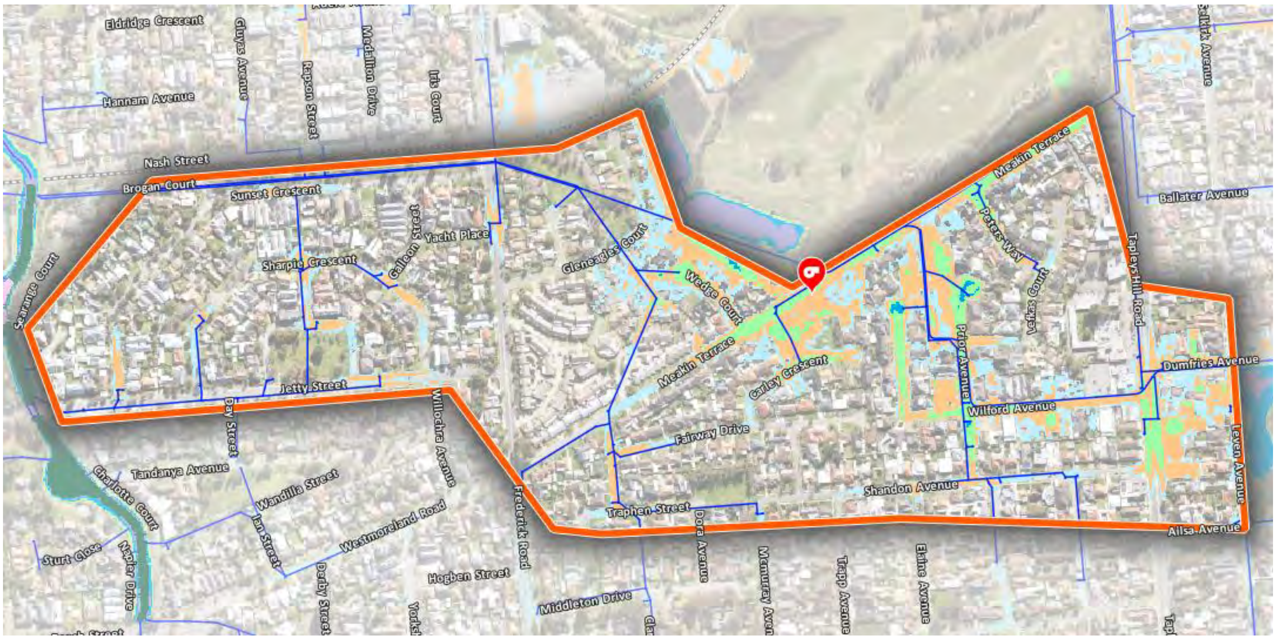

Figure 3.1 Flooding surrounding Meakin Terrace (20% AEP event)

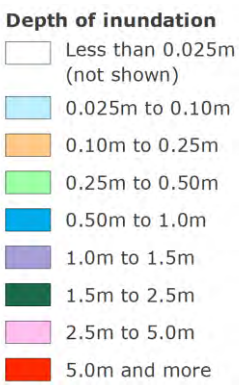

Figure 3.2 Flood inundation map legend

3.1.2 Step 2: Identify potential solutions

The following options to reduce flood risk have been identified:

1. Upgrade the trunk drain discharging to Grange Lakes so that there is no flooding or nearly no flooding in the identified area during a 20% AEP event.
2. Use the available open space within Wilford Reserve to construct a detention basin to detain runoff during rainfall events.
3. Educate the public – let people know that they are in a flood prone area.
4. Develop a flood warning system to provide residents with sufficient time to evacuate.

3.1.3 Step 3: Identify and evaluate the benefits and costs

This process would involve estimating the capital and ongoing costs associated with the mitigation measures. Flood damages would also be calculated, allowing the benefit to cost ratio of the works to be determined.

3.1.4 Step 4: Select the optimal solution

A comparison of the total scores of each option allows the optimal solution, based on the weighted criteria, to be identified.

In this instance, the Wilford Reserve detention basin obtained the highest score and would be the recommended measure to address the flood risk. Note that when working through the solutions in more detail, a combination of measures (such as pipe upgrades and the detention basin may be considered).

3.2 Example 2 – Water quality

This example is intended to show how the MCA works for non-flood related problems.

3.2.1 Step 1: Define the problem

The problem to be addressed is defined as follows: "Improve the water quality of runoff discharging to the Grange Lakes."

