City of West Torrens

Stormwater Management Plan

West Torrens Drainage Catchments



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City of West Torrens

Stormwater Management Plan

West Torrens Drainage Catchments

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Executive Summary

This Stormwater Management Plan (SMP) for the West Torrens Catchment has been prepared in accordance with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007).

This document contains:

- A summary of existing information relevant to management of stormwater in the catchment;
- Catchment specific objectives for management of stormwater runoff from the catchment;
- Potential management strategies that may be used to meet the identified management objectives;
- Estimated costs and benefits associated with each of the strategies
- A clear definition of the priorities, responsibilities and timeframe for implementation of the Stormwater Management Plan.

The Stormwater Management Plan catchment area totals 37.4 km^2. Local government jurisdiction over the catchment is shared between the City of West Torrens (33.5 km^2), City of Charles Sturt (1.8 km^2) and Adelaide City Council (2.1 km^2).

The existing stormwater network has not been designed to provide a 1% AEP overland flood standard (equivalent to 100 year ARI). For example, the large Cowandilla Mile End system was designed to cater for a 10% AEP event. A number of issues have emerged that are progressively reducing the performance of the existing stormwater network. These include:

- Increasing density of development. Greater proportions of impervious site coverage (thereby generating greater stormwater runoff) are occurring due to infill land division and development, and larger development footprints. Substantial further development of this nature is projected to occur within the catchment.
- Increasing storm rainfall intensity due to climate change. *Australian Rainfall and Runoff,* the pre-eminent guide to stormwater management practice in Australia provides clear direction on the extent to which rainfall stormwater intensities should be assumed to change in a future scenario.

In addition to the above, stormwater management practice has evolved over time, with an increasing focus now on management of the 1% Annual Exceedance Probability (AEP) event (or 100 year return interval event), to ensure that above floor inundation of dwellings and other buildings does not occur for events up to an including this event. The study area is vulnerable in such an event, due to the limited underground drainage capacity, and the urban development that spans across the Adelaide plains.

This study focusses on the local stormwater drainage systems and does not consider flooding caused by the major receiving watercourse of the River Torrens, Brown Hill Creek or Keswick Creek. Each of these watercourses have much larger catchment areas. Appropriate downstream water levels within the major receiving systems have been assumed for modelling purposes to ensure sensible assessment of the local stormwater network performance.

The total Catchment Study Area has been divided into several major subcatchments which discharge into different water bodies, before ultimately entering the Gulf St Vincent. The subcatchments and their respective receiving water body are listed below:

- Cowandilla Mile End Scheme (Patawalonga Creek)
- Airport (Patawalonga Creek)
- River Torrens subcatchment (River Torrens)
- River Torrens Pumping Stations (River Torrens)
- Lockleys (Patawalonga Creek)
- West Beach, Patawalonga Creek
- Keswick – Western Adelaide (Keswick Creek)
- Keswick Creek Lateral Drains (Keswick Creek)
- Brown Hill Creek Lateral Drains (Brown Hill Creek)

These catchments are used to distinguish the different costs, damages and benefits of the multiple drainage and water quality strategies proposed.

Flood plain mapping has been prepared that shows the risk posed under existing conditions, and several potential future scenarios that consider future infill development and climate change conditions. This mapping demonstrates that a number of areas are vulnerable in a major storm event, and that these risks will be substantially escalated under likely future long term (2050-2090) scenarios if no intervening strategy is implemented.

A series of structural works have been identified and scoped at an initial level to mitigate against these risks. Of the many upgrades proposed, there are four major works in the Henley Beach South to Fulham, Cowandilla to Mile End, Marleston to West Richmond, and North Plympton areas. Each of these areas is shown to have significant roadway ponding in all storm events and considerable property inundation in larger events.

An initial estimate values the total drainage system upgrade costs at $118m (capital costs estimated in 2020 $). The full delivery of these works is considered to be a long term (30+ year) objective, to reflect the progressive nature of change in catchment development and environmental conditions. A benefit cost analysis was carried out, considering the annual average damages (AAD) for the existing and upgrade scenario. While the drainage works have considerable capital costs involved, the majority have shown to be financially beneficial, as shown in the table below.

Proposed Drainage Strategy Benefit Cost Ratio Analysis (50 year period)

Catchment	Reduction in AAD	Capital Costs	Annual Costs	IRR	NPV	BCR
River Torrens Pumping Stations	$960,000*	$23.21m	$10,000	3%	-$4.00m	0.82
Lockleys	$190,000	$4.10m	-	4%	-$260,000	0.93

Catchment	Reduction in AAD	Capital Costs	Annual Costs	IRR	NPV	BCR
River Torrens	$1.32m	$8.08m	-	16%	$17.62m	3.28
Cowandilla Mile-End	$1.73m*	$26.23m	-	6%	$8.15m	1.32
Keswick Creek Lateral Drains	$4.76m*	$28.73m	-	17%	$64.06m	3.33
Brown Hill Creek Lateral Drains	$3.39m	$27.75m	-	12%	$38.62m	2.45

*Clarification on values is provided in Section 4.9.2

The measures currently in place to improve water quality prior to discharge to the receiving waters (River Torrens, Patawalonga Creek, Brown Hill Creek and Keswick Creek) include wetlands, gross pollutant traps and predominantly street scale raingardens. The primary water quality strategy proposed is to continue the expansion of raingardens within the street network. The number of raingardens that would be required to provide the required water quality improvements has been evaluated. A target number of raingardens has been nominated to strive to achieve, through integration with their road reconstruction and drainage construction programs.

In addition to the structural measures proposed, the SMP provides recommendations on several non-structural strategies to meet the SMP objectives for flooding and water quality improvements. These include strategies surrounding community consultation and education, integrating stormwater improvement measures with Council plans, ongoing maintenance of council assets and development controls (where possible).

The suitability of additional Managed Aquifer Recharge (MAR) schemes was also assessed as a part of the SMP. There are currently two relatively large stormwater harvesting and reuse schemes (Glenelg Golf Course, Adelaide Airport Managed Aquifer Recharge Schemes) already operating in the catchment area. The assessment identified several challenges in implementing new MAR schemes, including that the concentration of existing schemes along the coastal margin between Glenelg and Grange has resulted in increased pressures in the aquifer and impacts on existing users. It is suggested that further MAR schemes along the coastal margin may increase the problem.

Extension of the existing Glenelg to Adelaide Parklands Recycled Water Scheme is recommended as an alternative irrigation source for Council's parks and reserves.

A draft report was prepared for the purpose of enabling consultation with the local community, Cities of Adelaide and Charles Sturt, Green Adelaide and the Stormwater Management Authority. Following the collation of feedback from this process, this final report has been prepared and submitted to the City of West Torrens, Green Adelaide Board, and the Stormwater Management Authority (SMA) for formal endorsement.

Abbreviations

ABS	Australian Bureau of Statistics
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
AMLRNRMB	Adelaide and Mount Lofty Ranges Natural Resources Management Board
ANZECC	Australian and New Zealand Environment Conservation Council
ARI	Average recurrence interval
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASR	Aquifer storage and recovery
BCR	Benefit cost ratio
BDP	Better Development Plan
BOM	Bureau of Meteorology
CCS	City of Charles Sturt
CWT	City of West Torrens
DEW	Department of Environment and Water
DPA	Development Plan Amendment
DPLG	Department of Planning and Local Government
DIT	Department of Infrastructure and Transport
EPA	Environment Protection Authority
EWR	Environmental water requirement
EY	Exceedances per Year
GA	Green Adelaide
GIS	Geographic information system
GP	Gross pollutants
GPS	Global positioning system
HELSP	Housing and Employment Land Supply Program
IPCC	Intergovernmental Panel on Climate Change
LGA	Local Government Area
MAR	Managed Aquifer Recharge
ML	Mega litre
NRM	Natural Resources Management
NWQMS	National Water Quality Management Strategy
RCBC	Reinforced concrete box culvert

RCP	Reinforced concrete pipe
SAPPL	South Australian Planning Policy Library
SDR	Strategic Directions Report
SEP	Side-entry pit
SES	State Emergency Service
SMA	Stormwater Management Authority
SMP	Stormwater Management Plan
SWSDS	South Western Suburbs Drainage Scheme
TDS	Total dissolved solids
TN	Total nitrogen
TP	Total phosphorous
WAP	Water Allocation Plan
WMLR	Western Mount Lofty Ranges
WSUD	Water Sensitive Urban Design

1 Introduction

The City of West Torrens has prepared this Stormwater Management Plan (SMP) for the urban drainage catchments which discharge into the sections of Brown Hill Creek, Keswick Creek, River Torrens, Patawalonga Creek and Sturt River (downstream of McCann Ave - Glenelg North) located within the West Torrens local government area. In some locations, these drainage systems extend into neighbouring Council's areas (City of Adelaide, City of Charles Sturt).

While previous and ongoing work influences requirements for the management of the major drainage reaches (Brown Hill Creek, Keswick Creek, Sturt River and River Torrens), this plan has been prepared to provide a set of integrated stormwater management strategies that achieve stormwater management best practice with respect to the drainage networks operating at the local level. Appropriate downstream water levels within the major drainage reaches have been assumed for modelling purposes to ensure sensible assessment of the local stormwater network performance.

The preparation of the plan has been jointly funded by the City of West Torrens, the Stormwater Management Authority (SMA) and the Green Adelaide Board. This Stormwater Management Plan has been prepared in accordance with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007).

This Plan has been developed in accordance with the guideline framework whereby the productive and sustainable use of stormwater, reduction of pollution impacts, and enhancement of natural watercourses and ecosystems are key principles, in addition to flood minimization.

The strategies outlined in this Plan are proposed as a means of ensuring that the above goals are achieved in an integrated and coordinated manner. This document contains:

- A summary of existing information relevant to management of stormwater in the catchment;
- Catchment specific objectives for management of stormwater runoff from the catchment;
- Potential management strategies that may be used to meet the identified management objectives;
- Estimated costs and benefits associated with each of the strategies
- A clear definition of the priorities, responsibilities and timeframe for implementation of the Stormwater Management Plan.

In addition to Council staff, the plan has been prepared in consultation with Department of Infrastructure and Transport (DIT) staff, in their role as technical advisor to the SMA, and Green Adelaide staff (previously known as AMLRNRM).

A draft report was prepared for the purpose of enabling consultation with the local community, Cities of Adelaide and Charles Sturt, Green Adelaide and the Stormwater Management Authority. Following the collation of feedback from this process, this final report has been prepared and submitted to the City of West Torrens, Green Adelaide Board, and the Stormwater Management Authority (SMA) for formal endorsement.

2 Catchment Features

2.1 Catchment Extent

The Study Area boundary for this Stormwater Management Plan (refer Figure 2.2) is comprised of the catchments that drain into the sections of Brown Hill Creek, Keswick Creek, River Torrens, and Patawalonga Creek located within the West Torrens local government area). The total Study Area is 37.3 km^2 in area and extends across a number of local government areas as summarised in Table 2.1 below.

Table 2.1 – Plan Area Composition, by Local Government

Local Government Area	Area (km^2)	% Total Area
West Torrens	33.5	89.6
Charles Sturt	1.8	4.8
Adelaide	2.1	5.6
Total	37.4	100.0

The Study Area borders the 'Holdfast Marion' Stormwater Management Plan boundary to the south and the Sturt River Urban Catchments Stormwater Management Plan area to the southeast. The Study Area also overlaps the lower portion of the 'Brown Hill Keswick Creeks' Stormwater Management Plan area, as depicted in Figure 2.1, which addressed the creek channels, but not the lateral drainage network. This Stormwater Management Plan is concerned with the lateral drainage network, and not the major creek channels.

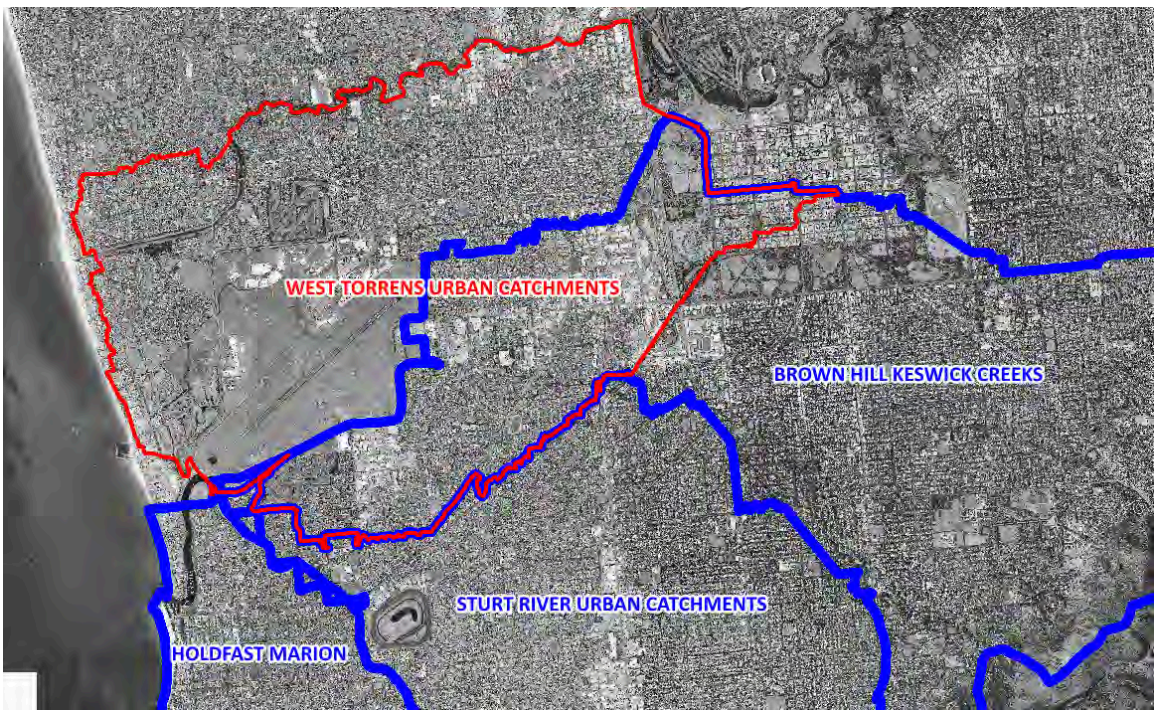


Figure 2.1 – Adjoining Stormwater Management Plan Areas

2.2 Topography

A digital terrain model for the Stormwater Management Plan area (refer Figure 2.3) was generated from available survey data as follows:

- West Torrens area – photogrammetric survey captured in January 2011 (3m regular grid points, breaklines interpolated to points every 1m)
- Charles Sturt area – photogrammetric survey captured in January 2012 (2m regular grid points, breaklines interpolated to points every 1m)
- Adelaide area – Adelaide City Council 500mm contour dataset

Inspection of these surface elevation models indicates that the Study Area is relatively flat with a number of trapped low points. The catchment has a general gradient in western direction towards West Beach.

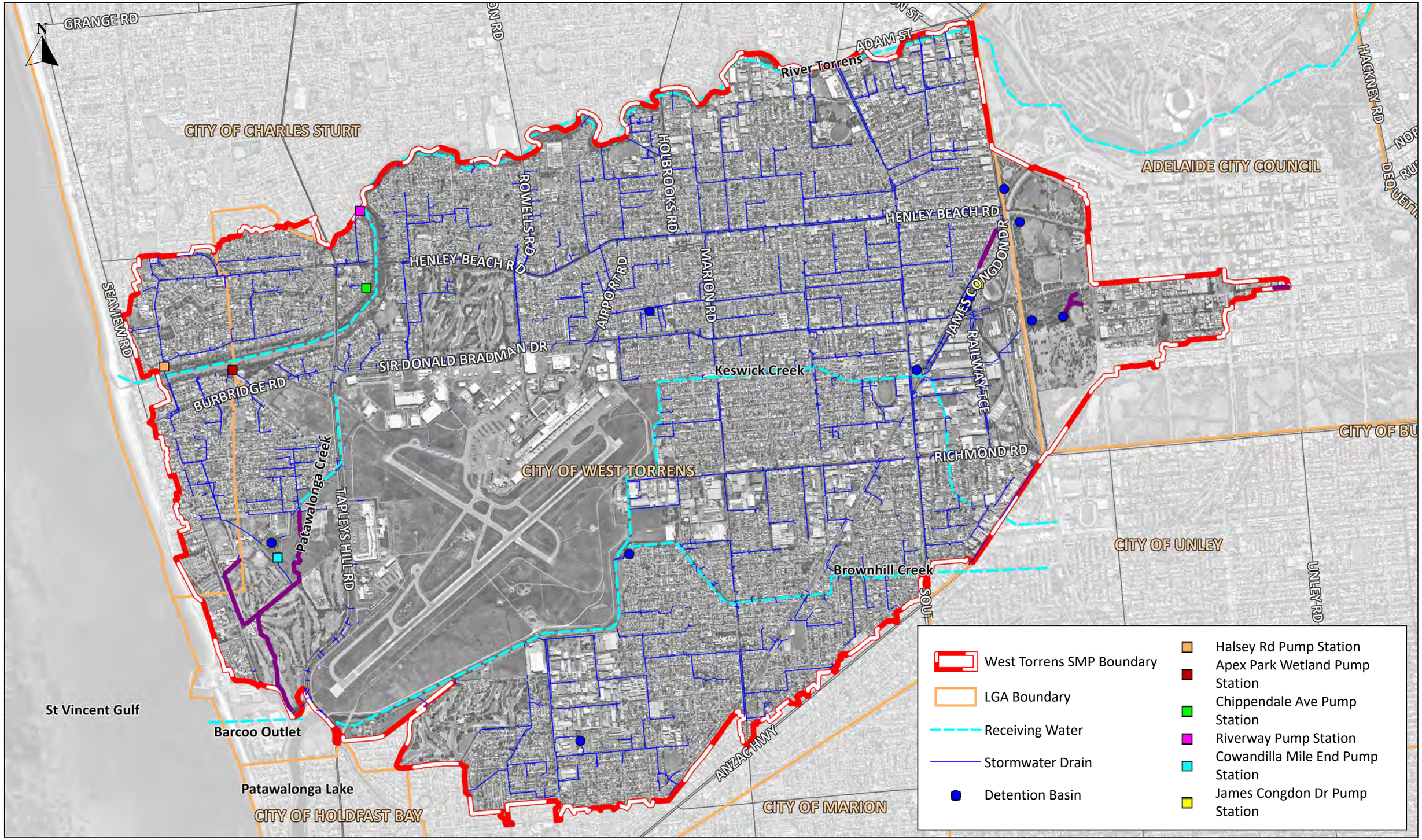
2.3 Receiving Watercourses

The majority of stormwater runoff from the West Torrens Study Area discharges into the Patawalonga Lake before entering the Gulf St Vincent via the Barcoo Outlet. Local catchment stormwater flows initially discharge into the following receiving watercourses prior to reaching the Barcoo Outlet:

- Keswick Creek – This is predominantly a concrete channel before it connects into Brown Hill Creek just south of Richmond Road along the eastern airport boundary. Along with receiving local catchment stormwater runoff, the Keswick Creek receives flows further upstream from the Glen Osmond Creek and South Parklands Creek.
- Brown Hill Creek – The downstream section is a vegetated earth channel. Various sections of the creek further upstream are concrete lined. The larger Brown Hill Creek catchment extends as far eastwards as Crafers. The ongoing Brown Hill Keswick Creek Stormwater Project (a collaborative undertaking by the affected councils) has identified several channel upgrades along the Creek, in particular the Lower Brown Hill Creek Upgrade. This upgrade, between Anzac Highway and the Airport, aims to convey increased stormwater flows, including stormwater diverted from Keswick Creek, and to reduce the risk of flooding in the western suburbs.
- Adelaide Airport channel – This channel runs along the northern and western edge of the airport. The low flow channel predominantly concrete lined. There is significant riparian vegetation along the banks of the channel.
- Patawalonga Creek – This creek was once a diverse watercourse running through the Adelaide plains. It has now been contained in many places through the suburbs in concrete channels. There is a small section of remnant creek and vegetation is located in the grounds of Adelaide Airport, west of Tapleys Hill Road (Telfer and Malone 2012).

These receiving watercourses are displayed in Figure 2.2 and Figure 2.6.

The northern local stormwater systems of West Torrens Study Area discharge directly into the River Torrens before entering the Gulf. The downstream end of the River in the Study Area is a ‘perched’ water course and the runoff from local catchments along this stretch of the River are discharged via pump stations.