3.2.2 Step 2: Identify potential solutions

The following options for improving water quality have been identified:

1. Install gross pollutant traps at all outlets to the Grange Lakes.
2. Undertake precinct-scale works within the catchment, such as the construction of raingardens.
3. Channel works (such as deepening and widening) and planting of vegetation (aquatic and riparian).
4. Channel works and plantings with creation of a wetland.

3.2.3 Step 3: Identify and evaluate the benefits and costs

This process would involve estimating the capital and ongoing costs associated with the mitigation measures. The benefits could be determined either qualitatively or quantitatively with a MUSIC model.

3.2.4 Step 4: Select the optimal solution

A comparison of the total scores of each option allows the optimal solution, based on the weighted criteria, to be identified.

In this instance, the channel works, plantings and wetland obtained the highest score and would be the recommended measure to improve water quality.

As with the flood mitigation worked above, it is likely that the preferred solution would be a combination of multiple options.

4 References

Department of Environment, Water and Natural Resources (2013), *Water sensitive urban design – Creating more liveable and water sensitive cities in South Australia*, Government of South Australia.

New Zealand National Asset Management Steering Group (2004), *Optimised decision making guidelines: A sustainable approach to managing infrastructure*, 1st Edition, Thames, New Zealand.

Appendix A – Worked example results

Option	Criteria	Flood Protection of Development		Runoff Quality and Effect on Receiving Waters					Beneficial Use of Stormwater			Social Values					Environmental Benefit			Economics				Total Criteria Weighting
	Sub-Criteria	Improved flood protection	Criteria weighting	Reduction in gross pollutants	Reduction in suspended solids	Reduction in nutrients	Reduction in micro plastics	Criteria weighting	Storage and reuse	Passive reuse	Criteria weighting	Improved visual amenity	Improved public safety	Additional useful open space	Disruption during implementatio n	Criteria weighting	Habitat creation	Increased biodiversity	Criteria weighting	Capital Cost	Economic viability	Recurring / Maintenance Cost	Criteria weighting	Total Weighted Score
	Sub-criteria Weighting	100	**30**	15	40	30	15	**25**	70	30	**10**	35	20	35	10	**5**	50	50	**5**	45	45	10	**25**	**100**
Upgrade trunk drain	Score (max=4)	4	**30**	0	0	0	0	**0**	0	0	**0**	0	2	0	0	**0.5**	0	0	**0**	0	2	3	**7.5**	**38.0**
	Weighted Score	30		0	0	0	0		0	0		0	0.5	0	0		0	0		0	5.6	1.88		
Wilford Reserve detention basin	Score (max=4)	3	**22.5**	1	2	1	0	**7.8**	1	1	**2.5**	2	1	0	2	**1.4**	1	1	**1.3**	1	2	1	**9.1**	**44.5**
	Weighted Score	22.5		0.94	5.00	1.875	0		2	1		0.88	0.25	0.00	0.25		0.63	0.63		2.81	5.63	0.63		
Education and awareness	Score (max=4)	1	**7.5**	0	0	0	0	**0.0**	1	0	**0.0**	0	1	0	4	**0.8**	0	0	**0.0**	3	3	2	**18.1**	**26.4**
	Weighted Score	7.5		0.00	0.00	0.00	0.00		0	0		0.00	0.25	0	0.50		0	0		8.4	8.4375	1.25		
Flood warning system	Score (max=4)	1	**7.5**	0	0	0	0	**0**	0	0	**0**	0	2	0	4	**1.0**	0	0	**0**	2	3	1	**14.7**	**23.2**
	Weighted Score	7.5		0	0	0	0		0	0		0	0.5	0	0.50		0	0		5.6	8.4	0.63		

Option	Criteria	Flood Protection of Development		Runoff Quality and Effect on Receiving Waters					Beneficial Use of Stormwater			Social Values					Environmental Benefit			Economics				Total Criteria Weighting
	Sub-Criteria	Improved flood protection	Criteria weighting	Reduction in gross pollutants	Reduction in suspended solids	Reduction in nutrients	Reduction in micro plastics	Criteria weighting	Storage and reuse	Passive reuse	Criteria weighting	Improved visual amenity	Improved public safety	Additional useful open space	Disruption during implementation	Criteria weighting	Habitat creation	Increased biodiversity	Criteria weighting	Capital Cost	Economic viability	Recurring / Maintenance Cost	Criteria weighting	Total Weighted Score
	Sub-criteria Weighting	100	**30**	15	40	30	15	**25**	70	30	**10**	35	20	35	10	**5**	50	50	**5**	45	45	10	**25**	**100**
Install gross pollutant traps	Score (max=4)	0	**0**	4	1	1	1	**9.0625**	0	0	**0**	2	0	0	3	**1.3**	0	0	**0**	3	3	3	**18.8**	**29.1**
	Weighted Score	0		3.75	2.5	1.875	0.9375		0	0		0.875	0	0	0.38		0	0		8.4375	8.4	1.88		
Precinct scale works (e.g. raingardens)	Score (max=4)	1	**7.5**	2	3	3	2	**16.9**	0	3	**2.3**	3	0	1	2	**2.0**	2	2	**2.5**	2	3	2	**15.3**	**46.4**
	Weighted Score	7.5		1.88	7.50	5.625	1.875		0	2		1.31	0	0.44	0.25		1.25	1.25		5.63	8.44	1.25		
Channel works and plantings (aquatic and riparian)	Score (max=4)	2	**15**	0	2	2	1	**9.7**	0	2	**1.5**	3	0	0	3	**1.7**	3	3	**3.8**	2	3	3	**15.9**	**47.6**
	Weighted Score	15		0.00	5.00	3.75	0.94		0	1.5		1.31	0	0	0.38		1.875	1.875		5.6	8.4375	1.88		
Channel works and plantings with creation of a wetland	Score (max=4)	3	**22.5**	2	4	4	3	**22.1875**	1	3	**4**	4	0	3	2	**3.3**	4	4	**5**	1	2	1	**9.1**	**66.1**
	Weighted Score	22.5		1.875	10	7.5	2.8125		1.75	2.25		1.75	0	1.3125	0.25		2.5	2.5		2.8	5.6	0.63		

Appendix G – Community engagement

Community Engagement Report for West Lakes Catchment Stormwater Management Plan

March 2022

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1. Project Overview

The West Lakes Catchment Stormwater Management Plan (West Lakes Catchment SMP) is a strategic document that provides a long-term vision for flood mitigation, stormwater quality improvement and harvesting opportunities.

The intent of a stormwater management plan is to set out strategies, actions and programs that can be implemented to provide a long-term, sustainable approach towards stormwater management.

A SMP seeks to ensure that stormwater management is addressed on a total catchment basis with buy-in from all relevant stakeholders including local government authorities and state government agencies. Together they are responsible for the catchment by working together to develop, fund and implement strategies and physical works to manage stormwater in the area.

The West Lakes Catchment is a very large catchment and includes the suburbs of West Lakes, West Lakes Shore, Semaphore Park, Woodville South, Seaton, Findon, Grange, Fulham Gardens and Henley Beach. Refer Study Area map.

The study area has a total area of approximately 25 km^2 and extends along the coast from Semaphore Park in the north to Henley Beach in the south and towards Port Road to the east. The study area is located entirely within the City of Charles Sturt. Stormwater from the catchment drains via several pipes and channels that discharge into West Lakes ('the Lake').

Rain Event – 28 February 2022
On the 28 February 2022, many suburbs in the West Lakes Catchment experienced a rare rain event. It is estimated 50-80 mm of rain fell in approximately one hour, resulting in flooding at many locations within the catchment. The event is estimated to have an annual exceedance probability (AEP) of 2%-1% (i.e. between a 1 in 50 to 1 in 100 AEP).

This report details the feedback received about the overall stormwater management plan and concerns about the Charles Sturt stormwater system after a flooding event.

2. Community Engagement Approach

Consultation was undertaken council-wide over a 28-day period in February/March 2022, where we sought feedback on the draft West Lakes Catchment Stormwater Management Plan and the key strategic measures.

The purpose of the consultation was to seek comments on:

- Proposed measures to provide better flood protection and management of stormwater within the catchment, that is shown in the map (figure 4)
- Sentiment on the draft SMP and how we can improve flood management, detention storages, increase biodiversity, water quality and potential re-use.

The engagement was promoted through the following channels:

- Brochures and draft plans distributed to Council libraries and Community Centres within the catchment areas
- Social media campaign (Facebook/Instagram)
- YourSay online website page, open to all users
    - View the draft plan, add a marker to the mapping tool, complete a survey
- Port Road banners (1)
- Emails sent to selected flood prone households

A sample of materials distributed to the community centres and libraries are within **Appendix A** of this report.