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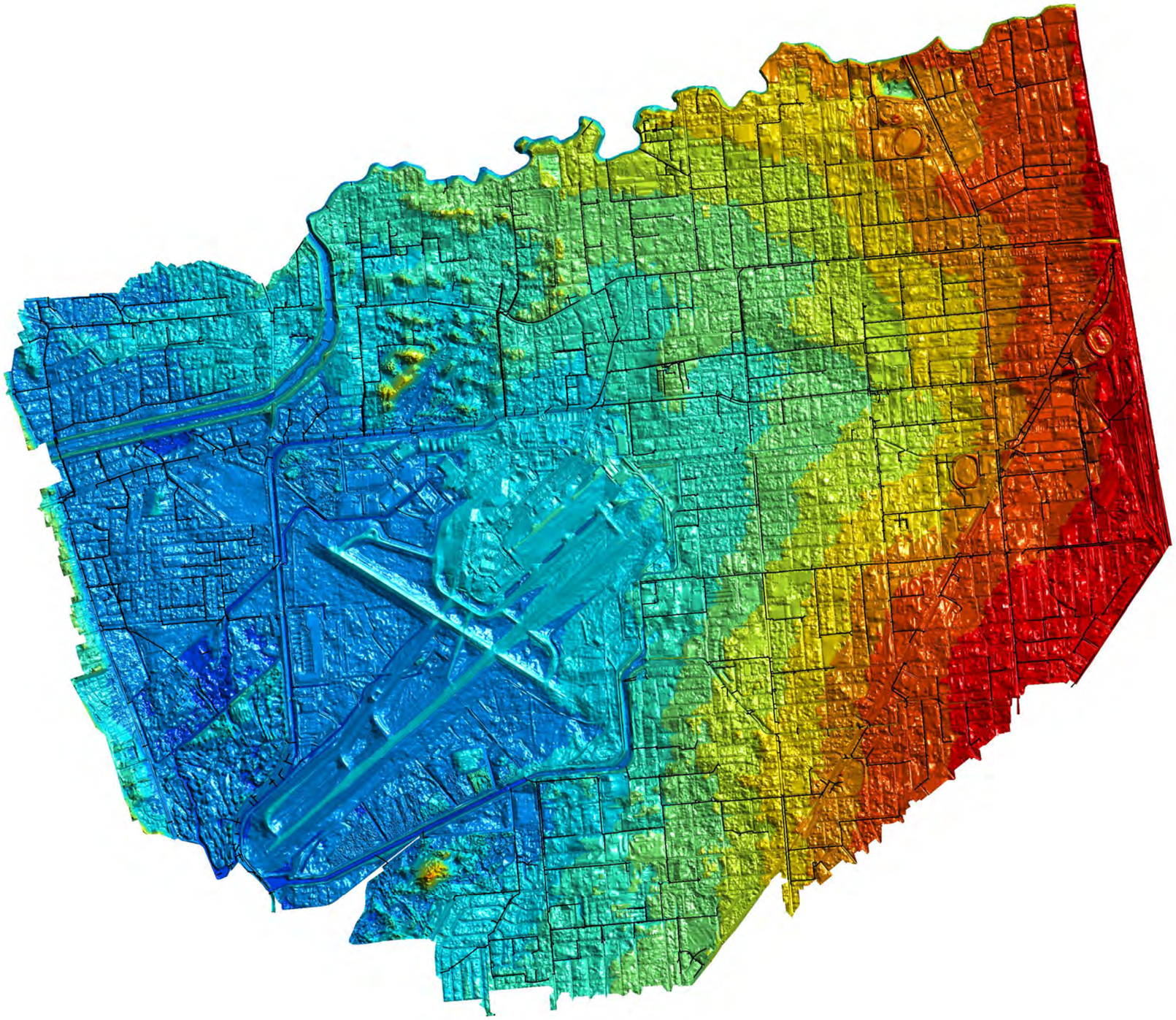
Data Sources:
City of West Torrens [Existing Stormwater Network]
NearMap [Aerial Photograph]

southfront

West Torrens
Stormwater Management Plan

Study Area
Figure 2.2

N



Elevation (mAHD)

- 20 to 22
- 16 to 20
- 14 to 16
- 12 to 14
- 10 to 12
- 8 to 10
- 6 to 8
- 4 to 6
- 2 to 4
- 0 to 2

Stormwater Drain

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Data Sources:
City of West Torrens [Existing Stormwater Network]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

Topographic Plan
Figure 2.3

2.4 Infrastructure

2.4.1 Drainage Conduits and Structures

Each of the Catchment Councils maintains a GIS database of existing stormwater infrastructure.

On receipt of the datasets, further assessment revealed a number of areas of missing drainage assets, missing drain/pit attribute data and a general deficiency in meeting the standards of a 'networked' GIS dataset, such that the data can be used for stormwater modelling.

Missing drainage assets and key information such as pipe sizes was completed with the support of each of the Catchment Councils and DIT. Further attribute data was infilled into the dataset to satisfy the requirements for subsequent modelling tasks, as follows:

- Surface RL – automated process utilising the DTM intersection of each node (pit)
- Pipe Invert RL (upstream, downstream) – Preferential retention of invert data where contained in supplied data. Generation of missing inverts through an automated routines that achieves 600mm minimum cover with manual modifications made to achieve connectivity to adjoining known levels and gravity drainage in areas where the drain is opposed to the natural gradient.

Existing pump station information was obtained through contact with relevant Councils and the Department if Infrastructure and Transport. In addition, a separate pump station desktop study was conducted for the City of West Torren's Riverway and Chippendale pump station to ensure the pump station data used for modelling purposes was accurate. This desktop study is provided in Appendix A. Locations of existing pump stations are provided in Figure 2.2.

A summary profile of existing infrastructure is provided in Table 2.2 below.

Table 2.2 – Stormwater Infrastructure Profile Summary

Asset Class	Description	Quantity
Pipes	Total	4870
Box Culvert	Total	440
Open Channel	Mile End Cowandilla Airport Drain Opie Reserve West Torrens Depot Brown Hill Creek Keswick Creek	6 total
Node	Side-entry pit Headwall Field Gully / Grated Inlet Junction Box Soakage Pit	2500 60 230 860 40

Asset Class	Description	Quantity
Pump Stations	Halsey Road (2 pump stations with max. rate of 284 L/s and 928 L/s respectively) Chippendale Avenue (max. pump rate of 400 L/s) Cowandilla Mile End Detention Basin (max. pump rate of 840 L/s) Apex Park Wetland (max. pump rate of 1,000 L/s) James Congdon Drive (max. pump rate of 350 L/s) Riverway (max. pump rate of 900 L/s)	6 total
Detention Basins	Cowandilla Mile End Detention Basin Lew St William St Railway Tce/James Congdon Drive Tolley Crescent West Parkland basins	10 Total

2.4.2 Stormwater Asset Age/Condition

The construction year for the existing stormwater network in the West Torrens Catchment ranges from 1937 to 2020. Figure 2.4 obtained from the City of West Torrens Stormwater Asset Management Plan (2020) provides the asset age profile for the Councils stormwater infrastructure.

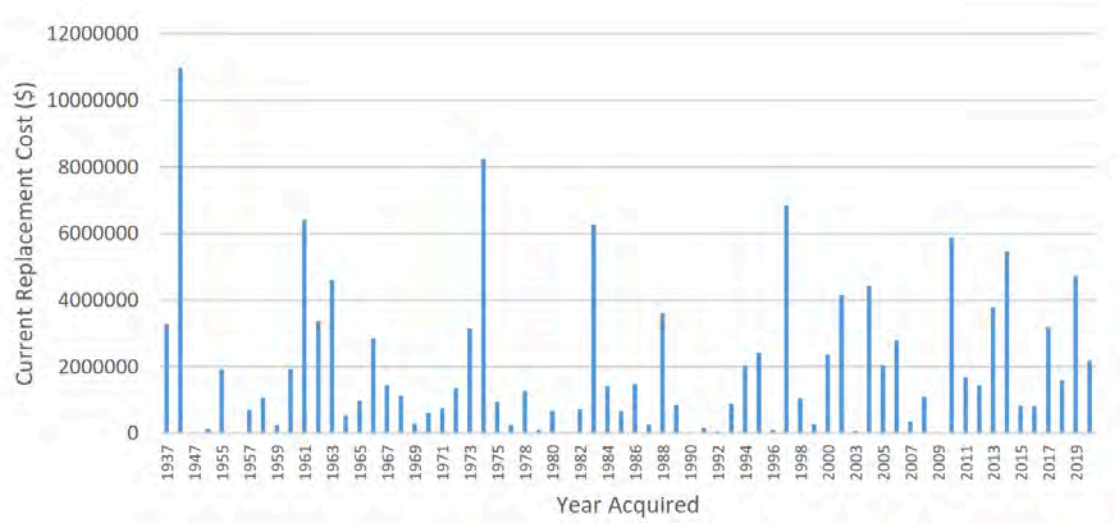


Figure 2.4 – Asset Age Profile (City of West Torrens Stormwater Asset Management Plan (2020))

Council currently monitors asset condition via annual CCTV condition audit programs. Findings from these audits are included in the Stormwater Asset Management Plan. Approximately two percent of the stormwater network is audited per year through this program.
The asset condition is measured using a grading system as detailed in Table 2.3 below (Table 5.1.3 extracted from the CWT Stormwater Asset Management Plan (2020)).

Table 2.3 – Condition Grading System (City of West Torrens Stormwater Asset Management Plan (2020))

Condition Grading	Description of Condition
1	**Very Good**: free of defects, only planned and/or routine maintenance required
2	**Good**: minor defects, increasing maintenance required plus planned maintenance
3	**Fair**: defects requiring regular and/or significant maintenance to reinstate service
4	**Poor**: significant defects, higher order cost intervention likely
5	**Very Poor**: physically unsound and/or beyond rehabilitation, immediate action required

As the annual condition audit program has only been implemented in recent years, condition data is only captured for approximately 17 percent of stormwater assets. The condition profile for those assets which have been assessed is shown in Figure 2.5. As can be seen, the majority of assets which have been assessed are graded as being in fair condition. Due to the random nature in which the annual audit program is developed, Council is satisfied to assume that the condition profile shown is similar for all stormwater assets in the network.

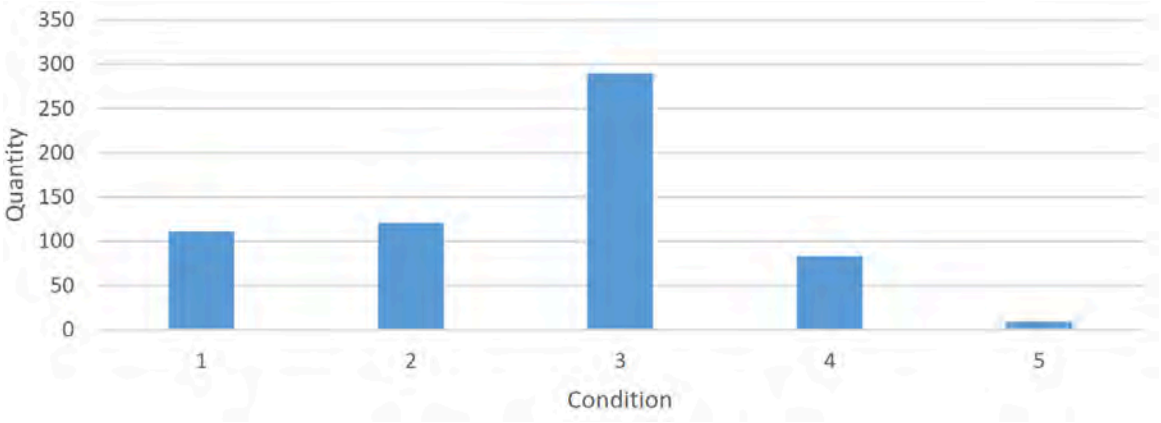


Figure 2.5 – Asset Condition Profile (City of West Torrens Stormwater Asset Management Plan (2020))

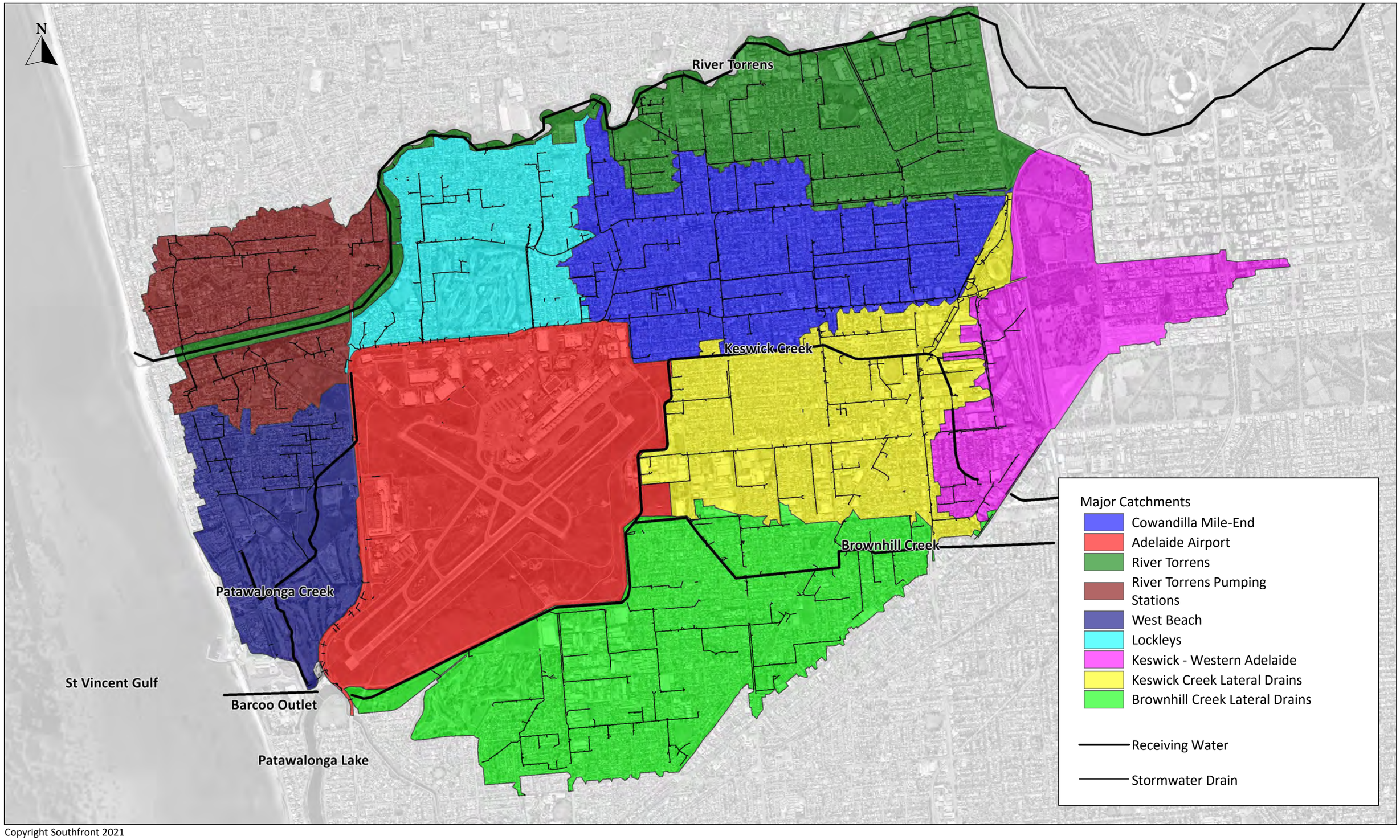
2.4.3 Major Drainage Catchments

The study area encompasses nine different major drainage catchments, including;

- Cowandilla Mile End Scheme
- Airport
- River Torrens
- River Torrens Pumping Stations
- Lockleys
- West Beach
- Keswick – Western Adelaide
- Keswick Creek Lateral Drains
- Brown Hill Creek Lateral Drains

The boundaries of these major drainage catchments are shown in Figure 2.6. The Adelaide stormwater runoff was accounted for in the SMP modelling. The detailed airport internal

drainage network was not obtained; hence a simplified modelling approach was required. The larger Airport Catchment split into several smaller subcatchments based on the topography and existing channels across the site. See section 4.3 for further details on Airport inflows.



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Data Sources:
City of West Torrens [Existing Stormwater Network]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

Major Drainage Catchments Map
Figure 2.6

2.4.4 Water Quality Assets

A summary Council's Water Quaility Assets is provided in Table 2.4. See section 5.5 for further details on the existing water quality assets within the West Torrens Study Area.

Table 2.4 – WSUD Assets Summary

Asset Class	Description	Quantity
Constructed Wetlands	Apex Park Wetland Sir Donald Bradman Drive Wetland Kings Reserve Wetland Glenelg Golf Course Wetland (privately owned) Western Parklands ephemeral wetland (Adelaide City Council)	5 total
Gross Pollutant Traps (GPT)	Trash Racks HumeGard GPT	3 5
Streetscape Raingardens	Tree pit Small Medium Large	47 55 55 27
Tree Infiltration Wells	Total	90

2.5 Urban Planning, Development Potential

A detailed assessment of the current urban planning context and future development potential was undertaken by Infraplan to appropriately inform the development of this Stormwater Management Plan. The full report prepared by Infraplan is enclosed in Appendix B, with findings of significance summarised in this section.

2.5.1 Existing Land Use

Existing land use across the Study Area is predominantly residential, with other land uses including commercial and industrial land uses along main road frontages. Figure 2.7 illustrates land uses across the Study area.

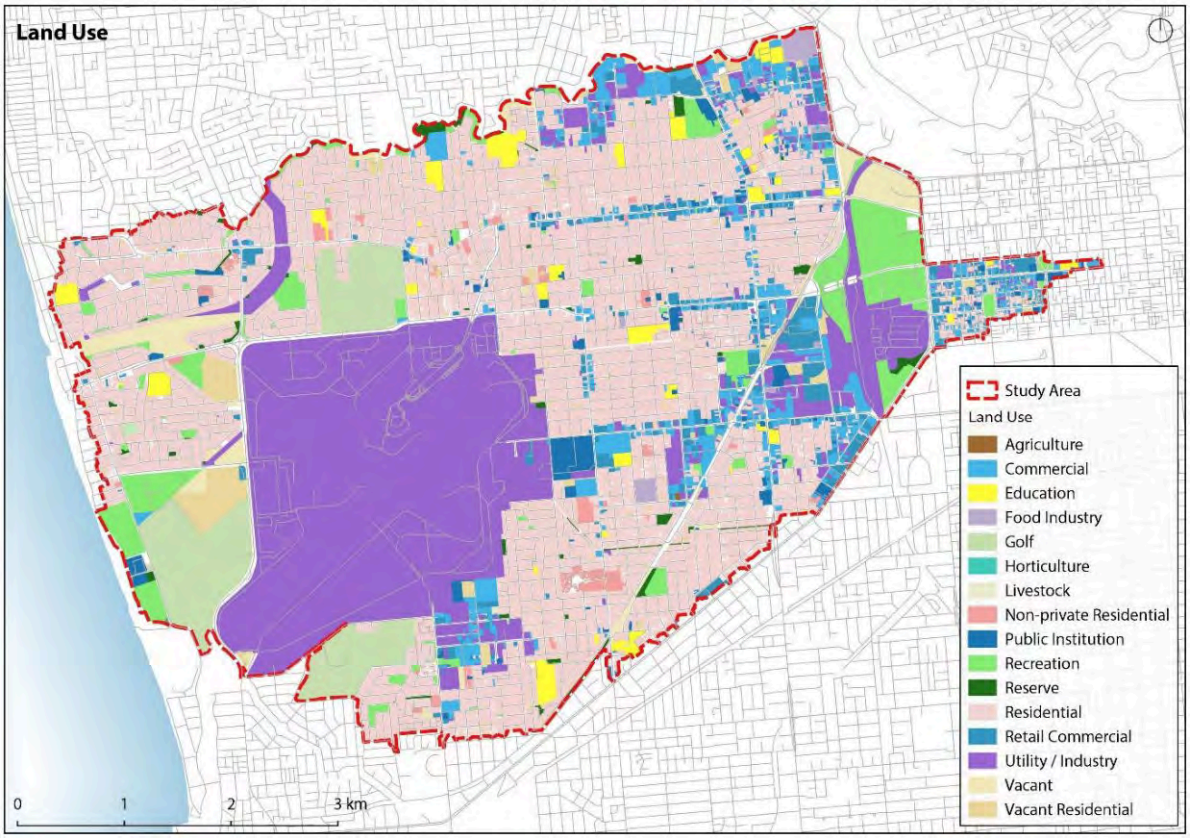


Figure 2.7 – Existing (Generalised) Land Use

2.5.2 Recent Development Trends

Adelaide is experiencing moderate densification across its metropolitan area. Growth in Adelaide's middle and inner suburbs (including the city centre) now accounts for over 70% of dwelling increases. This is a shift since the early 1990's from a position where population was falling in these locations.

Demolition, subdivision and redevelopment is increasing the housing stock within existing urban areas. Much of this development is categorised as 'minor infill' as most of these projects result in the production of only one or two additional dwellings. This is in comparison to 'greenfield' development which predominantly occurs on the urban fringe.

The *Residential Demolition and Resubdivision Report* (DIT, 2013) provides a detailed historical assessment of residential development across metropolitan Adelaide between 2004 and 2010. Of specific interest is the total dwelling increase on all demolition and resubdivision sites by LGA, as well as the site replacement ratios for finished demolition site. This type of development can broadly be defined as 'infill' development and is pertinent to established metropolitan areas.

The report shows that from 2004 to 2010, an additional 11,521 dwellings were added to the metropolitan Adelaide housing stocks through demolition and resubdivision, with approximately 2,470 of these occurring within the LGA's of the Study Area (refer Figure 2.8). The City of Charles Sturt accounted for a majority of these dwellings (approximately 70%), with the City of West Torrens and the Adelaide City Council accounting for the remaining 28% and 2% respectively. However it should be noted that much of the redevelopment within Charles Sturt occurred in the suburbs of Findon (141 dwellings) and Seaton (197 dwellings) which both sit outside the SMP Study Area.