3. Who did we hear from

We had 20 people across our City participate through the online survey or the mapping tool and provide feedback on the draft West Lakes Catchment Stormwater Management Plan.

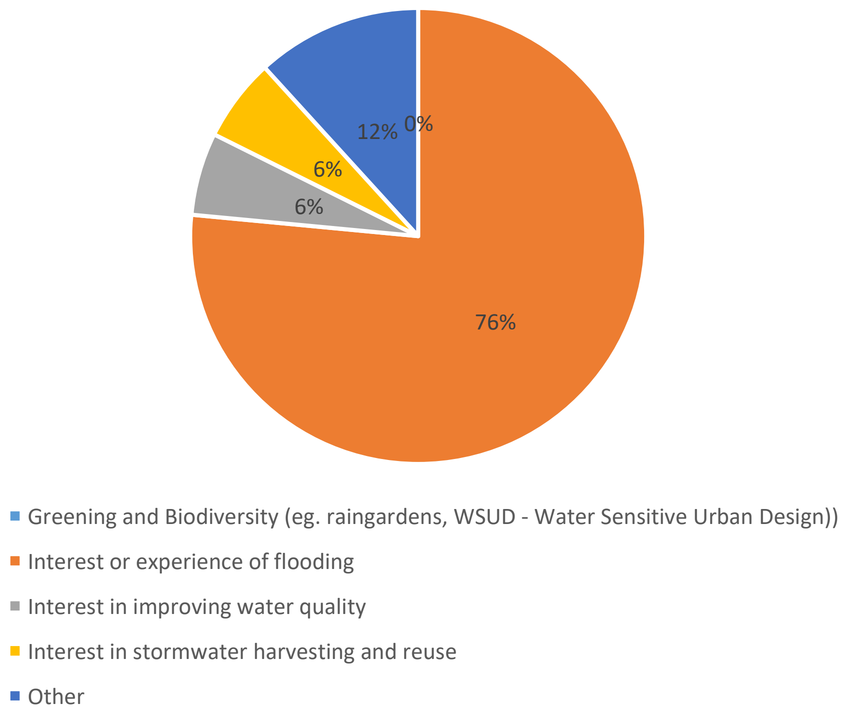
Source	Communication and Engagement Statistics	
	Community Reach	Community Participation (No. of participants)
Social Media (Facebook)	Broad Community 1279 cumulative reach 13 post engagements 21 link clicks	-
The Advertiser	Broad community 16 February 2022	-
Port Road Banner	Broad community 1 banner	-
Your Say Charles Sturt	4600 members, 14 project follows, 685 views, 557 visits, 360 visitors	20 contributions

4. What did we hear

A total of 20 responses were received through the YourSay platform. 17 respondents completed the survey and 3 respondents provided feedback through the online mapping tool.

All feedback from the survey and any other written comments are summarised in this section. This forms **Appendix B**

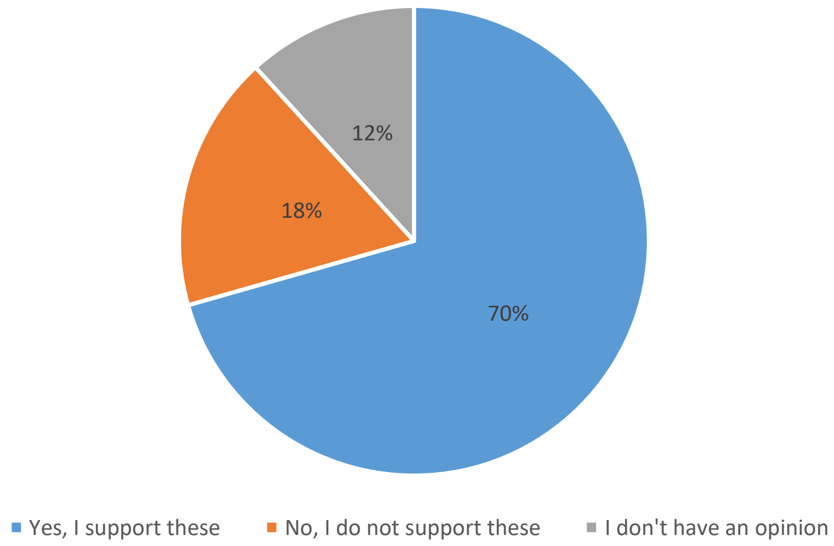
4.1 Which of the following best describes your interest in the West Lakes Catchment Stormwater Management Plan



4.2 The draft SMP proposes a range of measures to improve flood management, including detention storages and upgrades to drainage systems. The draft SMP also presents recommended priorities with preliminary estimated costing to aid in project selection and planning. Do you support the proposed measures to provide better flood protection and manage stormwater as shown in Figure 4 of the Consultation Summary Report?