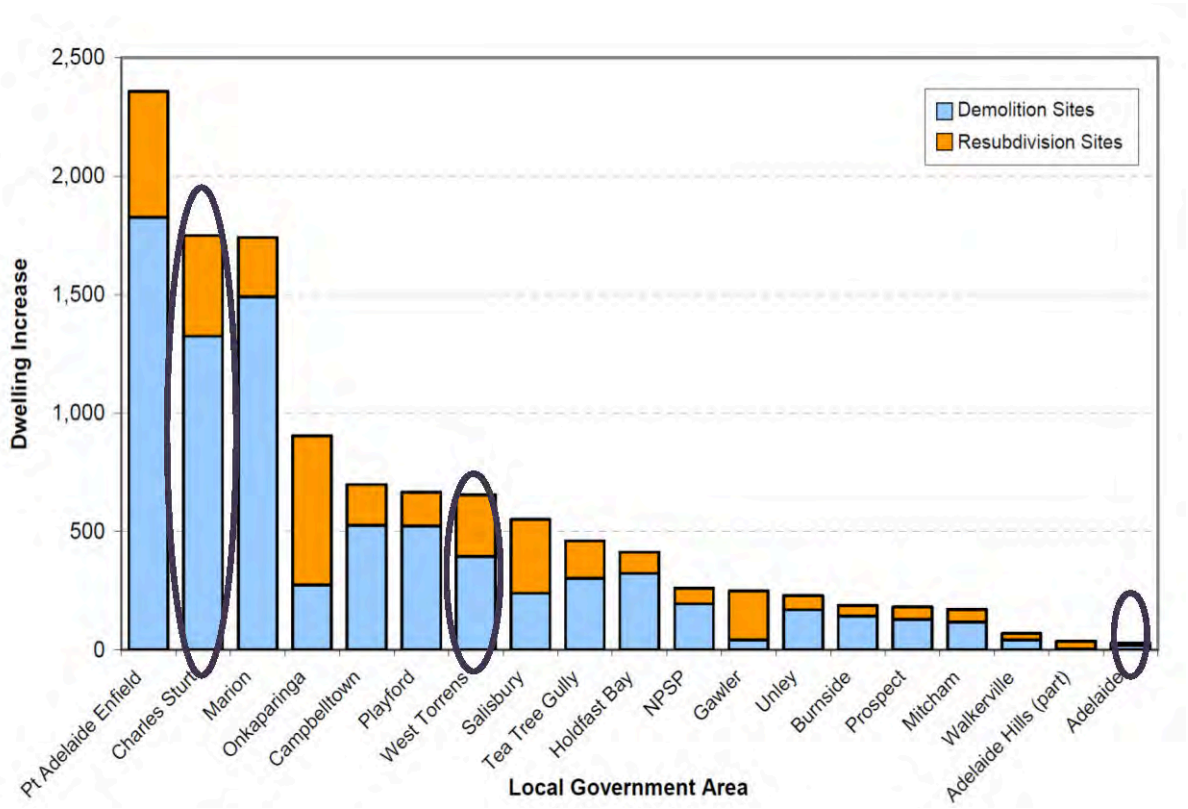


Figure 2.8 – Dwelling increase on demolition, resubdivision sites, 2004-2010 (DIT, 2013)

The replacement rates of development are also significant, as they also influence changes in dwelling density and impervious site coverage. Replacement rates are calculated by dividing the number of new dwellings constructed by the number of dwellings demolished. For example on a site where one dwelling is demolished and replaced with two new dwellings, the replacement rate is 1:2, which equates to an increase of one dwelling on the site. The City of Charles Sturt has one of the highest replacement rates across metropolitan Adelaide, of 1:1.8, where the City of West Torrens rate is 1:1.7 and Adelaide City Council is 1:1.6 (refer Figure 2.9). The dwelling increases in the City of West Torrens are most significant as the LGA makes up almost 90% of the study area. Of all LGA's in the SMP study area, West Torrens has the highest proportion of

new dwellings (approx. 27%) on sites with replacement rates of 1:1. Despite this, approximately 71% of new dwellings in the LGA were on sites with replacement rates of 1:2 or more.

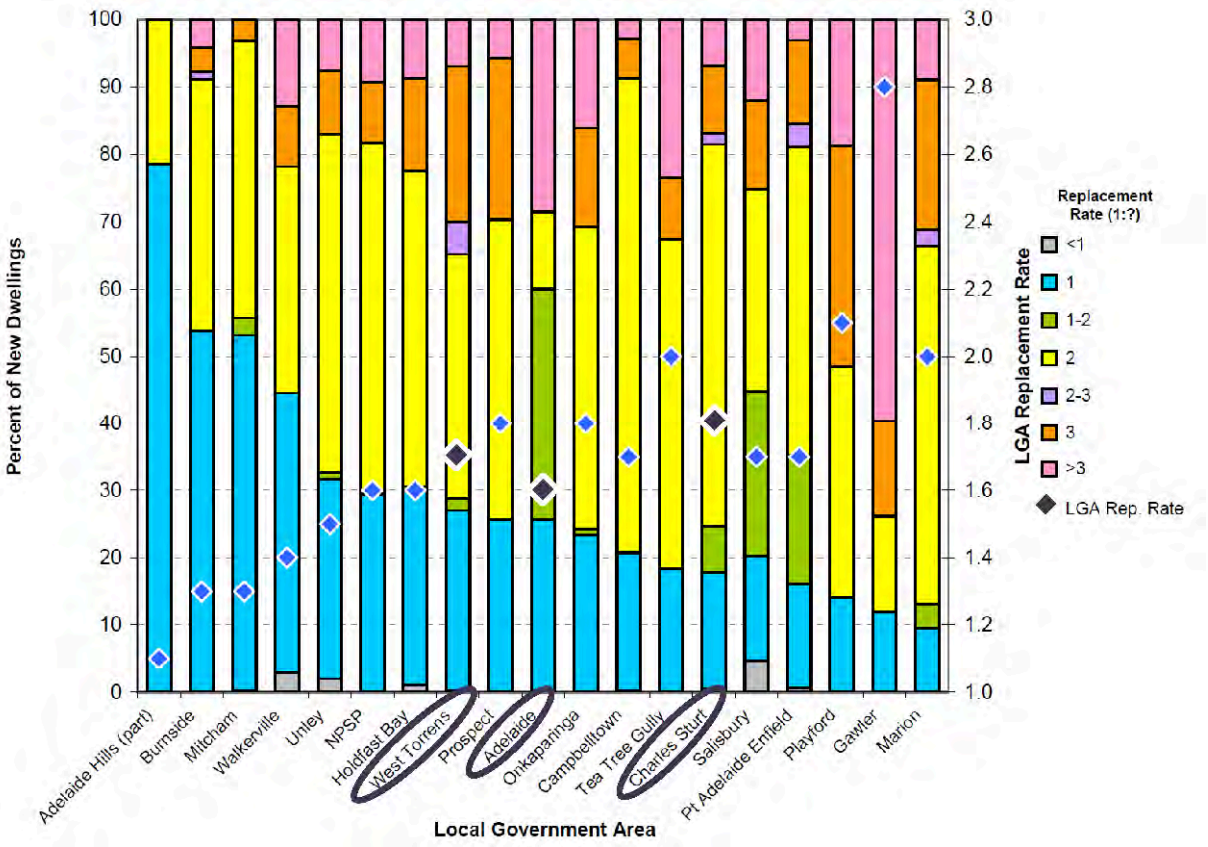


Figure 2.9 – New Dwellings Replacement Rates, 2004-2010 (DIT, 2013)

2.5.3 Future Development Scenarios

Population and dwelling number projections for the SMP area have been undertaken (Infraplan, 2017) to estimate the overall number of new and additional dwellings to be built over the 30 year forecast period (year 2046. A number of approaches were utilised, utilising various sources of available data. These approaches reflect various industry practices and include an assessment founded on a market based, residential development assessment tool developed by Infraplan and ipData.

As with any forecasting and estimating exercise, there are a range of supply and demand factors which will influence the eventual outcome. The assessments have produced several residential development yield estimates, for the purposes of identifying likely future catchment state(s) to assume in the development of commensurate stormwater management strategies.

The development scenario projection estimates are summarised in Table 2.5.

Table 2.5 – Future Development Scenario Projections Summary

Scenario Ref	Description / Method	Projected additional dwellings (yr 2046)[1]
	Existing development policy, known DPA's	
1A	'Flat Average' projection of recent growth trends	3,320
1B	'Increasing Trendline' projection of recent growth trends	3,190
2	Projection of Government Population Policy	6,680
3A	Capital Value / Site Value Analysis	6,310
4A	Residential Development Algorithm	5,000
	If development policies changed to permit greater density	
3B	Flexible policy Capital Value / Site Value Analysis	7,580
4B	Residential Development Algorithm (Flexible policy changes)	10,360

[1] Relative to the supplied 2016 land parcel data

The level of technical complexity and number of factors taken into account in association with the development scenario projections (and by inference, the corresponding level of confidence in the estimate) is considered to increase from Scenario 1A through to Scenario 4, with a convergence of estimates in the general range of 5,000 to 6,000.

This Stormwater Management Plan has adopted an increase of 5,800 dwellings for all 'future state' scenarios.

For the purposes of stormwater modelling, it is necessary to distribute the projected additional dwellings to specific locations. A methodology was developed, utilising a range of data sources which were considered to influence 'developability', including dwelling age (year built), parcel size (m^2), capital value site value ratio, land use (including dwelling type) and development plan zoning/policy areas. A 'developability' rating was then developed for each land parcel, which has been used to estimate the locations of future development associated with a particular future development scenario.

The utilisation of this information, to determine impervious site coverage fractions applicable to all 'future state' scenarios, is described in further detail in Section 4.2.1. 'Future state' scenarios have been considered in flood plain modelling (Section 4) and water quality modelling (Section 5).

2.6 Rainfall

2.6.1 Average Annual Rainfall

The Adelaide region experiences a Mediterranean climate, with cool wet winters and hot, dry summers. The mean annual rainfall in the Study area (as measured at the Adelaide Airport gauge during the period 1956-2019) is 438 mm/yr, with variability as follows:

- Lowest 235mm (2006)
- 5th percentile 277mm

- 10th percentile 303mm
- 90th percentile 576mm
- 95th percentile 597mm
- Highest 731mm (1992)

2.6.2 Rainfall Intensity

Design Intensity Frequency Duration (IFD) data has been prepared for the Study Area at Adelaide Airport utilising the (AR&R 2016) online procedure provided by the Bureau of Meteorology. This data is presented in Table 2.6 below.

Table 2.6 – Adelaide Airport Rainfall IFD (mm/h)

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
5 min	49.7	56.8	81.3	100	121	151	177
10 min	36.1	41.2	59.1	72.7	87.5	109	128
15 min	29	33.2	47.5	58.6	70.4	87.9	103
30 min	19.3	22	31.6	39	46.9	58.6	68.6
1 hr	12.4	14.2	20.4	25.1	30.2	37.8	44.3
2 hr	7.91	9.02	12.9	15.8	19	23.7	27.8
3 hr	6.04	6.89	9.79	12	14.4	17.9	20.9
6 hr	3.79	4.3	6.06	7.39	8.81	10.9	12.6
12 hr	2.34	2.64	3.68	4.45	5.27	6.41	7.35
24 hr	1.41	1.58	2.17	2.61	3.07	3.67	4.16
48 hr	0.825	0.922	1.25	1.48	1.73	2.04	2.28
72 hr	0.599	0.667	0.892	1.05	1.22	1.43	1.58

2.6.3 Impact of Climate Change

Climate change leads to changes in the frequency, intensity, spatial extent, duration and timing of extreme weather and climate events. Within a stormwater management context, potential future changes in rainfall patterns are of particular interest, as these result in changes to levels of flood protection, stormwater drainage performance and the availability of stormwater for harvesting and reuse.

Australian Rainfall and Runoff – Book 1 (2019) provides an approach for addressing the risks posed by climate change in projects and decisions that involve estimation of design flood characteristics. It draws on the most recent climate science, particularly the release of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (IPCC, 2013) as well as the new climate change projections for Australia (CSIRO and Bureau of Meteorology, 2015).

The procedure relies on the Climate Futures web tool developed by the CSIRO where projected changes from Global Climate Models (GCMs) can be explored for fourteen 20-year periods based on four Representative Concentration Pathways (RCPs) for greenhouse gas and aerosol

concentrations that were used to drive the GCMs. The pathways are provided by regional Natural Resource Management (NRM) clusters (divided into 11 regions nationally), with the West Torrens catchment falling within the Southern and South Western Flatlands (East) region.

ARR 2019 recommends the use of RCPs 4.5 and 8.5 (low and high concentration pathways, respectively) for rainfall intensity impact assessment. Further details can be found at the Australian Climate Futures website (https://www.climatechangeinaustralia.gov.au).

For this study, the assumed climate future outlook taken was predictions up to the year 2090. Using the web tool, Table 2.7 indicates the IPCC GCM consensus for rising temperatures as a result of rising greenhouse emissions for high and low scenarios for the region.

Table 2.7 – Global Climate Model Consensus

RCP Scenario	GCM Consensus	Projected Annual Mean Surface Temperature Change (°C)
4.5	Hotter (28 of 46)	+ 1.5 to + 3
8.5	Much Hotter (21 of 48)	> + 3.0

ARR 2019 recommends using the temperature midpoint of the projected annual mean surface temperature change in order to calculate changes to the projected rainfall intensity using the following equation:

$$I_p = I_{ARR} \times 1.05^{T_m}$$

Where I_p is the projected rainfall intensity, I_{ARR} is the design rainfall intensity for current climate conditions, 1.05 is the assumed temperature scaling based on the approximately exponential relationship between temperature and humidity, and T_m is the temperature at the midpoint of the selected class interval.

The recommended T_m can be accessed from the ARR Data Hub for different regions. The following temperature increases, and resultant climate change factors were accessed from the Data Hub:

- RCP 4.5 — 1.667°C increase, 8.5% increase to IFD data
- RCP 8.5 — 3.404°C increase, 18.1% increase to IFD data

The Intensity-Frequency-Duration (IFD) data for Frequent and Infrequent storms is shown in Table 2.8 with RCP 4.5 climate change factor applied. Table 2.9 provides the IFD data with RCP 8.5 climate change factor applied. Both sets of rainfall intensities will be used for modelling different climate scenarios.

Table 2.8 – IFD Design Rainfall Intensities (mm/hr) with RCP 4.5 Climate Change Factor (2090)

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
5 min	53.9	61.6	88.2	108.5	131.3	163.8	192.0
10 min	39.2	44.7	64.1	78.9	94.9	118.3	138.9
15 min	31.5	36.0	51.5	63.6	76.4	95.4	111.8

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
30 min	20.9	23.9	34.3	42.3	50.9	63.6	74.4
1 hr	13.5	15.4	22.1	27.2	32.8	41.0	48.1
2 hr	8.58	9.79	14.0	17.1	20.6	25.7	30.2
3 hr	6.55	7.48	10.6	13.0	15.6	19.4	22.7
6 hr	4.11	4.67	6.58	8.02	9.56	11.8	13.7
12 hr	2.54	2.86	3.99	4.83	5.72	6.95	7.97
24 hr	1.53	1.71	2.35	2.83	3.33	3.98	4.51
48 hr	0.895	1.00	1.36	1.61	1.88	2.21	2.47
72 hr	0.650	0.724	0.968	1.14	1.32	1.55	1.71

Table 2.9 – IFD Design Rainfall Intensities (mm/hr) with RCP 8.5 Climate Change Factor (2090)

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%**	**20%**	**10%**	**5%**	**2%**	**1%**
5 min	58.7	67.1	96.0	118.1	142.9	178.3	209.0
10 min	42.6	48.7	69.8	85.9	103.3	128.7	151.2
15 min	34.2	39.2	56.1	69.2	83.1	103.8	121.6
30 min	22.8	26.0	37.3	46.1	55.4	69.2	81.0
1 hr	14.6	16.8	24.1	29.6	35.7	44.6	52.3
2 hr	9.34	10.7	15.2	18.7	22.4	28.0	32.8
3 hr	7.13	8.14	11.6	14.2	17.0	21.1	24.7
6 hr	4.48	5.08	7.16	8.73	10.4	12.9	14.9
12 hr	2.76	3.12	4.35	5.26	6.22	7.57	8.68
24 hr	1.67	1.87	2.56	3.08	3.63	4.33	4.91
48 hr	0.97	1.09	1.48	1.75	2.04	2.41	2.69
72 hr	0.707	0.788	1.05	1.24	1.44	1.69	1.87

The Climate Futures web tool also showed that 50 of 68 GCMs suggest annual rainfall will decrease within the Southern and South Western Flatlands NRM Cluster. GCM consensus results for RCP scenarios 4.5 and 8.5 are shown in Table 2.10 (sourced in 2020).

Table 2.10 – GCM Predicted Changes to Annual Rainfall (2090)

RCP Scenario	GCM Consensus Rainfall	Projected Annual Rainfall Change (%)
4.5	Drier (35 of 68)	-15 to -5
8.5	Much Drier (44 of 70)	< -15

As can be seen, GMC consensus for RCP 4.5 indicates annual rainfall becoming 'drier' by the year 2090. GMC consensus for RCP 8.5 indicates annual rainfall becoming 'much drier' by the year 2090. In the context of the stormwater harvest yield and water quality modelling for this SMP, it is proposed to take a conservative approach by modifing the existing rainfall record for the West Torrens study area (or data from a suitable nearby gauge) with a 15% reduction to the mean annual rainfall based on both RCPs.

2.7 Hydrogeology

A desktop review of the local hydrogeological conditions and assessment of the potential for Managed Aquifer Recharge (MAR) has been undertaken to support the development of this Stormwater Management Plan.

A comprehensive report detailing this review (WGA, 2020) is enclosed in Appendix C, with a summary of catchment features presented below.

2.7.1 Geology

The West Torrens catchment occurs mainly within the St Vincent Basin. Basin strata are up to 700m thick and were deposited in a shallow graben bounded by folded and faulted Proterozoic and Palaeozoic rocks.

The St Vincent Basin is composed of several sub-basins, the largest being the Adelaide Plains Sub-basin. The majority of the West Torrens Catchment lies within the Adelaide Plains Sub-basin. The Catchment is bisected by the northeast/southwest trending Para Fault which separates the Adelaide Plains sub-basin from the Golden Grove Embayment (Figure 4, page 9 WGA report). The Golden Grove Embayment is an asymmetric tectonic valley in which the wedge of sediments dip gently southwards and thicken towards their faulted south eastern margins. These sub-basins consist of Quaternary and Tertiary aged sediment deposits.

Table 2 from the WGA report (page 10) provides the major stratigraphic and equivalent hydrostratigraphic units of the Adelaide Plains Sub-basin and the Golden Grove Embayment. The hydrostratigraphy of the Adelaide Plains Sub-basin is much simpler than the Golden Grove Embayment because of the greater uniformity and extent of the key geological units.

2.7.2 Hydrogeology

The Tertiary sedimentary aquifers constitute the largest and most important groundwater resource in terms of general use in the Adelaide Plains Sub-basin and Golden Grove Embayment. The Quaternary aquifers are relatively thin and of limited extent. They have typically been developed for abstraction by small-scale users for stock and domestic purposes in areas where the groundwater has favourable salinity.

Quaternary Aquifers

The Hindmarsh Clay is the major Quaternary sedimentary unit across the Adelaide Plains Sub-basin and Golden Grove Embayment. Quaternary aquifers are designated Q1 to Q6 in order of increasing depth. Note that not all six Quaternary aquifers are intersected in drillholes at all locations across the Adelaide Plains sub-basin and Golden Grove Embayment. Of the 695 potentially active domestic wells completed in the Quaternary aquifers 639 have a recorded salinity. The reported salinity ranges from 300 (mg/L) to in excess of 5,000 mg/L. Six percent of the wells have a reported groundwater salinity greater than 5,000 mg/L. Groundwater flow in the Quaternary aquifers is not well understood due to the poor definition of these aquifer units spatially and vertically throughout the Hindmarsh Clay. The general hypothesis is that flow in

the upper Q1 aquifer across the plains occurs towards the present-day drainage lines. In the coastal areas discharge from the perched aquifers within the dunes occurs as seepage along the foreshore. Flow in the deeper confined Quaternary aquifers is thought to occur from east to west.

T1 Aquifer
Within the Golden Grove Embayment and Adelaide Plains Sub-basin, the T1 aquifer is defined as the shallowest Tertiary aquifer system present. Reported salinity ranges from 400 mg/L up to 3,500 mg/L. Groundwater flow in the T1 aquifer west of the Para Fault in the Adelaide Plains Sub-basin occurs from east to west. Flow in the Golden Grove Embayment east of the Para Fault is more complex. From the CBD the apparent direction of groundwater flow occurs in a south-westerly direction before trending in a more east to west direction where the Tertiary sediments are more closely aligned each side of the Para Fault.

Due to the position of the Para Fault and depending on the nature of the bounding faults, the T1 aquifer in the Golden Grove Embayment can be hydraulically connected to Quaternary or Tertiary aquifers west of the Para Fault within the Adelaide Plains sub-basin.

The Munno Para Clay member consists of a stiff blue-grey calcareous clay and contains two thin (<30 cm) interbeds of white to grey limestone. It is typically 5 to 10 m thick and acts as a highly effective regional confining bed across most of the Adelaide Plains sub-Basin and Golden Grove Embayment separating the overlying T1 aquifer from the underlying second Tertiary (T2) aquifer.

T2 Aquifer
Throughout most of the Adelaide Plains Sub-basin area and Golden Grove Embayment, the T2 aquifer consists of well-cemented limestone of the lower Port Willunga Formation which underlies the Munno Para Clay. Reported groundwater salinity in the T2 aquifer ranges between 450 mg/L to 5,580 mg/L. Groundwater flow in the T2 aquifer west of the Para Fault in the Adelaide Plains Sub-basin occurs from the recharge area in the Mount Lofty Ranges to the coast (east to west). Groundwater flow east of the Para Fault in the Golden Grove Embayment is more complex. From the CBD the apparent direction of groundwater flow occurs in a south-westerly direction before trending in a more east to west direction where the Tertiary sediments align along the Para Fault offset.

T3 & T4 Aquifers
The Blanche Point Formation acts as an aquitard between the T2 aquifer and the underlying South (T3 aquifer) and North Maslin Sands (T4 aquifer). Little is known about these aquifers or their lateral extent as very few wells penetrate these aquifers across the Adelaide Plains sub-basin. No wells penetrate these units within the West Torrens Catchment study area. Both the T3 and T4 aquifers are reported to be hyper saline with recorded salinity up to 80,000 mg/L in the deeper T4 aquifer.

2.7.3 Groundwater Demand

Publicly available groundwater information from the Department for Environment and Water (DEW) WaterConnect database was sourced to determine that 1702 wells have been constructed in the West Torrens Catchment area. Table 3 in the WGA report provides a summary of the well information, including which aquifer water is being extracted from, the purpose and the number of potentially active and inactive wells. A total of 1606 wells are reported to be completed in the Quaternary Aquifer, 139 in the T1 Aquifer and 18 in the T2 Aquifer.

The WGA report provides figures (Figure 5 to Figure 13, WGA Report) showing the spatial distribution of groundwater wells, groundwater quality and yield within in the study area based on the information sourced from the WaterConnect database and presented in the tables and figure in the report.

Table 2.11 below (extracted from the WGA report) provides estimations of groundwater use from each aquifer. Groundwater use is not currently metered in the West Torrens Catchment. An estimation of groundwater use by aquifer has been made using typical volumes from areas where use is metered in South Australia. See Section 4.2 of WGA report.

Table 2.11 – Table 5 WGA Report: Estimated Annual Groundwater Use

Aquifer	Estimated Number of "Active" Taking Wells	Estimated Taking (ML)	Estimated Total Groundwater Use (ML)
Quaternary (Q1 to Q6)	583[1]	0.0005 per well	0.29
T1 Aquifer	75 (irrigation)	5 ML/ha over 268 ha	1,340
	14 (industry)	75 ML/well	1,050
T2 Aquifer	5 (irrigation)	5 ML/ha over ~10 ha	50
	3 (industry)	75 ML/well	225

[1] 583 wells return a reported salinity result less than 3,000 mg/L. This is assumed to be the upper limit of salinity for domestic use.

2.7.4 Existing MAR Schemes

There are two operational MAR systems that occur in the West Torrens Catchment. These are located at the Adelaide Airport and Glenelg Golf Club.

Adelaide Airport Scheme:

- Located on James Melrose Road on the southern side of the airport
- Commenced injection in 2014
- The scheme has four wells which target the T2 aquifer and a designed injection capacity of around 300 ML/a. The wells are between 220 to 280 m deep and the native groundwater salinity varies significantly between 970 to4,300 mg/L
- Operated by SA Water
- Sources water from Brown Hill Creek
- Water is treated through vertical infiltration biofilters and sand filters

Glenelg Golf Club Scheme:

- Commenced injection in 2011
- Injects water into two separate aquifers. Of the three MAR wells, two target the T1 aquifer and one targets the T2 aquifer. This came about because the Para Fault, bisects the site. The T2 well can yield approximately 13 L/s compared to 8 to 9 L/s in each T1 well.

- Captures water from the Brown Hill Creek diversion drain located along the southern boundary of Adelaide Airport
- Harvested stormwater initially flows into a gross pollutant trap, then a deep sedimentation pond, before flowing through two large wetlands
- In recent years, the scheme has injected in the order of 110 ML/a., with the maximum scheme capacity in a high rainfall year of the order of 200 ML/a.

2.7.5 MAR Investigation Sites

Investigations into the feasibility of MAR at the West Beach Parks Golf undertaken by Resource and Environmental Management (REM) in 2007. Stormwater runoff and drainage water from Adelaide Airport was to be used for recharge and reuse.

The preliminary investigations verified that the aquifer at this location was suitable for MAR however, lack of funding and uncertainty about the reliable harvest volumes of drainage water from the airport catchment resulted in the project not progressing. Adelaide to Glenelg Pipeline (GAP) water became available the golf course at the same time.

2.7.6 Potential for Additional MAR Activity

The suitability of the aquifers for MAR was assessed and it was determined that the Tertiary aquifer system on the western side of the Para Fault is the most likely aquifer. Implementation of additional MAR systems in this catchment will face several challenges, and careful assessment concerning feasibility would be required. The challenges include:

- The availability of open space to install large holding basins to maximise capture of stormwater flows especially where the drainage network is designed to enable rapid conveyance of stormwater through the catchment.
- Potential demand nodes for using the captured stormwater especially where schemes already exist and there is competition from other water supply sources e.g. GAP Water.
- The concentration of schemes along the coastal margin between Glenelg and Grange has resulted in increased pressures in the aquifer and impacts on existing users. Further MAR schemes along the coastal margin may increase the problem.
- Potential to intercept water in the upper catchment impacting on the opportunity to harvest water by the schemes (Adelaide Airport and Glenelg Golf Course) located in the lower catchment.

3 Stormwater Management Plan Objectives

3.1 Stormwater Management Authority Guidelines

The development of a catchment-based Stormwater Management Plan requires the identification of specific objectives that are relevant to the local context, and measurable. The Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007) stipulates that:

"As a minimum, objectives are to set 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 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."*

3.2 State Government WSUD Objectives

A number of documents have been published which have attempted to define desirable catchment-wide stormwater management performance measures, in relation to water quality improvements to manage marine impacts (CSIRO, 2007), and to mandate Water Sensitive Urban Design principles in new development (Department for Water, 2012).

The document titled *WSUD – Creating more liveable & water sensitive cities in South Australia* (DEWNR, 2013) outlines the following water quality improvement targets:

- Suspended solids 80%;
- Phosphorous 60%;
- Nitrogen 45%; and
- Gross Pollutants 90%.

These targets have been selected as a basis for water quality improvement objectives for this Stormwater Management Plan.

3.3 AMLR NRM Board Plan (now Green Adelaide)

The *Adelaide and Mount Lofty Ranges Natural Resources Management (AMLRNRM) Plan 2014-15 to 2023-24* (Adelaide and Mount Lofty Ranges Natural Resources Management Board, 2013) was developed in partnership with the community and key stakeholders. It provides leadership, encourages community action and fosters valuable partnerships for better managing the region's natural resources. It is noted that the SMP objectives process was undertaken while the AMLR NRM Board was in effect, prior to establishment of Green Adelaide.

The plan includes long-term goals and targets for the condition of natural resources in the region. The Board's investment priorities are defined over a three-year period and are delivered through a range of strategic actions.

The Plan sets out a 10-year strategic plan for the region that is consistent with the vision of the State NRM Plan. The Strategic Plan is supported by a *Business and Operational Plan 2016-17 to 2018-19* (Adelaide and Mount Lofty Ranges Natural Resources Management Board, 2016b) which outlines how the Board will invest the money that it raises through levies and other funding sources.

The plan refers to 20-year Regional Targets that were developed in 2008 to support the vision and goals expressed in the previous iteration of the NRM Plan. Those targets relevant to stormwater management in the West Torrens Study Area are shown in Table 3.1.

Table 3.1 – AMLR NRM 20 Year Regional Targets extract

Target	Explanation	Indicator
T1 - The region will have system capacity to harvest up to 35GL of stormwater	Projects such as stormwater wetlands and harvesting systems are being developed in the Region and the stormwater target is intended to be ambitious reflecting community desires.	Volume of stormwater generated and used; Volume of stormwater discharged to coast or marine environment.
T2 - Aquatic ecosystems and groundwater condition is maintained or improved	"Defined environmental values" refers to the process for stakeholder agreement to a set of environmental values and water quality objectives under the Environment Protection (Water Quality) Policy. Long-term monitoring of water quality is vital to protecting environmental values. Of course, it is not possible to monitor everything so key water quality parameters will be monitored across the Region.	Exceedance of specified water quality parameters (e.g. turbidity, nutrients, salinity, pH).
T3 - All water resources used within sustainable yield (allowing for variability)	This target is about ensuring that the long term use of water in the Region is sustainable, that is that the use of water for a range of purposes does not have an unacceptable impact on the environment. This target includes "allowing for variability" in recognition of future changes to water supply as a result of climate change impacts.	Volume of water allocated and used; Groundwater level; Surface water flow; Water required for the environment compared to water provided for the environment.
T7 - Condition and function of ecosystems (terrestrial, riparian) recovered from current levels	Although some native vegetation remains in the Region, it is not fully functional, because of degradation due to edge effects, fragmentation, weed invasion, grazing and inappropriate fire regimes. This means it does not provide the appropriate ecosystem services and habitat it might once have done. This target is	Condition of native vegetation (terrestrial, riparian, water dependent ecosystems).

Target	Explanation	Indicator
	about ensuring that the condition, structure and function of our remnant vegetation is improved.	
T8 - Extent of functional ecosystems (coastal, estuarine, terrestrial, riparian) increased to 30% of the Region (excluding urban areas)	For the Region to retain ecosystem function and to prevent further decline of native species, largescale restoration of native ecosystems is required. Restored ecosystems need to be carefully planned and designed (according to restoration priorities) so that they will provide equivalent structure, function and habitat features to that which would have occurred in the local area.	Distribution of native vegetation; Area of native vegetation.
T10 - Land based impacts on coastal, estuarine and marine processes reduced from current levels	The Adelaide Coastal Waters Study identified turbidity, from high levels of suspended solids related to stormwater and wastewater, as a contributing factor to seagrass loss and a major cause of poor recreational water quality. ACWS technical reports have established some relevant current baselines for evaluation of targets.	Catchment sediment load; Stormwater discharged to coast or marine systems.
T12 – All coast, estuarine and marine water resources meet water quality guidelines to protect defined environmental values		

3.4 Council Strategic Objectives

The City of West Torrens 'Community Plan 2030' contains the references as summarised in Table 3.2 to topics that are relevant to stormwater management. The City of West Torrens' 'Community Plan 2030' is the lead document in Council's suite of strategic management plans. It provides a range of strategic objectives aimed at delivering the vision of: "West Torrens - committed to being the best place to live, work and enjoy life."

Table 3.2 – City of West Torrens Community Plan 2030 Extract

Theme: Environment and Sustainability	
Our Focus: We protect and conserve the natural environment, reuse and recycle resources, support biodiversity and respond to climate change.	Strategic Objectives: • Reduce the City's impact on the environment. • Prepare for and respond to the challenges of a changing climate.

Theme: Community Life	
Our Focus: We support diversity, health and well-being, community cohesion and connections, and create opportunities to learn and enjoy the local area.	Strategic Objectives: • Facilitation of community health, wellbeing and safety.
Theme: Built Environment	
Our Focus: We ensure housing, urban development and infrastructure contribute to attractive and safe neighbourhoods, and how we travel in and beyond our area.	Strategic Objectives: • Infrastructure that meet the needs of a changing city and climate. • An attractive, safe and cohesive urban environment that supports better quality development assessment outcomes, diverse housing choice and compatible non-residential development.
Theme: Organisational Strength	
Our Focus: Council ensures its services lead to quality outcomes and exceptional experiences for our community	Strategic Objectives: • A resilient organisation that is able to effectively respond to emergency incidents and events.
Theme: Prosperity	
Our Focus: We support jobs, businesses and industries to generate local economic growth and activity.	Strategic Objectives: • A diverse, resilient and competitive economy, including small business, tourism and export sectors.

3.5 Objectives for this Stormwater Management Plan

The consolidated objectives adopted to guide the development of this Stormwater Management Plan are summarised in Table 3.3 below. These objectives were established through discussions with the City of West Torrens and based on the previously listed SMA guidelines, State Government WSUD objectives, AMLR NRM Board Plan (2014) and Council's strategic objectives.

Table 3.3 – West Torrens SMP Objectives

ID	Goal	Objective
O1	Provide an acceptable level of flood protection to the community and both	Aspire to achieve no above floor inundation of properties for all events up to and including the 1% AEP (100 year ARI) storm. Where this is not

ID	Goal	Objective
	private and public assets from flooding	practically achievable, a 5% AEP (20 year ARI) standard shall be sought. New developments to achieve a minimum 300mm freeboard to the 1% AEP flood level.
O2	Provide an acceptable level of performance in the minor (underground) drainage system and pits	Aspire to achieve minimum service standards for new or upgraded drainage systems as follows: ➤ Hydraulic grade line (HGL) for 0.2 EY storms to be minimum 150 mm below gutter level
O3	Improve the quality of runoff and reduce the impact of stormwater on receiving waters	Aspire to reduce pollutant loads discharged from the catchment by the following averages: ➤ Suspended solids 80% ➤ Phosphorous 60% ➤ Nitrogen 45% ➤ Gross Pollutants 90% Integrate water quality improvement goals into Council development requirements.
O4	Make beneficial use of stormwater runoff	Identify precinct-level opportunities for beneficial reuse of stormwater where economically viable. Expand on street-scale civic reuse activities. Encourage landowners to implement allotment-level opportunities for the retention and reuse of stormwater.
O5	Provide conditions which would allow desirable (improved) end-state values for receiving waterways to be achieved	Support ongoing strategies seeking to restore and sustain the ecological processes, environmental values and productive capacity of the River Torrens, Patawalonga Creek and Brown Hill Keswick Creek by minimising the urban runoff volume and nutrient loads discharged into these receiving watercourses.
O6	Sustainable management of stormwater infrastructure, including maintenance	Stormwater infrastructure will be resilient in consideration of the likely impacts of climate change. Ensure appropriate monitoring and asset management plans are in place to maintain infrastructure and public safety.
O7	Desirable planning outcomes associated with new development and management of open space, recreation, and amenity	Ensure new development complies with stormwater management development requirements, designed to achieve outcomes that are complimentary to the SMP objectives and goals. Maximise the use of open space for stormwater/rainfall infiltration WSUD and/or stormwater reuse.
O8	Effective communication and	Effectively engage with the community on stormwater management issues and proposed

ID	Goal	Objective
	consultation with catchment stakeholders, businesses, and community members	strategies including WSUD and stormwater reuse opportunities where possible. Raise awareness to enable businesses and the community to respond efficiently to extreme weather and flood warnings. Identify opportunities for partnerships with the community and agencies in the development and implementation of strategies. Achieve increased alignment between the goals of the SMP and the activities of stakeholders and community volunteers.
O9	Multi-objective outcomes for stormwater management projects involving open space	Maintain the existing use of open space and provide new opportunities for public access and recreation where it is safe and practical to do so. Provide opportunities for sustainable landscaping, increased biodiversity, stormwater treatment and passive reuse. Maximise linkages with pedestrian and cycle networks. Develop flood mitigation solutions that minimise the frequency of inundation of active recreation areas and permit more frequent inundation of passive recreation areas.

4 Stormwater Drainage Infrastructure Performance

4.1 Modelling Approach Overview

The performance of the existing stormwater drainage infrastructure and creek systems and the associated flood inundation risk was assessed using the following modelling platforms:

- DRAINS – to perform hydrological calculations and generation of flow hydrographs to each side-entry pit / drainage entry location across the Study Area
- TUFLOW – to assess the hydraulic performance of the pipe network, open channels and overland flood flow paths across the floodplain

4.1.1 DRAINS Stormwater Model

DRAINS is a multi-purpose Windows program for designing and analysing urban stormwater drainage systems and catchments (Watercom, 2017).

Working through a number of time steps that occur during the course of a storm event, it simulates the conversion of rainfall to stormwater runoff and routes the runoff through networks of pipes, channels and streams. In this process, it integrates:

- Design and analysis tasks;
- Hydrology (four alternative models) and hydraulics (two alternative procedures);
- Closed conduit and open channel systems;
- Headwalls, culverts and other structures;
- Stormwater detention systems; and
- Large-scale urban and rural catchments.

Within a single package, DRAINS can carry out hydrological modelling using ILSAX, Rational Method and storage routing models, together with quasi-unsteady and unsteady hydraulic modelling of systems of pipes, open channels and surface overflow routes.

For the purposes of this investigation, DRAINS was utilised solely for hydrological modelling purposes.

4.1.2 TUFLOW Hydrodynamic Floodplain Model

Hydraulic floodplain modelling was carried out using the TUFLOW computer program. TUFLOW (Two-dimensional Unsteady FLOW) is specifically orientated towards establishing flow and inundation patterns in coastal waters, estuaries, rivers, floodplains and urban areas where the flow behaviour is essentially 2 dimensional (2D) in nature and cannot or would be awkward to represent using a 1 dimensional (1D) model (BMT WBM, 2016).

A powerful feature of TUFLOW is its ability to dynamically link to 1D networks. The user sets up a model as a combination of 1D network domains linked to 2D domains. As such, the 2D and 1D domains are linked to form one overall model.

The TUFLOW model is based on the Stelling (1984) solution scheme, which is a finite difference, alternating direction implicit scheme solving the full 2D free surface flow equations. The ESTRY model is based on a numerical solution of the unsteady momentum and continuity fluid flow equations (BMT WBM, 2017).

The model area is divided into fixed square cells that can be either wet or dry during a simulation. The model has the ability to simulate the variation in water level and flow inside each cell once information regarding the ground resistance, topography and boundary conditions are entered.

The TUFLOW model was utilised to assess underground drainage system performance and flood plain mapping.

4.2 Hydrological Model Parameters

4.2.1 Catchment Impervious Fractions

Sample residential allotments were selected for a detailed of impervious site coverage across the Study Area, to determine suitable average 'directly connected' and 'indirectly connected' impervious site coverage values associated with a corresponding 'year built' age range. A minimum of eight allotments were sampled within each age range. A summary of the results of this analysis is presented in Table 4.1.

This analysis confirms the widely reported trend of higher levels of impervious site coverage associated with more recent development.

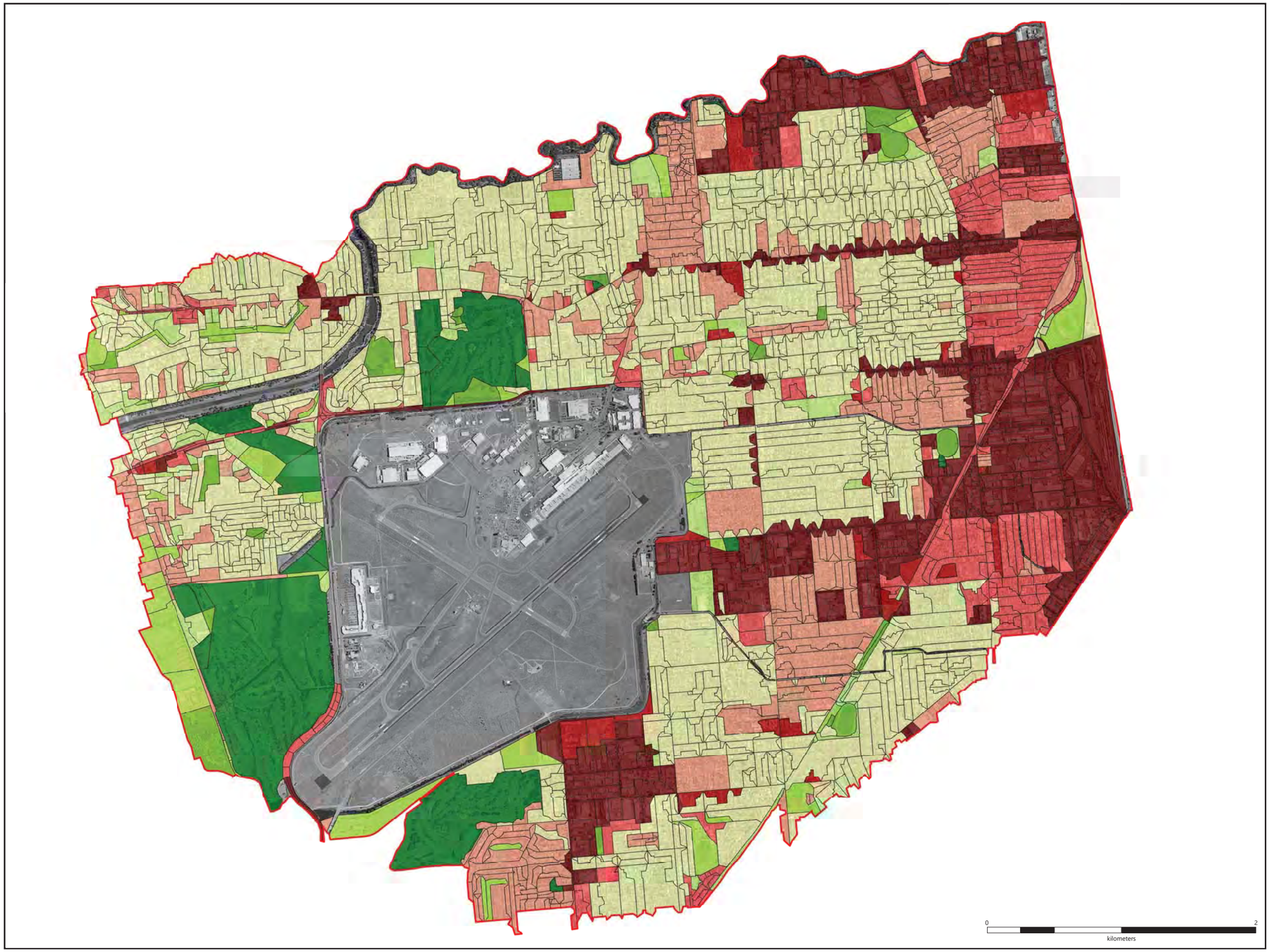
Table 4.1 – Impervious Fractions, Analysis Summary

'Year Built' Range / Land Type	Directly Connected Impervious %	Indirectly Connected Impervious %	Total Impervious %
1800 – 1939 (residential)	28%	16%	44%
1940 – 1969 (residential)	30%	32%	62%
1970 – 1989 (residential)	37%	26%	63%
1990 – 2004 (residential)	60%	8%	68%
2005 – 2016 (residential)	67%	4%	71%
Strata Title	63%	7%	70%
Community Title	68%	8%	75%
Road Reserve	80%	0%	80%

The average values presented in Table 4.1 have applied to estimate impervious site coverage values for each individual subcatchment. In subcatchments where other land types not listed in Table 4.1 were present (i.e. industrial and commercial land, reserves, open space) the values were adjusted based on the level of impervious site coverage observed to be within that subcatchment.

The 'existing state' impervious site coverage values adopted for this SMP are displayed in Figure 4.1. Pursuant to the future development scenario adopted for this Stormwater Management

Plan as described in Section 2.5.3, corresponding values for the 'future state' scenario are displayed in Figure 4.2.