It was identified that there was a large proportion (70.59%) of respondents that support and agree with the proposed measures in the Plan which area:

1. Gleneagles Reserve underground tank
2. Findon Road/Crittenden Road pipe upgrade
3. Beatrice Avenue/Trimmer Parade pipe upgrades
4. Matheson Reserve underground tank
5. Frank Mitchell Reserve underground tank
6. Nedford Reserve detention basin
7. Golfers Avenue pipe and pump upgrades
8. Sansom Road pipe upgrades
9. Recreation parade detention basin
10. Market Corner pipe upgrades
11. Holland Street pipe upgrades
12. Main Street pipe upgrades



Community Sentiment
11.8% positive, 5.9% mixed, 29.4% negative, 52.9% neutral

17.65% told us they do not agree and 11.76% did not have an opinion or provided other comments.

The inundation event on the 28 February 2022 came through the feedback with many experiencing flooding in some capacity and the need from residents for Council to look at many other areas as priorities.

These areas include:
- Georgia Avenue, Grange
- Judith Place, Grange
- Military Road, Grange
- Baker Street, Grange
- Fraser Street, Woodville South
- Charles Sturt Avenue, Grange

A suggestion was made to have each project listed with its cost benefits along with how the proposed measures/upgrades bring positive change.

There was some concern with improving the Crittenden Road, Findon Road and Trimmer Parade drains that are linked to the Grange Lakes channel and for its capacity to improved, to avoid future flooding.

Residents feel they are experiencing more than the annual rain fall and the stormwater infrastructure cannot cope with its current capacities.

4.3 Do you have any further suggestions regarding the draft SMP?

When asking this question, it was discovered that the community sentiment around the Stormwater Management plan was more related to the recent rain event that occurred on 28 February 2022.

Community Sentiment
14.4% positive, 7.7% mixed, 46.2% negative and 30.8% neutral

The following key themes and suggestions that were presented throughout the comments are:

- Capacity of the Grange Lakes to be increased
- Increased stormwater drain capacity in local streets to protect from future flooding
- More detail on the stormwater management map showing priorities and timelines
- Stormwater upgrades to take priority over other amenity upgrades

4.4. Community Open Days (1 March and 5 March)

Charles Sturt residents were invited to come along to a drop-in session on Tuesday 1 March and Saturday 5 March where our consultant Tonkin presented the stormwater management plan.

We had 8 people attend the Tuesday 1 March session and 6 attend the Saturday 5 March session.

Many of those that came had all experienced flooding from the recent rain event on 28 February, with the key streets being Batty Place, Almond Avenue in Woodville South; Gluyas Avenue, Grange; Wilford Avenue, Seaton; Leven Avenue, Seaton; Flavel Street, Seaton. Attendees expressed concerns that flooding in the road reserve and within property, occurs frequently at these locations (on an average once a year since 2016) and that Council need to look at these areas as priorities.

Most attendees were thankful that Council is aware of the flooding hot spots and a prioritised program to mitigate flooding is included in the SMP and the long-term financial plan.

Attendees also understood that Council will not be able to resolve all flooding for rare rain events (similar to the one that occurred on 22/02/2022) and Council's aim is to minimise flooding during more frequent storm events.

Attendees raised concerns about on- going maintenance including potential blockages in the stormwater drains that may have resulted in flooding. Field Services were notified of the concerns and drains have been inspected and cleaned at these locations.

Some questions asked were:

- o Will household insurance be affected by what happened and will it change when the SMP comes in?
- o Have you looked at the golf courses to capture water and possible reuse
- o Does SES have bigger trucks to pump water from streets?

Appendix A
Consultation Materials

1. **Figure 4 - Key Measures Map**
2. **Community Engagement Poster (Community Centres and libraries)**
3. **Port Road Banner**
4. **YourSay Charles Sturt website page**

ID	Report section	Description
1	6.1.1	Gleneagles Reserve underground tank
2	6.1.2	Findon Road / Crittenden Road pipe upgrades
3	6.1.3	Beatrice Avenue / Trimmer Parade pipe upgrades
4	6.1.4	Matheson Reserve underground tank
5	6.1.5	Frank Mitchell Reserve underground tank
6	6.1.6	Nedford Reserve detention basin
7	6.1.7	Golfers Avenue pipe and pump upgrades
8	6.1.8	Sansom Road pipe upgrades
9	6.1.9	Recreation Parade detention basin
10	6.1.10	Market Corner pipe upgrades
11	6.1.11	Holland Street pipe upgrades
12	6.1.12	Main Street pipe upgrades

tonkin

Job Number: 20190818
Filename: 20190818GQ010A
Revision: B
Date: 2021-10-27
Drawn: MM

Data Acknowledgement:
Aerial imagery from City of Charles Sturt, 2019
Roads and railways from Data SA, 2019

CITY OF CHARLES STURT

WEST LAKES STORMWATER MANAGEMENT PLAN
OVERVIEW OF STRUCTURAL MITIGATION STRATEGIES

Figure 4

HAVE YOUR SAY

ON THE DRAFT WEST LAKES CATCHMENT STORMWATER MANAGEMENT PLAN

CONSULTATION OPEN UNTIL 15 MARCH 2022

VISIT WWW.YOURSAYCHARLESSTURT.COM.AU TO PROVIDE YOUR FEEDBACK

HAVE YOUR SAY

on the West Lakes Catchment Stormwater Management Plan

Consultation closes 15 March 2022

yoursaycharlessturt.com.au

City of Charles Sturt

MEANS THE WORLD

West Lakes Catchment Stormwater Management Plan

Our draft stormwater management plan outlines actions to mitigate flooding, increase biodiversity and updating stormwater assets. Tell us what you think.

+ Follow

What is a Stormwater Management Plan?

The West Lakes Catchment Stormwater Management Plan (West Lakes Catchment SMP) is a strategic document that provides a long-term vision for flood mitigation, stormwater quality improvement and harvesting opportunities.

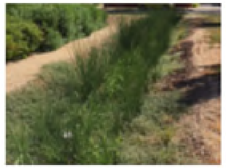
The intent of a stormwater management plan is to set out strategies, actions and programs that can be implemented to provide a long-term, sustainable approach towards stormwater management.

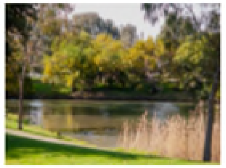
A SMP seeks to ensure that stormwater management is addressed on a total catchment basis with buy-in from all relevant stakeholders including local government authorities and state government agencies. Together they are responsible for the catchment by working together to develop, fund and implement strategies and physical works to manage stormwater in the area.

What suburbs are included in the West Lakes Catchment?

The West Lakes Catchment is a very large catchment and includes the suburbs of West Lakes, West Lakes Shore, Semaphore Park, Woodville South, Seaton, Findon, Grange, Fulham Gardens and Henley Beach. Refer Study Area map.

The study area has a total area of approximately 25 km2 and extends along the coast from Semaphore Park in the north to Henley Beach in the south and towards Port Road to the east. The study area is located entirely within the City of Charles Sturt. The study area for the West Lakes Catchment Stormwater Management Plan consists of eight sub-catchments and stormwater drains via several pipes and channels that discharge into West Lakes ('the Lake').





How do I get involved?

Consultation is open until Tuesday 15 March 2022.

- **View** the Draft West Lakes Catchment Stormwater Management Plan (in parts below) or at the following Libraries (West Lakes, Findon, Henley Beach, Woodville).
- **Attend** one of our Community Drop In Events and talk with an expert
  - Tuesday 1 March, drop in anytime between 4.30pm & 6.30pm, Seaton Neighbourhood Community Centre. Cairns Avenue, Seaton). Short presentation at approx 5pm.
  - Saturday 5 March, drop in anytime between 10am & 12noon, Woodville Rugby Clubrooms (Gleneagles Reserve, Ailsa Avenue Seaton). Short presentation at approx 10.30am.
- **Add a marker** to the map below and tell us your suggestions or any other comments about the SMP by 15 March 2022.
- **Complete** our short **survey** below, by 15 March 2022.
  - you may find it useful to refer to the Flood Mitigation Measures Map (Figure 4) and Consultation Report

West Lakes Catchment Stormwater Study Area

Key Dates

16 February – Tuesday 15 March 2022
Consultation Period

Tuesday 1 March 2022 04:30 pm – 06:30 pm
Community Drop In Event - Seaton Neighbourhood Community Centre
Seaton Neighbourhood Community Centre
Cairns Avenue, Seaton
Drop in anytime between 4.30pm and 6.30pm to speak to an expert. There will be a 15 minute presentation at 5.30pm.