Percentage Directly Connected Impervious

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 100

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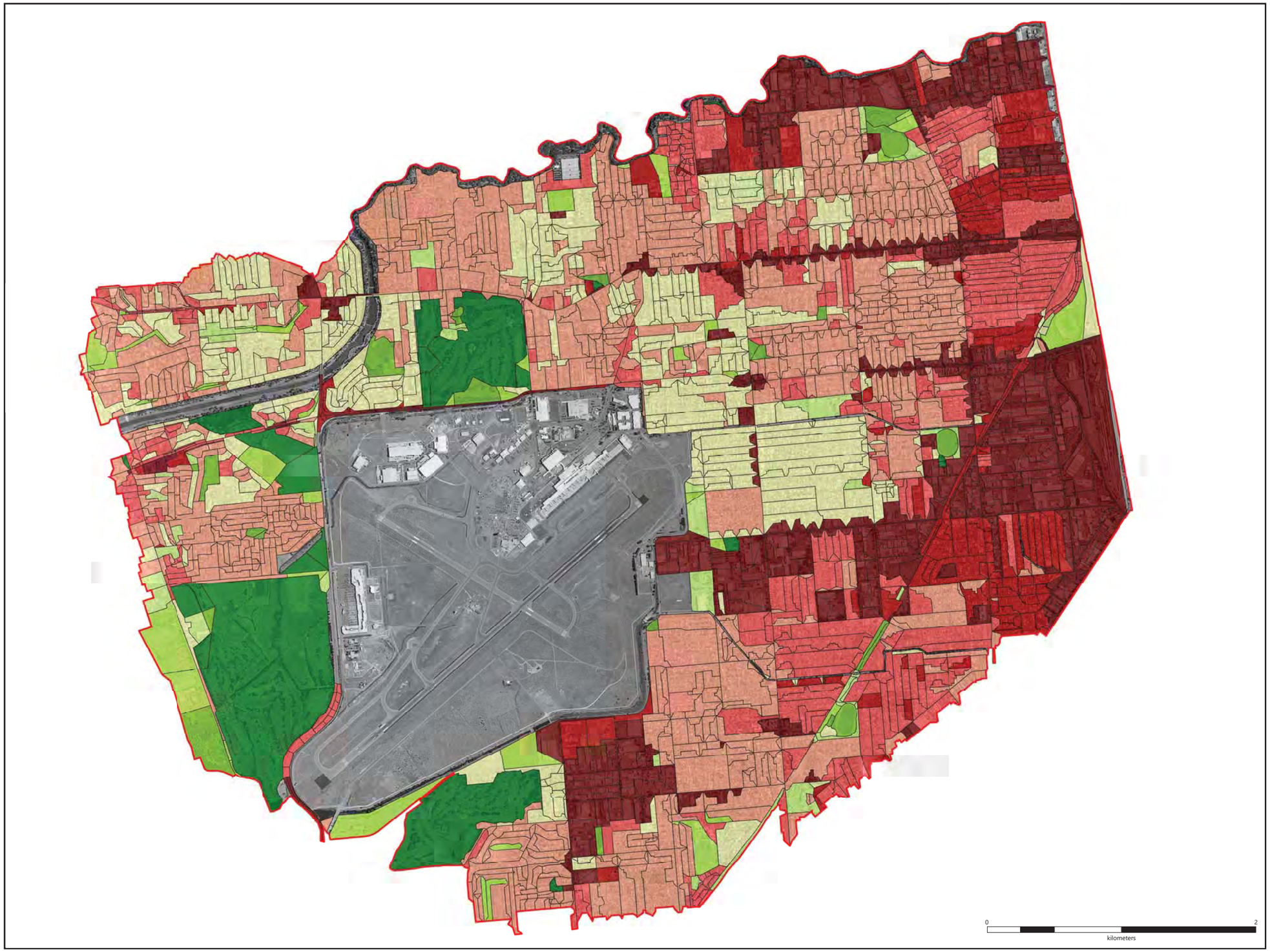
Data Sources:
Runoff Coefficients (Southfront)
Aerial Photography (City of West Torrens)

southfront

West Torrens Drainage Catchments SMP

Figure 4.1

Existing Directly Connected Impervious Site Coverage Plan



Percentage Directly Connected Impervious

- 0 to 10
- 10 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 100

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Data Sources:
Runoff Coefficients (Southfront)
Aerial Photography (City of West Torrens)

southfront

West Torrens Drainage Catchments SMP

Figure 4.2

Future Directly Connected Impervious Site Coverage Plan

4.2.2 Urban Areas Hydrological Model

The ILSAX model has been adopted as the hydrological model for urban catchments within the DRAINS model, with depression storages of:

- Paved = 1 mm;
- Supplementary paved = 1 mm; and
- Grassed = 45 mm.

A custom soil type was selected, with values entered to achieve a continuing loss of 3mm/hour.

4.2.3 IFD Rainfall Data

Design Intensity Frequency Duration (IFD) data as presented in Table 2.6 (Adelaide Airport) has been utilised as the design rainfall for the model.

4.2.4 Time of Concentration

The following assumptions were used when determining subcatchment time of concentrations:

- Residential: 5 minutes to street kerb
- Commercial/Industrial: 10 – 15 minutes to street kerb
- Kerb flow travel time to inlet pit: Figure 4.6 from the Queensland Urban Drainage Manual (*Figure 4.6 – Kerb and channel flow time using Manning's equation,* (pg. 4-17))

4.3 TUFLOW Modelling Parameters

4.3.1 1D/2D Hydraulic Model Domains

The models were developed so that the underground stormwater drainage system was modelled in 1 dimension (1D) using ESTRY, while overland flow paths on the surface were modelled in 2 dimensions (2D) using TUFLOW. The 1D and 2D domains within each model were hydro-dynamically linked, allowing flows in both domains to interact.

4.3.2 2D Cell Size

Determining an appropriate 2D cell size to be used by TUFLOW requires a compromise between the accuracy of modelling necessary to sufficiently reproduce the hydraulic behaviour of the floodplain as well as limitations in computing power and processing time. A detailed understanding of the requirements of the Study was also required. In this instance, the Study is a broad scale catchment wide analysis which aims to identify the main flood prone areas and assess the performance of any proposed flood mitigation options at a conceptual level.

TUFLOW's new Sub-grid Sampling capability has been utilised, ensuring the fine topography detail from the DTM has been recognised in the model. Sub-grid sampling (SGS) stores and uses curves representing the sub 2D cell terrain data from the DTM to construct the model instead of each 2D cell and each 2D face having one elevation. A cell size of 3 metres was selected for modelling which corresponds to approximately 3.9 million cells within the model.

4.3.3 Time Step

The model was run with the latest version of TUFLOW HPC. This version of the software uses adaptive time stepping to progress through the simulation, where the timestep is continually adjusted to comply with the mathematical stability criteria of a 2d shallow water explicit

solution. This generally results in a timestep smaller than what would be used in a TUFLOW Classic model.

4.3.4 Topography

A Digital Terrain Model (DTM) of each of the model domain areas was acquired to define the existing topography of the catchment as stated in Section 2.2. The DTM was used to assign elevations to individual cells within the 2D domain.

4.3.5 Resistance Parameters

The bed resistance is an essential element used to define the flow and hence the water depth at any location within the 2D model domain. In TUFLOW, bed resistance values for 2D domains are most commonly created by using GIS layers containing polygons with varying Materials values. The Materials values specified in GIS correspond to a user defined Manning's Roughness Coefficient described in the Materials File. This approach allows for a relatively quick and simple adjustment of Manning's Roughness Coefficient values.

The bed resistance values used in the modelling are specified in Table 4.2.

Table 4.2 – Bed Resistance Parameters

Manning's Roughness Coefficient	Type of Land Use
Concrete channel	0.014
Roads	0.022
Creek channel	0.035
Golf Course / Vegetated Open Channel	0.04
Densely Vegetated Open Space / Creek	0.08
Commercial / Residential / Dense Riparian Vegetation	0.2

Relatively high values of Manning's Roughness Coefficient are used for residential and commercial development to compensate for the lack of building envelopes in the DTM. The Manning's Roughness Coefficient value used for modelling of underground drains was 0.012.

4.3.6 Boundary Conditions

As part of the modelling, consideration was given to the boundary conditions within the 1D and 2D domains. The 1D boundary conditions consist of the inflows to stormwater pits which allow flows to travel between the 1D domain (underground drainage system) and the 2D domain (ground surface defined by the DTM) as governed by hydraulic conditions that vary over the course of a storm event.

2D Model Boundary
Within the 2D domain, the boundary condition is the edge of the model where, a "HQ" (stage-discharge) type boundary has been used. The purpose of this approach was to allow water to "disappear" once flood flows reached the model boundaries and ensure that results in the floodplain were not affected at model edges. This is relevant to sections of each boundary edge where there is a possibility of a local catchment ponding or flowing over the boundary.

Brown Hill / Keswick Creek
Consideration was given to the conditions at the point of discharge for all gravity drains. Since hydraulics within the open channels of Keswick Creek and Brown Hill Creek were not modelled

as a part of this study, a boundary condition was placed on all drains discharging to these channels to account for the backwater affects. A 1d boundary node was modelled on each of these drains, applying a head water level equal to a 300mm freeboard to the top of bank or lowest pit elevation from a system discharging into the respective creek. Figure 4.3 provides map of the key outlet levels (m AHD) assumed for Brown Hill Creek and Keswick Creek.

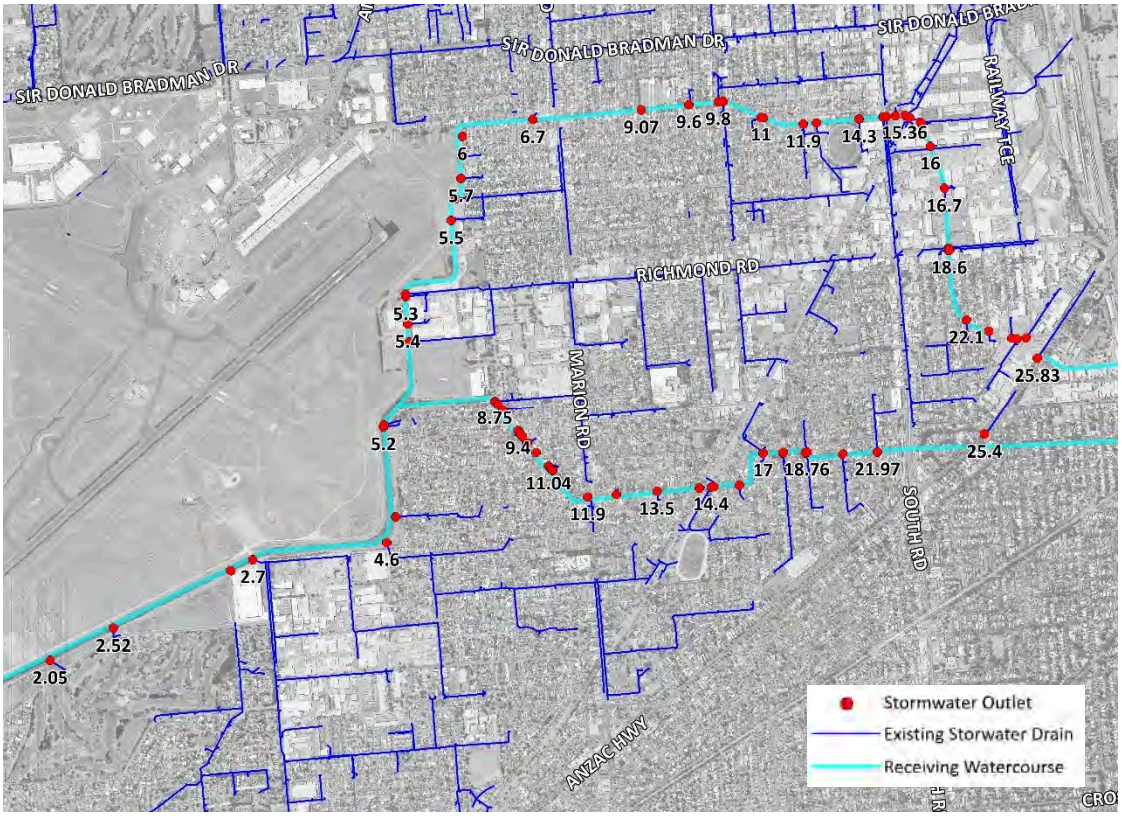


Figure 4.3 – Assumed outlet tailwater levels in metres AHD for Brown Hill Creek and Keswick Creek

River Torrens

The River Torrens Catchment (north-east major catchment) drains into the River Torrens via gravity drainage. The majority of these subcatchments sit high in relation to the River Torrens water levels. The catchments modelled have relatively short response times (less than 6 hours duration), while the River Torrens has a much longer response time, in the order of 24 hours (Tonkin Consulting (2012), *HEP, Torrens East, Western Coastal & Patawalonga Catchments Flood Inundation Mapping Report, for the City of Charles Sturt*). It is seen as a reasonable assumption that the modelled catchments would have discharged well before the peak flood levels in the River Torrens are reached. For these reasons, the River Torrens Catchment outlets were allowed to freely discharge into the River Torrens, as this is the most likely scenario during a storm event.

Sensitivity of Assumed Tailwater Levels

A limitation of the assumed outlet levels into the creeks is the assumption the creeks are performing adequately and have the capacity to take the flows from the local catchments. In large storm events there are low lying areas in the local catchments that would be below high creek water levels. In these scenarios, the performance of the local stormwater systems cannot be assessed appropriately as it effectively assuming the creeks do not have sufficient capacity.

Separate studies have previously been conducted which look at the capacity and flooding caused by the Brown Hill Creek and Keswick Creek in various storm events. Later in the SMP document, a strategy of further investigation into the capacity of Keswick Creek is recommended. Brown Hill Creek is currently undergoing capacity upgrade as a part of the Brown Hill Keswick Creek Stormwater Project. It is understood that upgrades to the creek systems are now being designed to achieve a flood level below ground level.

It is expected that local systems discharging into the River Torrens would see a minimal difference to the resultant flood extent if the tailwater levels were increased. This is due to the catchments being relatively higher than the River. In extreme events the water levels in the Torrens would impact the local systems, however, as previously stated it is seen as a reasonable assumption that the modelled catchments would have discharged well before the peak flood levels in the River Torrens are reached.

Low lying areas near the Brown Hill Creek and Keswick Creek would likely experience a greater flood extent if higher tailwater levels are used. The impact of higher tailwater levels would have less of an impact further upstream of these systems. Sensitivity to increases or decreases in of the downstream water levels have not been assessed in the SMP. It is expected that further design development of individual upgrades will investigate the sensitivity of tailwater levels and suggest any appropriate amendments to designs accordingly.

4.3.7 Inflows

Pit Subcatchments

The inflow hydrographs at each inlet were derived from DRAINS modelling. These flows were applied as point source inflows at the entrances to all pits. This approach allows the inlet capacity of each pit to be represented and allows flows exceeding the capacity to continue along the 2D domain travelling overland via the road reserve. The capacity of each pit type to take on flows was depicted by flow versus depth inlet curves. These pit inflow curves were based on inlet data published by the University of South Australia (http://www.unisa.edu.au/IT-Engineering-and-the-Environment/Natural-and-Built-Environments/Our-research/AFMG/South-Australian-Road-Stormwater-Drainage-Inlets-Hydraulic-Study/, accessed 8 May 2019). Pit blockage was not considered in the modelling.

For catchments which have no existing underground drainage infrastructure, inflow hydrographs were applied directly into the 2D domain.

Western Adelaide CDB catchments

Western Adelaide CDB catchments and stormwater drainage were modelled separately in DRAINS. Outflow hydrographs were modelled for all storm events and were applied in the TUFLOW model at the two locations shown in Figure 4.4 below where the Western Adelaide stormwater systems connect with the West Torrens' systems.

The existing detention/surcharge basins in the western parklands were accounted for in the DRAINS modelling. Their locations are shown in Figure 4.4. The basin volumes were determined utilising a 1m x 1m DTM (Geoscience Australia).

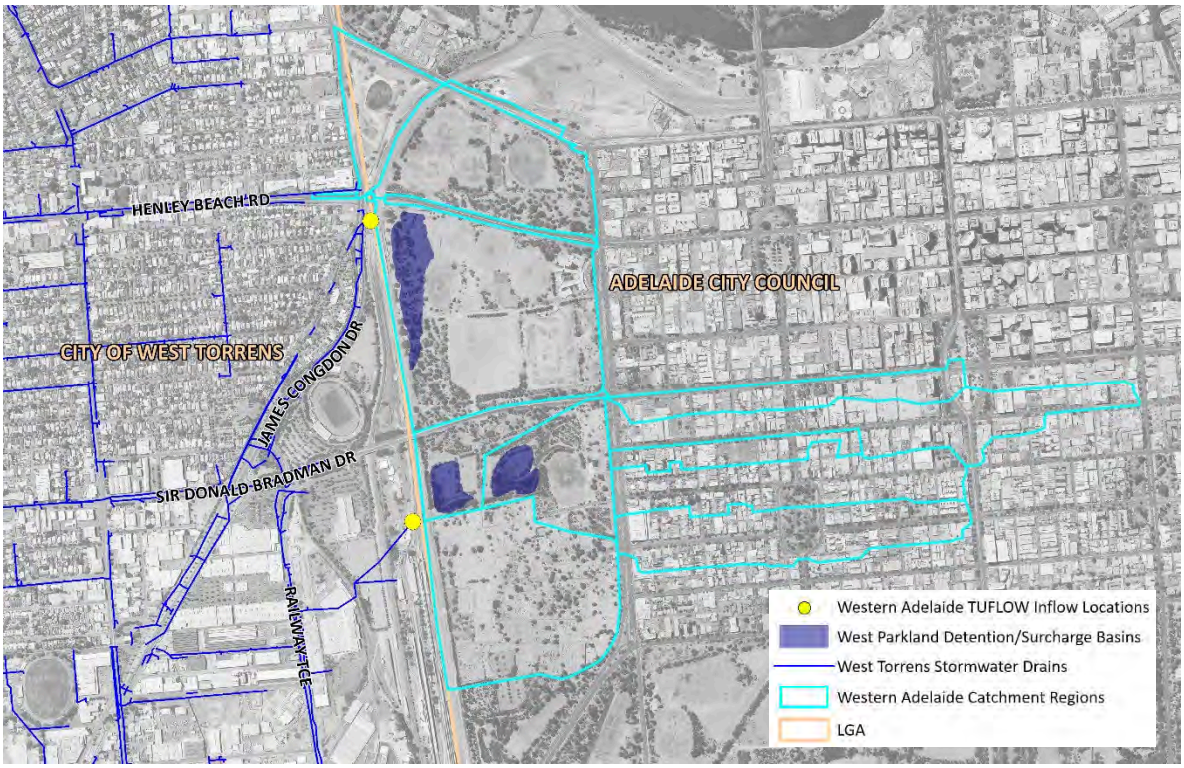


Figure 4.4 – Inflow locations in TUFLOW model for western Adelaide catchments

Adelaide Airport

Stormwater flows generated from the Adelaide Airport was modelled in a simplified manner. The large catchment was split into smaller subcatchments based on topography and existing airport channels. Flows generated by these catchments were applied directly into the 2D domain. The Airport catchment was accounted for in the flood modelling as the flows produced from this catchment do interact with Council catchment generated flows at the downstream end of the Patawalonga Creek.

Adjoining Catchment Inflows

The recently completed Draft Sturt Urban Catchments SMP bounds the West Torrens Catchment to the south. Flood mapping from the Sturt SMP indicates three areas where flows could potentially spill into the adjoining West Torrens Catchment as shown in Figure 4.5. Inflows from adjoining catchments were not included in the scope of modelling for the West Torrens SMP. The implications of these inflows should be assessed in future design development of any proposed stormwater upgrades in the areas of concern.

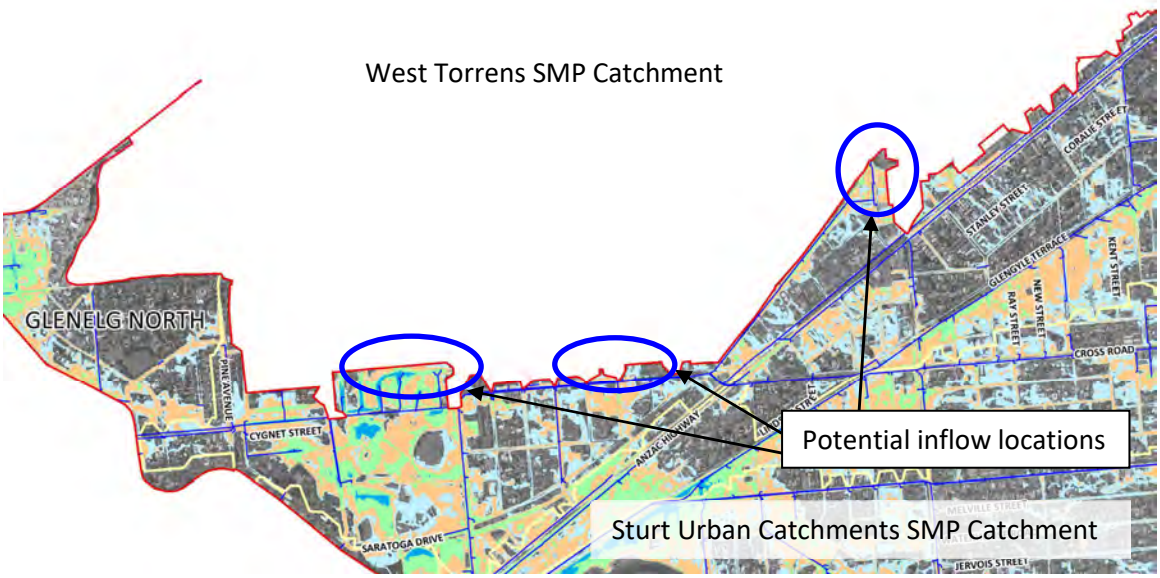


Figure 4.5 – Indication of potential inflows from the Sturt Urban Catchments SMP (Existing Infrastructure Scenario 4, 1% AEP Floodplain Extent, Draft Issue 06/08/2019)

4.4 Scenarios

Several scenarios have been adopted for this Stormwater Management Plan to assess the performance of existing and proposed upgrade strategies under different catchment development states and design rainfall changes arising from climate change. The climate change factors listed were collected from the *Australian Rainfall & Runoff Data Hub* in 2018 for the study area location.