Saturday 5 March 2022 10:00 am – 12:00 pm
Community Drop In Event - Woodville Rugby Clubrooms
Woodville Rugby Clubrooms

Mardon, and include the subject "West Lakes Catchment Stormwater Management Plan", to be received by 15 March 2022.

presentation at 11.00am.

Consultation has now closed and we are preparing a report for the Asset Management Committee. Thank you to those who have provided their feedback and recent experiences. More details will come soon.

Join the conversation today
Create an account or sign in to share your thoughts and ideas.

Sign up   Login

Closed

Online Survey

We would like to understand your views on the proposed measures for managing stormwater within the West Lakes Catchment. Review our Draft Stormwater Management Plan and complete our survey.

Start

Relevant Documents

Summary of Key Actions
PDF (71.90 KB)

Flood Mitigation Measures Map (Figure 4)
PDF (3.67 MB)
Reference in the survey

Draft West Lakes Catchment Stormwater Management Plan - Consultation Summary Report (Short Version)
PDF (9.55 MB)

See more

Closed

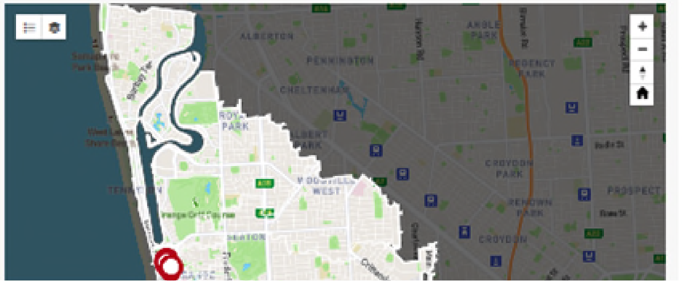
Tell us anything further about how we can better manage stormwater in the catchment.

Add a marker on the map below. You may want to tell us about:

Greening and Biodiversity
Water quality improvements
Stormwater harvesting and reuse

3 contributions

Enter an address



Project Timeline

Initial Key Stakeholder Engagement
June 2020 - October 2021

Report to Council on Draft plan
Seeking endorsement on the Draft Stormwater Management Plan for community consultation.
November 2021

Community Consultation on Draft Stormwater Plan
16 February 2022 to 15 March 2022

Reviewing Feedback
March 2022

Report to Asset Management Committee
April 2022

See less

Contact Us

Have questions or want to learn more about a project, contact us below:

Name Kath Mardon - Community Engagement Officer
Phone 8408 1270
Email eng-consultation@charlesstur.sa.gov.au

Name Murali KG - Coordinator Engineering Projects
Phone 8408 1171
Email mkg@charlesstur.sa.gov.au

Appendix B
Survey responses

Survey Responses (all questions)