The scenarios adopted are summarised in Table 4.3.

Table 4.3 – SMP Scenarios

Reference	Stormwater Infrastructure	Catchment Development	Rainfall Intensity Climate Change Factor[2]
Existing Infrastructure Scenario 1	Existing	Existing	0%
Existing Infrastructure Scenario 2	Existing	Future[1]	0%
Existing Infrastructure Scenario 3	Existing	Future[1]	+ 8.5%
Existing Infrastructure Scenario 4	Existing	Future[1]	+ 18.1%
Future Upgrade Infrastructure Scenario	Upgrade[3]	Future[1]	+ 18.1%

[1] 30 year planning horizon (as described in Section 2.5.3, 4.2.1)
[2] Increased rainfall intensity due to climate change (as described in Section 2.6.3)
[3] As described in Section 4.8

4.4.1 Design Event Runs

The scope of this Study involved flood plain mapping of the 0.5EY, 0.2EY, 10% AEP, 5% AEP, 2% AEP and 1% AEP. Various storm durations were modelled within each AEP event in order to determine which durations were critical for each catchment and event.

It was found that the flooding extents in various parts of the catchment differed based on the storm duration that was modelled. Due to the significant size of the catchment, six durations were modelled for each storm event; 20 minutes, 1 hour, 2 hours, 3 hours, 6 hours and 12 hours. Therefore, the results presented in the drain standard and flood plain maps are based on a combination of critical events and can be assumed to represent the worst case scenario or flood envelope for each storm event.

4.5 Minor System Performance

Drainage system 'failure' was defined as occurring whenever the hydraulic grade line (HGL) level results in freeboard within the upstream pit of less than 150 mm. The performance standards for each existing drain for Scenario 1 are illustrated in Figure 4.8 and the plans for all four scenarios are presented in Appendix D. It is desirable for underground drainage networks to achieve performance standards of 0.2 EY.

Table 4.4 lists the existing drainage networks that were assessed to perform below the 0.2 EY target performance standard for Scenario 1 (<150 mm freeboard to pit). This table provides a summary of potential ponding hotspots/locations that are expected to be subject to large gutter flows. They do not necessarily identify areas that require immediate or any action if surface overflows from these systems can be appropriately managed, as determined from the floodplain mapping which is addressed in Section 4.6.

However, when these existing drainage systems require renewal, Council may consider constructing larger underground drains and/or additional inlet pits to achieve the desired performance standard. Furthermore, if an existing problem is due to inadequate pit inlet capacity and there is redundancy in the pipe system, the construction of additional inlet pits may be warranted in the short-term.

Table 4.4 – Existing Underground Drains, Identified System Issues (Scenario 1)

Drains with Low Performance Standard	Performance Standard AEP
West Beach	
Ingerson St to Southern Ave lateral drains	< 0.5 EY
Miami Ave	< 0.5 EY
Military Rd	< 0.5 EY
Mason St, Dineen Pl	< 0.5 EY
River Torrens Pumping Stations	
Newlands Dr	0.5 – 0.2 EY
Hurcombe St	< 0.5 EY
Hector St	< 0.5 EY
Pennine St, Burbridge Rd	< 0.5 EY
Snowden St	0.5 – 0.2 EY

Drains with Low Performance Standard	Performance Standard AEP
Waldron St to Burford Rd	< 0.5 EY
Halsey Rd, Lowry St	< 0.5 EY
Henley Beach Rd	< 0.5 EY
Ayton Ave	< 0.5 EY
Hmas Australia Rd	< 0.5 EY
Kandy St	0.5 – 0.2 EY
Henley Beach Rd (east)	< 0.5 EY
River Torrens	
Garden Terrace, Hinton St, Howard St	< 0.5 EY
Sherriff St	< 0.5 EY
Hardys Rd, Ashwin Parade	< 0.5 EY
Ashley St	< 0.5 EY
Henley Beach Rd (west of South Rd)	0.5 – 0.2 EY
Henley Beach Rd (east of South Rd)	< 0.5 EY
George St	< 0.5 EY
Cawthorne St	< 0.5 EY
Ann Nelson Dr	< 0.5 EY
Lockleys	
Henley Beach Rd	< 0.5 EY
Rowells Rd laterals	< 0.5 EY
Rundle Ave	< 0.5 EY
Franciscan Ave	< 0.5 EY
Strathmore Ave	< 0.5 EY
Darwin St	0.5 – 0.2 EY
Kingswood Cres	< 0.5 EY
Cowandilla Mile End	
Beachway Ave, Henley Beach Rd	0.5 – 0.2 EY
Holbrooks Rd	0.5 – 0.2 EY
Pine St	< 0.5 EY
Clifford St	< 0.5 EY
Neil Rd, Marion Rd	< 0.5 EY
Turner St	0.5 – 0.2 EY
Tarragon St + laterals	< 0.5 EY
Milner Rd	< 0.5 EY
Sir Donald Bradman Dr (east of South Rd)	< 0.5 EY
Keswick Creek Lateral Drains	
Davenport Terrace + laterals	< 0.5 EY

Drains with Low Performance Standard	Performance Standard AEP
Brooker Terrace, Kingston Ave	< 0.5 EY
South Rd, London Rd	< 0.5 EY
Marion Rd (upstream of Passmore St system)	< 0.5 EY
Richmond Rd trunk drain and laterals (Marion Rd, Sutton Terrace, Ritchie Terrace)	< 0.5 EY
Alexander Ave, South Rd	< 0.5 EY
Keswick – Western Adelaide	
Railway Terrace (north of Scotland Rd)	< 0.5 EY
Richmond Rd (southern drain)	< 0.5 EY
Marleston Ave, Alexander Ave	< 0.5 EY
Hampton Rd	< 0.5 EY
Brown Hill Creek Lateral Drains	
Beauchamp St	< 0.5 EY
Selby St	< 0.5 EY
Warwick Ave	< 0.5 EY
Durant St, Birdwood Terrace	< 0.5 EY
Marion Rd, Galway Ave	< 0.5 EY
Marion Rd (just south of Brown Hill Creek)	< 0.5 EY
Marion Rd (south of south of Hawson Ave)	< 0.5 EY
Long St, Glenburnie Terrace	< 0.5 EY
Streeters Rd, Spring St, Hawson Ave, Neston Ave, Lewis Cres	< 0.5 EY
Deeds Rd, Kinkaid Ave, Gardner St	< 0.5 EY
Penong Ave, Myer Ave, Emma Pl	< 0.5 EY
Raffle Cres	< 0.5 EY
Albert Ave	< 0.5 EY
Mooringe Ave, Morphett Rd	< 0.5 EY
Bonyton Ave	< 0.5 EY
James Melrose, Glenelg Golf Course east drain	0.5 – 0.2 EY
Electra St	< 0.5 EY
Ansett Ave	< 0.5 EY

Each major catchment has several stormwater systems with a low underground standard. Of particular note, are the major systems along Ayton Avenue (Fulham), Tarragon Street (Mile End, Richmond Road (Marleston to Netley), Davenport Terrace (Richmond), Brooker Terrace (Richmond), and Morphett Road (North Plympton), which all have drain standards less than 0.5 EY.

In some cases, rather than a pipe being undersized, an undersized pump station results in pipes being assigned a low standard. This occurs throughout the River Torrens Pumped Catchment. An

example of the is the Riverway Pump Station. Figure 4.6 below shows the long section from Riverway to Tapleys Hill Road. In this case, it cannot be concluded that the pipes are undersized because the low pump rate is the limiting factor. The HGL at the downstream end (pump station) is already at a similar level to the upstream pit ground levels and so an increase in pipe size will have little impact on the HGL upstream which is close to being 'flat'.

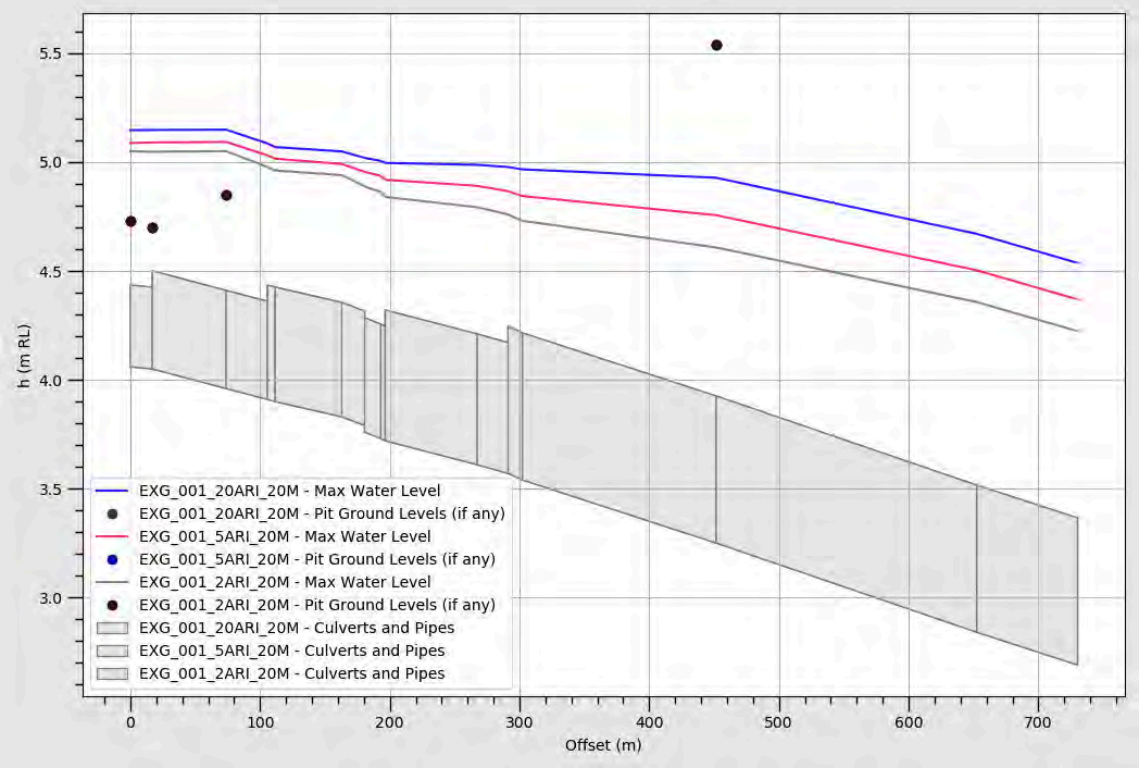


Figure 4.6 – Long section of Riverway Pumped Stormwater System

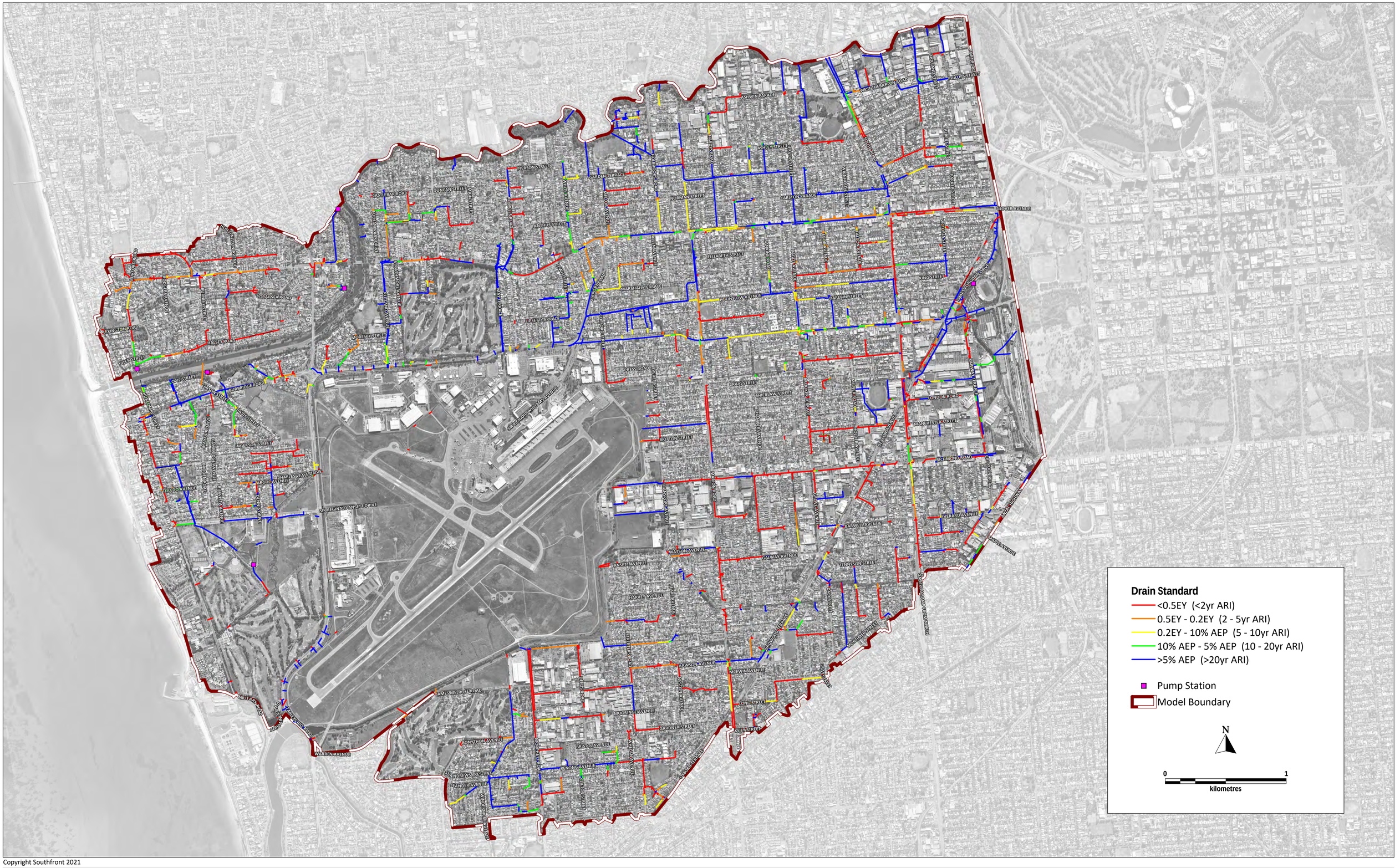
Analysis of TUFLOW model output and standard maps show that some drains did not exceed or reach capacity in any of the modelled AEP events up to and beyond the 1% AEP event. This is generally due to restrictions in the upstream drainage system limiting the flows that can enter these drains (i.e. undersized lateral drains), rather than these drains being oversized. Two examples of this are Passmore St drain and the Riverway pumped system. Drain standard maps indicate that these drains have a high capacity. However, many of the contributing drains in the upstream catchments are shown to have capacities of less than 1 EY. Should these upstream systems be upgraded, it is unlikely that the trunk drains would perform at such a high standard.

The capture capacity of the existing drainage inlets (i.e. side entry pits, grated inlet pits) was assessed by comparing the magnitude of the 5 year ARI approach flows (Scenario 1) to the theoretical capacity of the corresponding pit. The capacity of the inlet was estimated utilising the inlet data published by the University of South Australia (http://www.unisa.edu.au/IT-Engineering-and-the-Environment/Natural-and-Built-Environments/Our-research/AFMG/South-Australian-Road-Stormwater-Drainage-Inlets-Hydraulic-Study/, accessed 8 May 2019), with inlet approach gradients generalised by region as shown in Figure 4.7.



Figure 4.7 – Generalised Inlet Approach Gradient

Each stormwater pit has been categorised according to the corresponding ratio of approach flow / inlet capacity, as presented in Figure 4.9.



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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Drain Standard]
NearMap [Aerial Photograph]

southfront

West Torrens
Stormwater Management Plan

Drainage Standard Map
Scenario 1 - Existing Development, Existing Infrastructure, Figure 4.8



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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Approach Flow Ratios]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

Pit Inlet Capacities - 0.2 EY Event
Figure 4.9

4.6 Major System Performance

A1 format flood plain depth and hazard maps for each storm event (Scenario 1 to 4) have been prepared and are presented in Appendix E.

Analysis of the flood mapping results have identified a number of flood prone regions throughout the study area. Whilst there are numerous flooding hotspots, the majority of flooding can be categorised within several regions. The City of West Torrens have reviewed the existing flood maps and are satisfied that known flooding hotspots throughout the Study Area are being represented in the modelling. A high level description, highlighting the major flood areas is provided below.

The floodplain maps referenced in this section use the following flood depth contour band (Figure 4.10).

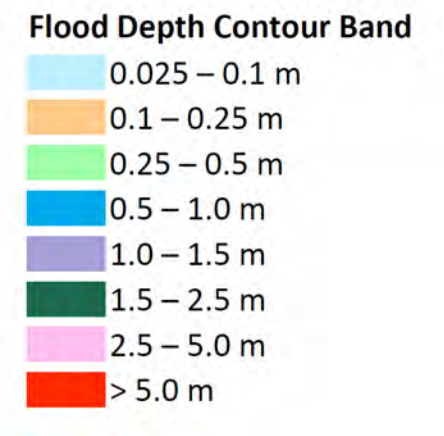


Figure 4.10 – Flood depth contour band

Fulham / Henley Beach South
The upstream end of the Halsey Pump Station system, in Fulham, currently does not provide a 0.5 EY flood protection standard to the properties in the area. This section of Fulham is a trapped low area, with significant upwelling from pits occurring in the larger storm events. Figure 4.11 provides a clip of the 1% AEP floodplain in the area. Substantial inundation also occurs at the downstream end, towards the pump station. The existing pump station and stormwater system has been identified as being undersized. Figure 4.12 provides a long section from the pump station to the trapped low area in Fulham. As can be seen the pit levels in Fulham are well below the 1% AEP HGL.

The Riverway Pump Station System drainage system provides up to a 0.2 EY flood standard but in larger storm events significant property inundation occurs, particularly along Murray Street.

The Chippendale Pump Station system provides up to a 5% AEP flood standard with property inundation occurring in larger AEP events.



Figure 4.11 – Scenario 1, 1% AEP Floodplain, Fulham / Henley Beach South

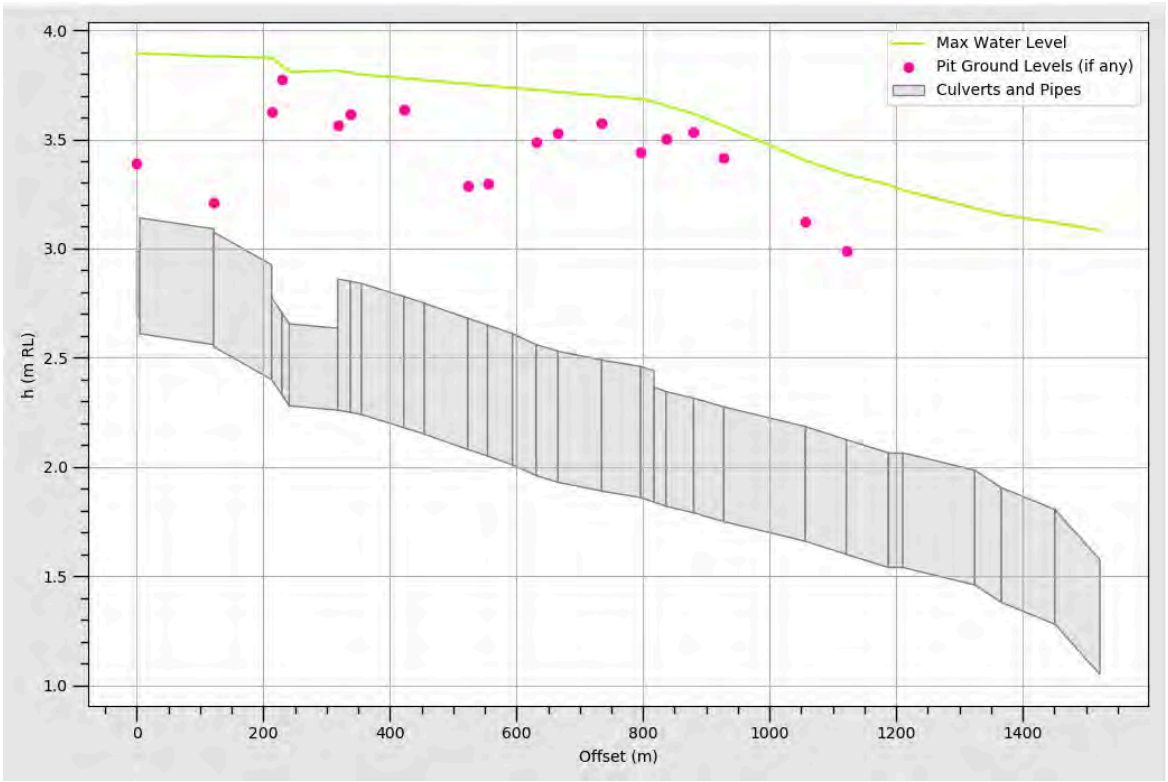


Figure 4.12 – Long-section from Halsey pump Station to Ayton Avenue (Scenario 1, 1% AEP)

Lockleys

Two significant flooding hotspots are seen in Lockleys, surrounding Arcoona Avenue and Strathmore Avenue (Figure 4.13). Property inundation increases in both these areas for storm events greater than the 5% AEP event. The recent system upgrades in this area were designed to a 5% AEP flood standard, with investigations informing that design identifying the substantial practical issues and costs in providing a higher performance standard to this location.



Figure 4.13 – Scenario 1, 1% AEP Floodplain, Lockleys

Torrensville

Road ponding occurs throughout Stephens Avenue in the 0.5 EY event, with minor property inundation surrounding the intersection with Ashley Street. In larger AEP events the road ponding becomes significantly worse with many properties experiencing inundation, including the areas surrounding the western end of Ashley Street and Sheriff Street (see Figure 4.14). Inundation occurs in some industrial properties towards the northern end of Torrensville in the larger storm events.