#	Do you support the proposed measures to provide better flood protection and manage stormwater as shown in Figure 4 of the Consultation Summary Report? Please explain your response from the previous question.	Do you have any further suggestions regarding the draft SMP?
1	Good through explanation of projects. To compare projects each one needs to have cost associated with them, so they can be compared. A char would be helpful. Project, Floating, H2O Quality, Reuse, Cost.	
2	The area that concerns me is the improving of the Crittenden Rd, Findon Rd & Trimmer Pde pipelines that feed into Kirkcaldy Creek (waterway that flows from Kirkcaldy Park to West Lake). This improvement will increase the amount of stormwater that flows into Kirkcaldy Creek. On 28 February 2022 Grange experienced a rainfall event that overwhelmed the existing stormwater structure causing flooding in Grange and nearby suburbs. I feel that the Kirkcaldy creek waterway also needs to be improved (increased capacity) to accommodate the proposed increase in stormwater from these pipeline improvements to avoid future flooding.	I would like to see an improvement in the stormwater management on Georgia Ave & Judith Place Grange. There are just 3 stormwater drains for 40 dwellings. The adjacent streets Sierra Ave & Diane Place have 8 stormwater drains for 28 dwellings. During a rain event on 28 February 2022 Georgia Ave and Judith place experienced flooding that whereby two cars that attempted to drive through knee deep stormwater succumbed to water ingestion. Yet on adjacent street Sierra Ave with more stormwater drains, cars continued to traverse that street throughout this event.
3	Future proofing against changing climate is needed.	No
4	I live in Georgia Avenue Grange which sustained a recent flooding event.	There is only one stormwater drain in Georgia Ave. and would ask that this area be included in ongoing flood investigations for the West Lakes Zone to protect against further flooding events such as that which occurred on Monday 28th Feb. 2022.
5	The area that concerns me is the improving of the pipeline from Findon Rd & Crittenden Rd. This improvement will increase the stormwater that flows into Kirkcaldy Creek. On 28 February 2022 Grange experienced a rainfall event that overwhelmed the existing stormwater structure causing flooding in Grange and nearby suburbs. I feel that the Kirkcaldy creek will also need to be improved to accommodate the proposed increase in stormwater from Findon/Crittenden Roads. If this additional improvement was included, then I would support this draft.	I would like to see an improvement in the stormwater management on Georgia Ave & Judith Place Grange. There are just 3 stormwater drains for 40 dwellings. The adjacent streets Sierra Ave & Diane Place have 8 stormwater drains for 28 dwellings. During a rain event on 28 February 2022 Georgia Ave and Judith place experienced flooding that whereby two cars that attempted to drive through knee deep stormwater succumbed to water ingestion. One house on Georgia Ave was completely surrounded by stormwater. Yet on adjacent street Sierra Ave with more stormwater drains Cars continued to traverse that street throughout this event without difficulty.
6	I don't support them at present, as it's not clear to me if our section of Military Road is even included?	Yes, the included map needs to have more detail and a way to clearly identify which area it services and how proposed changes will bring about substantial positive change. To date I haven't read anything on timelines. When works will begin? How long to completion? Degree and time length of proposed benefits?
7	I can no longer get insurance due to the creek overflow into my property. Premiums are now sky high and who knows what damage its causing to my foundations. One angry resident	
8	Given a resident of the Charles Sturt council area and a person that has experienced property damage caused by flooding due to inadequate stormwater management, I	

	firmly believe the council needs to act immediately to resolve this issue. It should place highest on the priority list.	
9	Flood management improvement is required in Baker st, Grange. Many times a year results in water levels at the top of street gutters at the front of our house	Address the frequent flooding of Baker St.
10	Avoiding flooding of homes during severe weather events is fundamental to the safety and well-being of residents.	Recent experience suggests the flooding of Matheson reserve and Frank Mitchell park we’re significant and impacted residences properties, parked cars and sadly some houses.
11	We live in Fraser St, Woodville South and have had considerable flooding over the years. I would definitely like to see it fixed properly.	
12	I'm assuming that the draft management plan has been researched and written by engineers who would recommend what is required to resolve the large-scale problem of flooding in the West Lakes catchment zone.	This project needs to be a priority and approved for funding. It was reported on the news that many rate paying residents had to clean water out of their homes - which is unacceptable. This project should take priority over any proposals to upgrade parks/facilities etc for aesthetic pleasure. I personally had to upgrade my house insurance to safe guard against my house being flooded, as water was up to my doorstep during heavy rainfall last year.
13	There do not appear to be any plans to improve the stormwater drainage in Baker St, Grange. For residents of [redacted] Baker St this is a serious issue. We are not familiar with the areas for which new management strategies are proposed.	Improve drainage between Military Rd and Charles Sturt Ave.
14	I feel that the area of Grange and West lakes is very much within a flood zone and needs constant inspection of the existing flood protection facilities	Just keep up the maintenance and improvement of the existing flood mitigation protection for the area.
15	It’s very important to living here	No
16	If it needs to be done I just hope it's done right	No
17	It is an important subject to reverse flooding and to use the excess water elsewhere	It looks good to me

Mapping Tool

3 responses were made on the map with the following comments:

In relation to	Comments
Baker Street, Grange	Stormwater flooding Baker St near units at number [redacted]. Photos show debris water line once water had subsided 1/3/2022, after flooding on evening of 28/2/2022. The water was up to the house side of the letterbox at Unit 2.
Baker Street, Grange	When it rains heavily the stormwater on the nearby curve in Baker St banks up and floods the street. The level of the water is higher than the stormwater exits from private properties, preventing stormwater draining from the yard. This last happened in December 2021, causing the Emergency Services to visit to check on residents.
Charles Sturt Avenue, Grange	Re. Stormwater harvesting, great idea, are there any plans to capture the storm water that builds up in Charles Sturt avenue. Recent rain storms have caused flooding in the street and during one storm in 2021 water came halfway up our drive flooded our front garden and was lapping onto the edge of our concrete verandah.