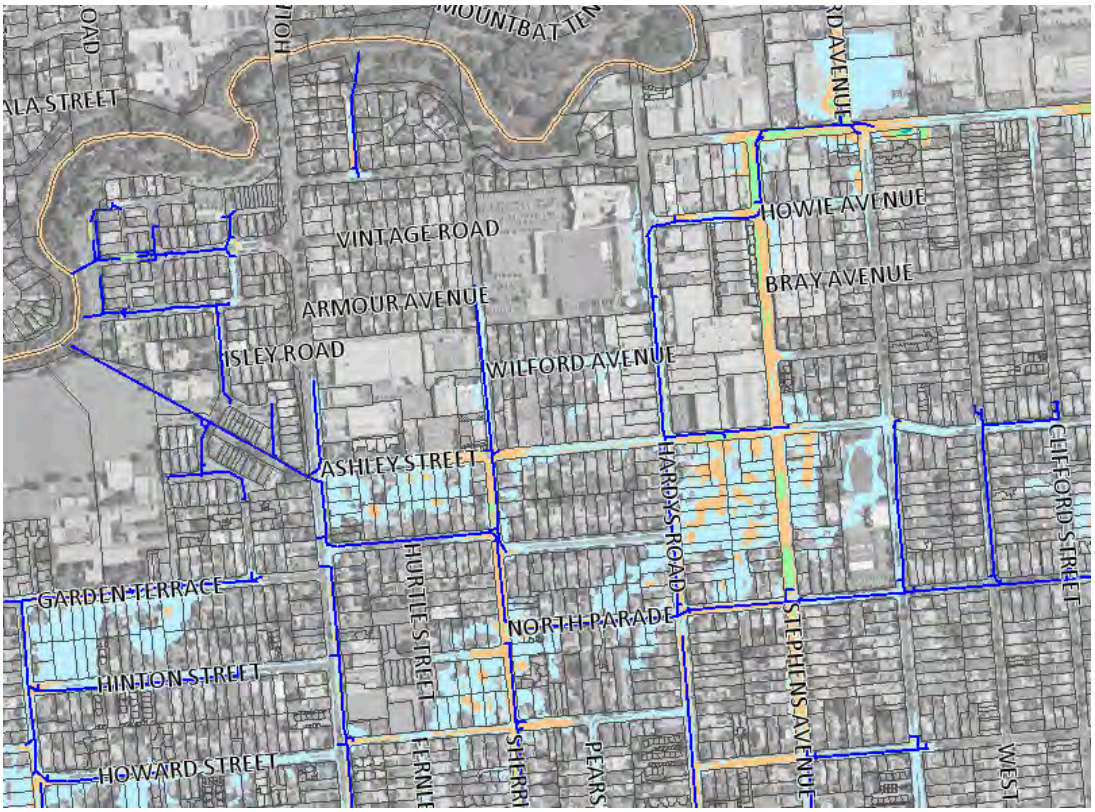


Figure 4.14 – Scenario 1, 1% AEP Floodplain, Torrensville

Thebarton

Property inundation occurs in the area between South Road, Dew Street and north of George Street in the 10% AEP event, with the number of properties affected increasing for the larger AEP events (Figure 4.15). Considerable road ponding is present in all AEP events including the 0.5 EY.



Figure 4.15 – Scenario 1, 1% AEP Floodplain, Thebarton

Brooklyn Park / Cowandilla / Mile End

The existing Cowandilla Mile End stormwater system, which converges into a channel running along the northern boundary of Adelaide Airport, was designed to cater for a 10% AEP event. Flooding in these areas is not significant for the smaller AEP events, however, the existing system clearly reaches its threshold beyond the 5% AEP event, with significant property inundation occurring through low lying areas of Brooklyn Park and Cowandilla. Floodplain mapping depicts a north-east to south-west movement towards Adelaide Airport. These major flood hotspots are shown in the flood map clip of the 1% AEP event below (Figure 4.16). In some cases, property inundation depths exceed 700mm surrounding the intersections of Beverley Avenue and Vincent Street with Sir Donald Bradman Drive (Scenario 4).

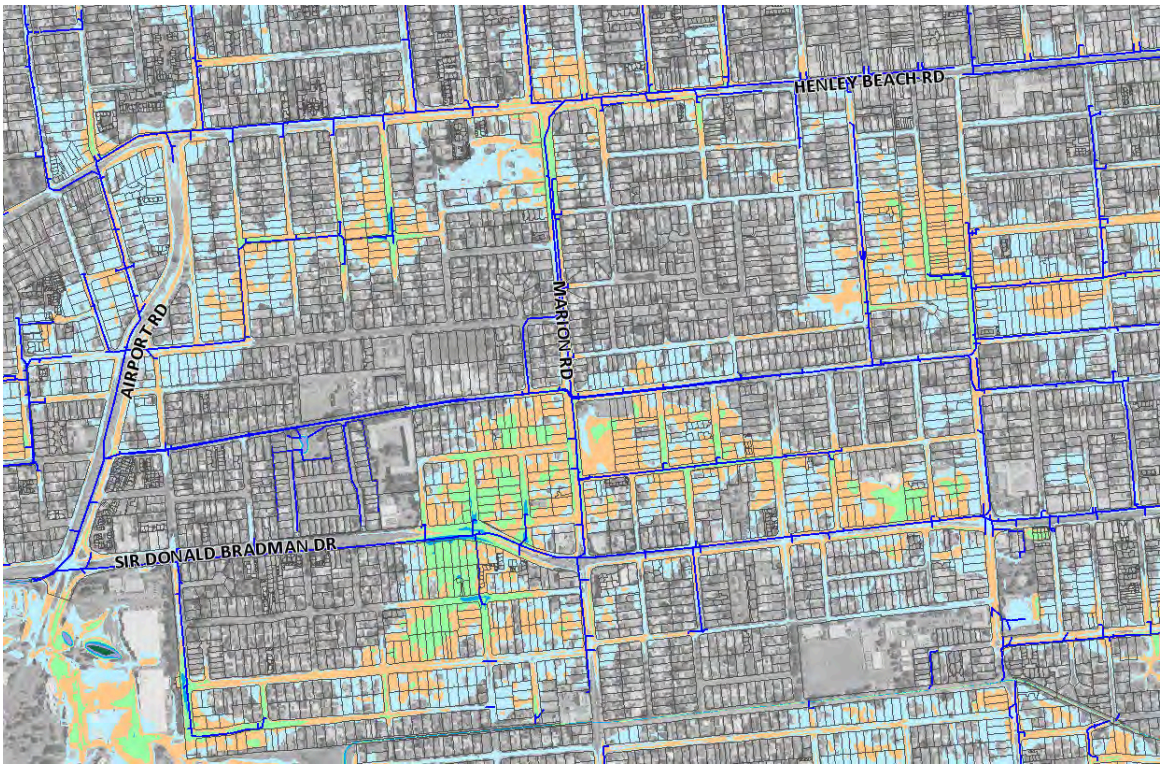


Figure 4.16 – Scenario 1, 1% AEP Floodplain, Brooklyn Park / Cowandilla / Mile End

Richmond / Netley

The stormwater lateral systems discharging into Keswick Creek all have low AEP underground standards. In the larger AEP events property inundation is shown to be substantial, especially in the residential areas West Richmond and along Brooker Terrace and Davenport Terrace. The industrial precinct in Netley also incurs large extents of inundation in the larger AEP events according to the floodplain mapping. This would be occurring because of the undersized existing trunk drain and laterals running down Richmond Road to Keswick Creek. Figure 4.17 highlights these flooding hotspots for 1% AEP event (Scenario 1).

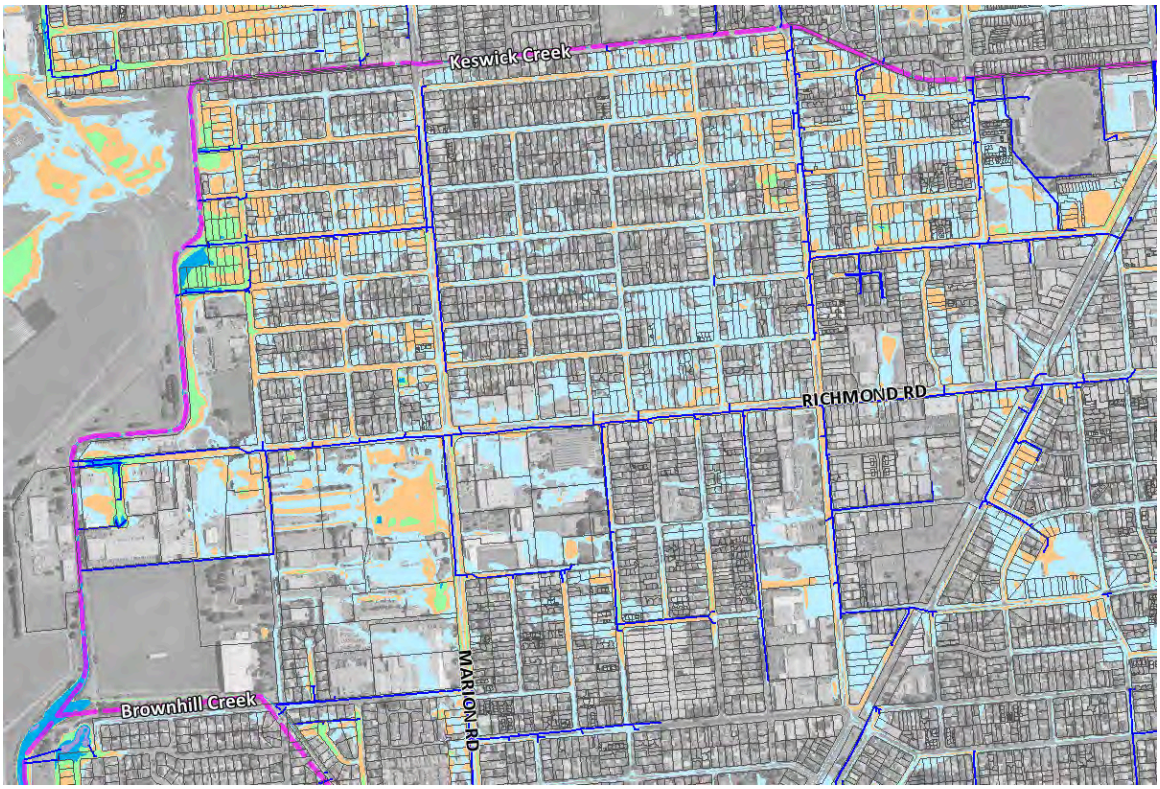


Figure 4.17 – Scenario 1, 1% AEP Floodplain, Richmond / Netley

Mile End South

Large extents of road ponding and inundation surrounding commercial and industrial properties in Mile End South occurs in the 0.2 EY event, becoming noticeably worse in the larger AEP events (Figure 4.18). Many of these large properties would have internal drainage and detention systems which have not been assessed in this modelling task for the SMP, and so the large extent of ponding in these commercial and industrial areas is uncertain for the low to mid-range storm events (5-20% AEP).

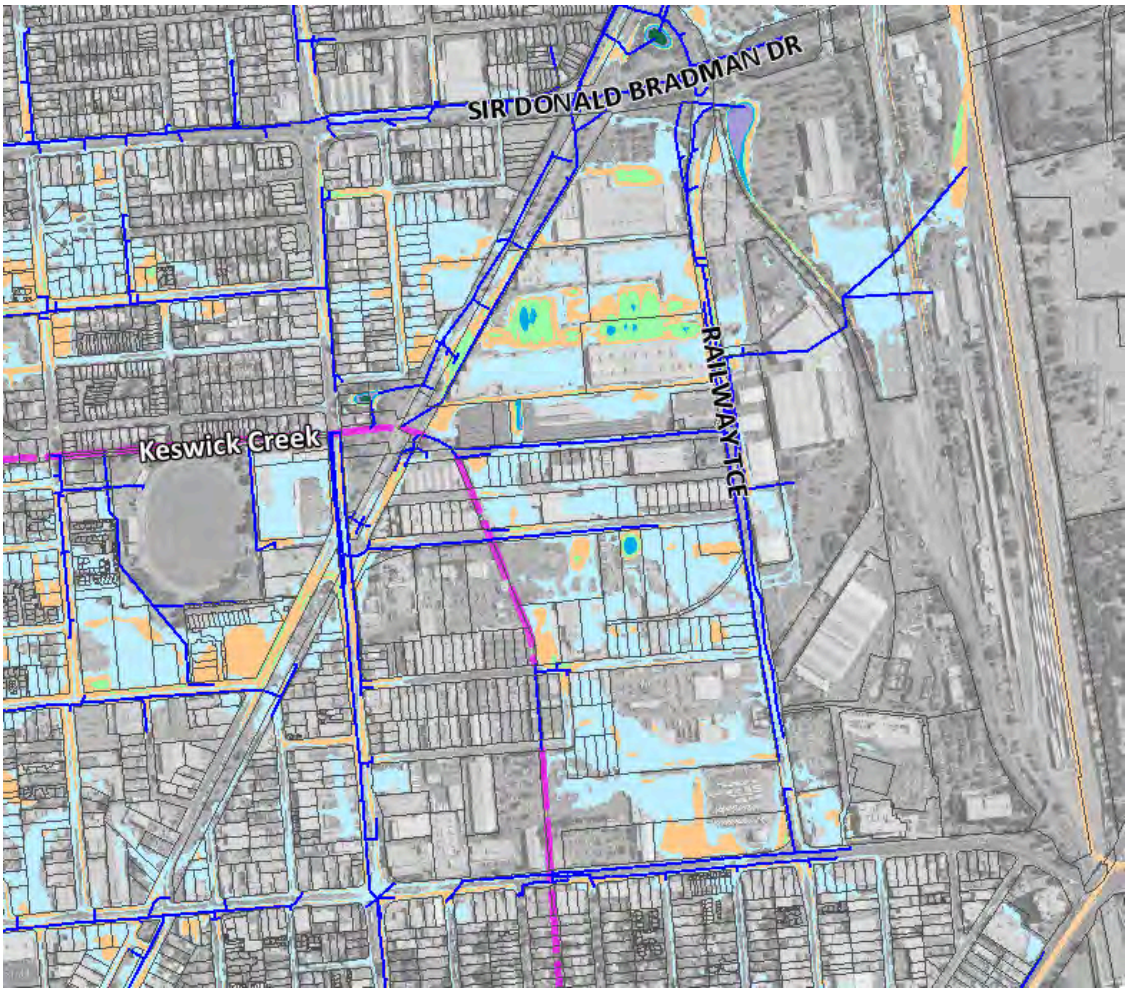


Figure 4.18 – Scenario 1, 1% AEP Floodplain, Mile End South

Kurralta Park

Minor property inundation occurs in the 0.2 EY event on the southern side of Brown Hill Creek in Kurralta Park. There are a number of stormwater lateral drains connecting to Brown Hill Creek which are undersized. Property inundation significantly increases for the larger AEP events as shown in Figure 4.19.

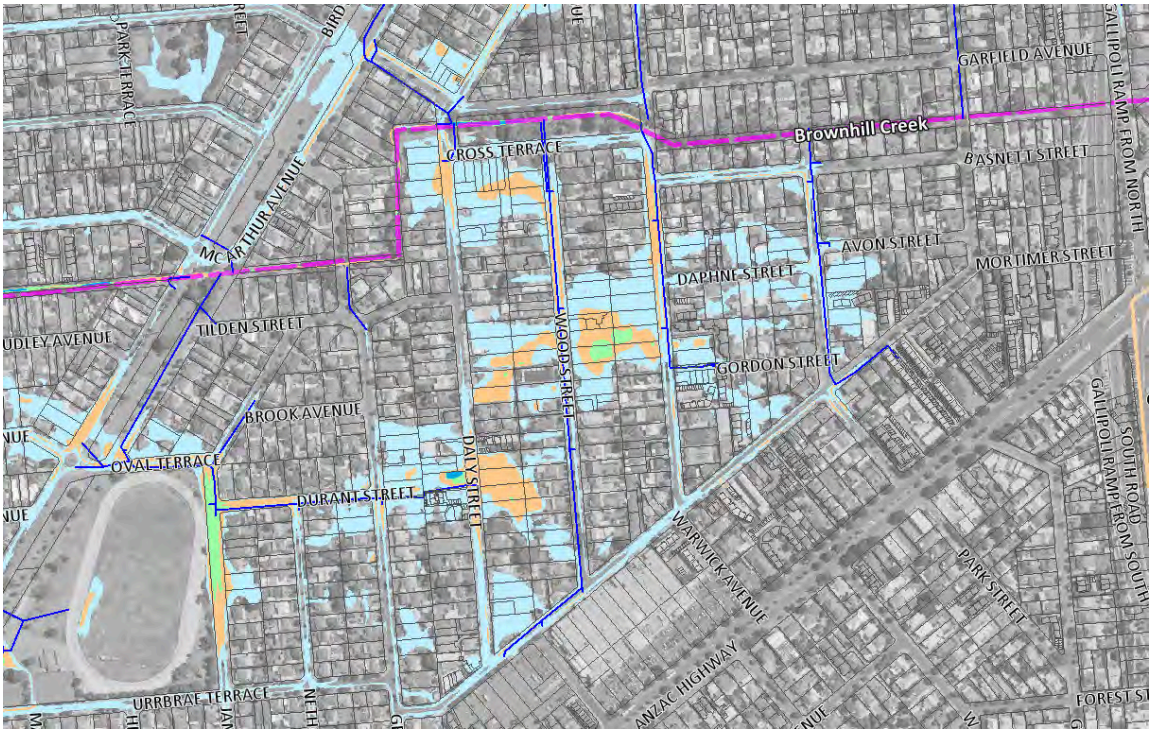


Figure 4.19 – Scenario 1, 1% AEP Floodplain, Kurralta Park

North Plympton / Camden park

There are three large existing stormwater systems in this area. Significant road ponding and minor property inundation occurs in areas of all three systems in the 0.5 EY event. In larger storm events property inundation considerably increases, especially at the downstream end of the systems in industrial/commercial land. Refer to Figure 4.20 below. The following locations all experience significant property inundation in the 10% AEP to 1% AEP events:

- Plympton international college
- Albert Ave
- Fitzroy Avenue
- Lewis Crescent
- Hawson Ave
- Deeds Road
- Kinkaid Avenue
- Morphett Road / James Melrose Road intersection

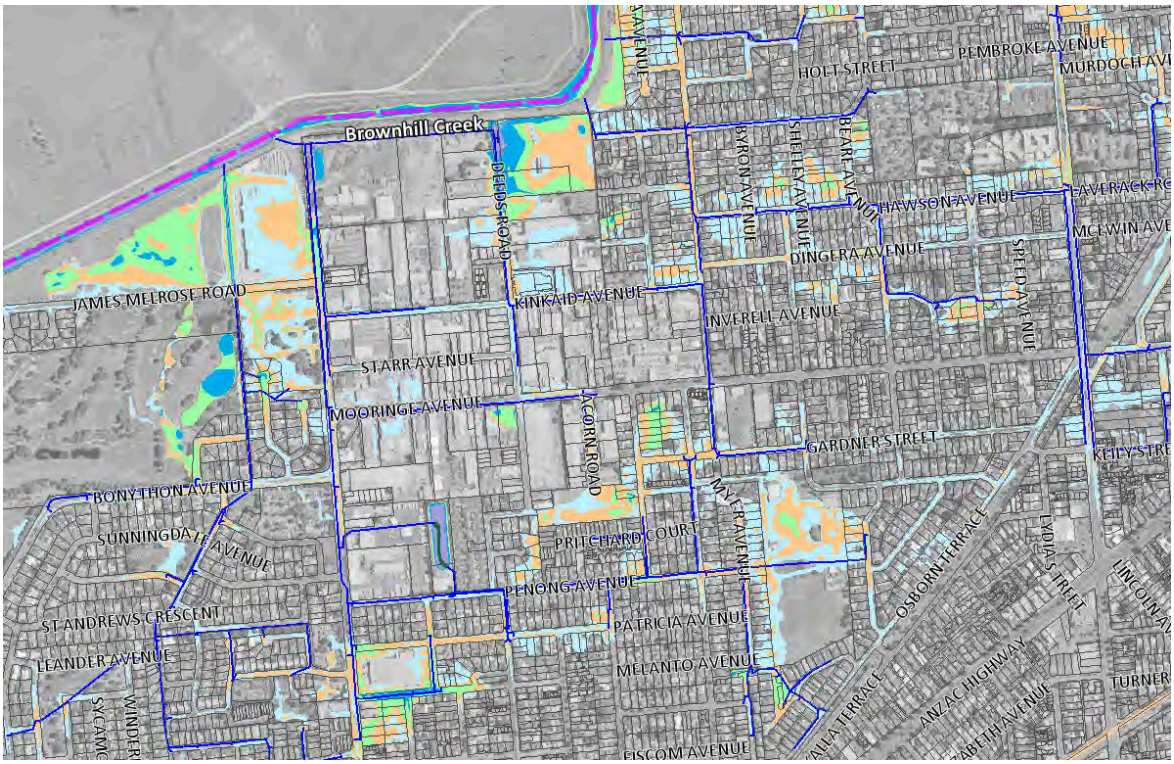


Figure 4.20 – Scenario 1, 1% AEP Floodplain, North Plympton / Camden park

4.6.1 Scenario Comparison

The future development and climate change scenarios resulted in larger flood extents and depths as expected. The magnitude of inundation is substantially worse for Scenario 4 which considers both the future development runoff coefficients and 18.1% rainfall intensity increase due to climate change. Comparison 1% AEP flood map clips of the Brooklyn Park / Cowandilla / Mile End flood prone region for Scenario 1 and Scenario 4 are shown in Figure 4.21 and Figure 4.22.

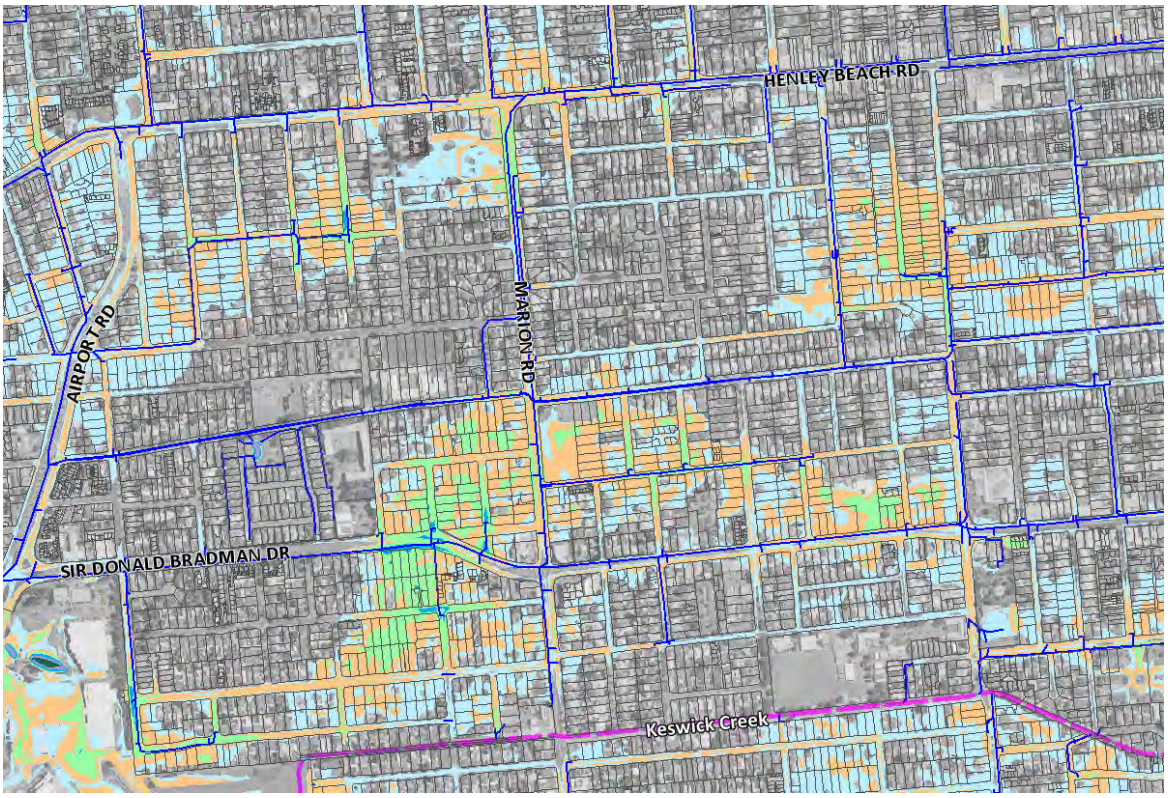


Figure 4.21 – Scenario 1, 1% AEP Floodplain, Brooklyn Park / Cowandilla / Mile End

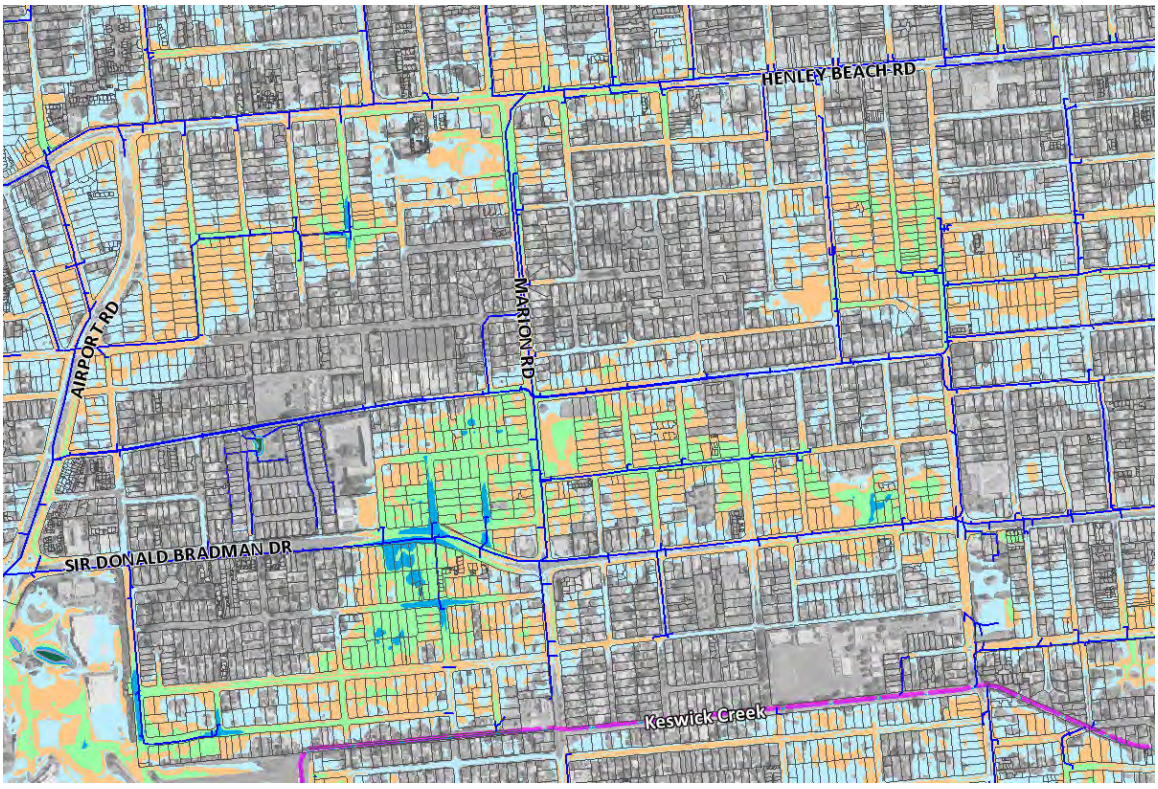


Figure 4.22 – Scenario 4, 1% AEP Floodplain, Brooklyn Park / Cowandilla / Mile End

Table 4.5 compares total properties impacted for the four existing infrastructure scenarios. A catchment summary for Scenario 4 of the number of properties subject to inundation of depths greater than 50 mm for each storm event is shown in Table 4.6. Note that the number of properties inundated by depth greater than 50 mm is to be used as an indication of regions which are most at risk of flooding, however, is not used in the damages assessment in the following section.

Table 4.5 – Property Inundation

Scenario	Number of Properties Inundated > 50 mm					
	0.5 EY	0.2 EY	10% AEP	5% AEP	2% AEP	1% AEP
1	90	163	299	541	1,086	1,694
2	114	224	392	701	1,299	1,925
3	141	280	503	883	1,613	2,291
4	172	375	659	1,152	1,967	2,735

Table 4.6 – Property Inundation by Catchment, Scenario 4

Catchment	Number of Properties Inundated > 50 mm					
	0.5 EY	0.2 EY	10% AEP	5% AEP	2% AEP	1% AEP
West Beach	2	3	8	19	36	50
River Torrens Pumping Stations	26	44	65	107	163	233
Lockleys	7	18	33	83	154	234
River Torrens	12	27	45	72	123	189
Cowandilla Mile-End	8	46	140	367	724	1,022
Keswick Creek Lateral Drains	62	133	223	297	459	588
Keswick - Western Adelaide	1	2	4	12	15	20
Brown Hill Creek Lateral Drains	54	102	141	194	286	390
Adelaide Airport	0	0	0	1	7	9
Total	**172**	**375**	**659**	**1,152**	**1,967**	**2,735**

4.7 Existing Infrastructure Flood Damages Estimation – Scenario 4

Existing infrastructure flood damages were calculated for Scenario 4 which was decided on by the Project Steering Committee. This allows for a fair comparison with the upgrade scenario flood damages which was modelled with future development runoff coefficients and an 18.1% rainfall intensity increase.

4.7.1 Background

Estimates of flood damages provide important information that can be used to prioritise flood mitigation works. The estimates indicate the magnitude of damages caused by a design flood event of a given AEP.

Flood damages can be classified into two categories:

- 'Tangible' damages represent the financial cost of recovering from flooding. These include 'direct tangible' costs arising from loss or damage to property and physical assets, and 'indirect tangible' costs associated with interruptions to business and the flood response by property owners and emergency services; and
- 'Intangible' damages relate to the effect on the physical and mental health of individuals who are impacted by flooding. Intangible damages are difficult to quantify in monetary terms, however similar studies have noted that these damages may match or even exceed the tangible damage cost.

This Study has included an assessment of the 'direct tangible' damages from flooding on the West Torrens study area, using the floodplain mapping results for the ultimate development scenario with the existing stormwater drainage infrastructure. The magnitude of flood damages is dependent upon a number of factors including land use, property values, depth of inundation and the preparedness of the community to respond to the threat of flooding. These factors (and others) are included in the damages assessment calculations and are detailed in the following sections.

4.7.2 Evaluation Approach

Properties within the floodplain have been assessed according to their land use type, and categorised as either Residential, Commercial – Office, Commercial – Retail or Industrial. No capital or 'improved value' data for individual properties has been made available for this Study. Therefore, an assumed improved value has been assigned to each property category, which represents the value of the structures or infrastructure that are susceptible to damages as a result of inundation, as shown in Table 4.7. Improved Values are based on estimated replacement values for 200sqm buildings as derived from Rawlinson's 2018.

Table 4.7 – Assumed 'Improved Values' of Flood Affected Properties

Property Category	Improved Value ($ 2018)
Residential	$195,000
Commercial – Office	$276,000
Commercial – Retail	$330,500
Industrial	$621,500

The flood depth at each property was determined for the 0.5 EY, 0.2 EY, 10% AEP, 5% AEP, 2% AEP, 1% AEP, 1:500 year AEP and the Probable Maximum Flood (PMF) events, and categorised into the following ranges:

- 0 – 0.1m;
- 0.1 – 0.15m;
- 0.15 – 0.25m;
- 0.5 – 1.0m;
- 1.0 – 1.5m; and
- 1.5 – 2.5m.

The 1:500 year AEP and the Probable Maximum Flood (PMF) events were modelled to obtain damage costs to enable calculation of the Average Annual Damages (Section 4.7.6).

In the absence of surveyed floor level data, an assumption was made of the typical floor level of residential and commercial/industrial buildings (relative to the ground level determined by the DTM). This is required to ensure that the damage estimates consider that building floor levels are often situated at higher elevations than the ground levels as determined by the DTM, particularly in the case of residential dwellings. These assumptions are:

- Residential – Floor level 150 mm above the property DTM level; and
- Commercial/Industrial – Floor level at the property DTM level.

Damage multiplier curves from the *Brown Hill Keswick Creek Stormwater Management Plan* (2016) as summarised in Table 4.8 were used to assign flood damage costs by inundation depth for each property category, as summarised in Table 4.9. These were used as this plan was recently prepared and approved, with a large portion of the catchment overlapping the West Torrens catchment. Refer to section 5.3.4 of the publicly available *Brown Hill Keswick Creek Stormwater Management Plan 2016* for further details of how the damage multiplier curves were developed.

Table 4.8 – Flood Damage Multiplier, by Inundation Depth

Property Category	Multiplier by Flood Depth						
	0-0.1	0.1-0.15	0.15-0.25	0.25-0.5	0.5-1.0	1.0-1.5	1.5-2.5
Residential	0.021	0.032	0.276	0.336	0.414	0.555	0.924
Commercial – Office	0.330	0.414	0.414	0.504	0.621	0.828	1.386
Commercial – Retail	0.438	0.552	0.552	1.872	3.047	5.296	8.770
Industrial	0.364	0.489	0.489	1.046	1.476	2.185	3.419

Table 4.9 – Flood Damage Cost by Property Type and Inundation Depth

Property Category	Flood Damage Cost by Inundation Depth						
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	1.5 – 2.5
Residential	$4,095	$6,240	$53,820	$65,520	$80,730	$108,225	$180,180
Commercial – Office	$91,080	$114,264	$114,264	$139,104	$171,396	$228,528	$382,536
Commercial – Retail	$144,759	$182,436	$182,436	$618,696	$1,007,034	$1,750,328	$2,898,485
Industrial	$226,226	$303,914	$303,914	$650,089	$917,334	$1,357,978	$2,124,909

4.7.3 Damages to Residential Properties

The number of residential properties that are at risk of inundation during various storm events was estimated by overlaying the flood inundation maps for these events over the cadastral layer and aerial photography. The results of the analysis for each AEP and depth range are shown in Table 4.10.

Table 4.10 – Residential Damages, Ultimate Development / Existing Drainage / Climate Change RCP 8.5

AEP	No. of Residential Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	359	28	17	5	0	0	$2,890,000
0.2 EY	745	62	46	14	0	0	$6,830,000
10% AEP	1204	137	77	30	0	0	$11,900,000
5% AEP	1782	245	180	57	2	0	$22,410,000
2% AEP	2436	407	380	147	8	0	$43,240,000
1% AEP	2980	553	513	280	16	0	$62,900,000

4.7.4 Damages to Commercial and Industrial Properties

The number of commercial and industrial buildings that would potentially become inundated during various storm events was estimated by overlaying the flood inundation maps for these events over the cadastral layer and aerial photography. The results of the analysis for each AEP and depth range are shown in Table 4.11, Table 4.12 and Table 4.13.

Table 4.11 – Commercial - Office Damages, Ultimate Development / Existing Drainage / Climate Change RCP 8.5

AEP	No. of Office Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	42	7	6	1	1	0	$5,620,000
0.2 EY	61	9	12	0	1	0	$8,130,000

10% AEP	90	6	17	1	1	0	$11,140,000
5% AEP	125	12	13	10	1	0	$15,800,000
2% AEP	186	24	22	12	0	1	$24,100,000
1% AEP	237	33	25	25	3	1	$32,430,000

Table 4.12 – Commercial - Retail Damages, Ultimate Development / Existing Drainage / Climate Change RCP 8.5

AEP	No. of Retail Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	26	0	0	0	0	0	$3,760,000
0.2 EY	39	0	0	0	0	0	$5,650,000
10% AEP	49	5	0	0	0	0	$8,010,000
5% AEP	70	6	2	1	0	0	$12,210,000
2% AEP	104	12	3	2	1	0	$20,040,000
1% AEP	124	20	7	4	1	0	$26,360,000

Table 4.13 – Industrial Damages, Ultimate Development / Existing Drainage / Climate Change RCP 8.5

AEP	No. of Industrial Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	23	2	3	0	0	0	$6,720,000
0.2 EY	32	6	6	0	0	0	$10,890,000
10% AEP	41	6	7	2	0	0	$14,530,000
5% AEP	53	10	8	2	1	0	$19,680,000
2% AEP	74	18	13	6	1	0	$30,980,000
1% AEP	84	19	16	11	2	0	$38,630,000

4.7.5 Summary of Total Damages

The total damages for the ultimate development scenario with existing drainage infrastructure are summarised in Table 4.14, and have been presented on a per catchment basis in Table 4.15.

Table 4.14 – Total Direct Tangible Damages, Ultimate Development / Existing Drainage / Climate Change RCP 8.5

AEP	Residential	Commercial – Office	Commercial – Retail	Industrial	Total
0.5 EY	$2,890,000	$5,620,000	$3,760,000	$6,720,000	$19,000,000
0.2 EY	$6,830,000	$8,130,000	$5,650,000	$10,890,000	$31,490,000

10% AEP	$11,900,000	$11,140,000	$8,010,000	$14,530,000	$45,560,000
5% AEP	$22,410,000	$15,800,000	$12,210,000	$19,680,000	$70,100,000
2% AEP	$43,240,000	$24,100,000	$20,040,000	$30,980,000	$118,360,000
1% AEP	$62,900,000	$32,430,000	$26,360,000	$38,630,000	$160,320,000

Table 4.15 – Total Direct Tangible Damages per Catchment, Ultimate Development / Existing Drainage / Climate Change RCP 8.5

Catchment	Total Damages Estimate per Catchment ($000)					
	0.5 EY	0.2 EY	10% AEP	5% AEP	2% AEP	1% AEP
West Beach	$ 230	$ 350	$ 400	$ 840	$ 1,420	$ 2,640
River Torrens Pumping Stations	$ 670	$ 1,620	$ 24,230	$ 3,600	$ 5,310	$ 7,050
Lockleys	$ 530	$ 800	$ 1,110	$ 2,070	$ 4,860	$ 7,230
River Torrens	$ 1,490	$ 4,630	$ 6,050	$ 9,650	$ 15,190	$ 20,520
Cowandilla Mile-End	$ 1,250	$ 2,270	$ 4,740	$ 11,590	$ 25,530	$ 39,960
Keswick Creek Lateral Drains	$ 8,070	$ 13,230	$ 18,820	$ 25,670	$ 37,960	$ 46,220
Keswick - Western Adelaide	$ 1,370	$ 1,850	$ 2,580	$ 3,750	$ 7,450	$ 9,570
Brown Hill Creek Lateral Drains	$ 5,390	$ 6,740	$ 9,210	$ 12,260	$ 18,900	$ 24,440
Adelaide Airport	$ -	$ -	$ 230	$ 680	$ 1,750	$ 2,700

4.7.6 Average Annual Damages

Average Annual Damage (AAD) values were calculated for each Catchment area and summarised in Table 4.16. The AAD value is based on flood damage results for each AEP modelled and includes damage results for the 1:500 year AEP event and Probable Maximum Flood (PMF). Refer to Appendix I for a summary of the total direct damages for the 1:500 year AEP event and Probable Maximum Flood. Figure 4.23 provides the damage probability curve, highlighting the change in total damages with frequency of storm event.

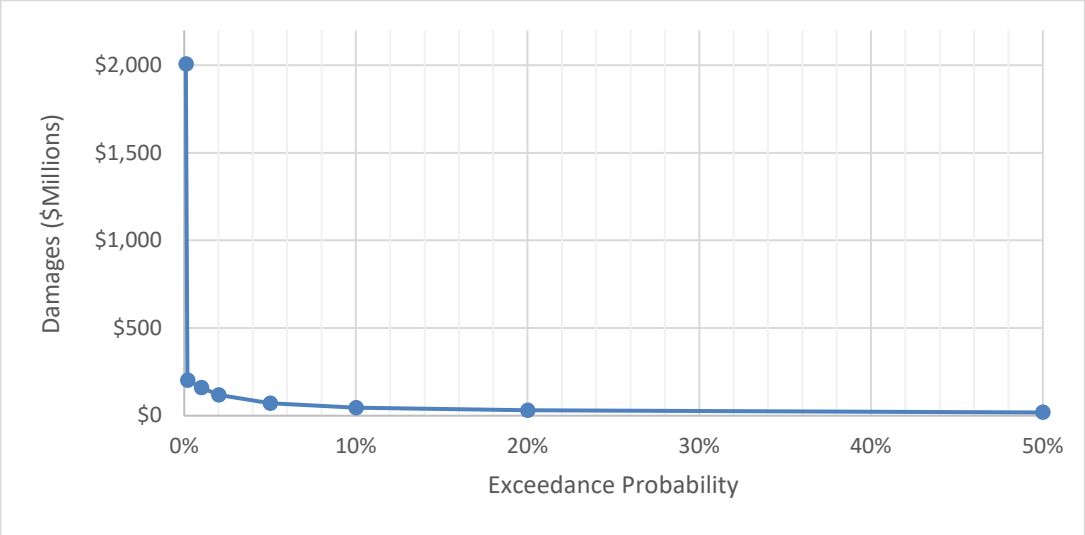


Figure 4.23 – Damage Probability Curve, Total Average Annual Damages

The Average Annual Damage value for the full catchment area was calculated to be approximately $21 million. A breakdown for each Catchment area is presented in the table below.

Table 4.16 – Average Annual Damages by Catchment

Catchment	Average Annual Damage (AAD) Value
West Beach	$ 280,000
River Torrens Pumping Stations	$ 1,030,000
Lockleys	$ 670,000
River Torrens	$ 2,760,000
Cowandilla Mile-End	$ 2,850,000
Keswick Creek Lateral Drains	$ 7,960,000
Keswick - Western Adelaide	$ 1,230,000
Brown Hill Creek Lateral Drains	$ 4,190,000
Adelaide Airport	$ 130,000
Total	$ 21,090,000

4.8 Flood Mitigation Strategies

4.8.1 Strategy Overview

Flood mitigation strategies are outlined in this section. These strategies have been developed with a view to maximising the level of flood protection that can be achieved within practical constraints, for example, where providing the desired 1% AEP (100 year ARI) flood protection standard would be infeasible or cost prohibitive. Scenario 4 was used as the existing case to compare to; hence the upgrades have been designed for future development and an 18.1% increase to rainfall intensity due to climate change. Council owned land and public space was

prioritised for upgrade strategies. Acquisition of private land was not considered unless an obvious opportunity was identified.

The following assumptions were used to determine if reaching the 1% AEP flood protection standard was seen to be infeasible or cost prohibitive:

- Pipe or culvert sizes required to reach the standard do not fit within the road reserve.
- Required culvert sizes would result in inevitable service clashes with significant services that would be extremely costly to relocate and be likely to stop a construction project going ahead.
- A proposed upgrade would result in the whole downstream existing system to be upgraded, an example being the airport drain servicing the Mile End Cowandilla system.

Early strategy development and modelling clearly indicated that reaching the 1% AEP standard was not practical due to the sizes and numbers of drains required. Hence a 5% AEP flood standard (no above floor inundation of private property) was agreed upon through consultation with the City of West Torrens. Floor level survey (outside of the scope of this study) would be required to confirm whether these performance standards have been achieved for all properties. This would occur during detailed design of the strategies.

Adopting a flood standard of 5% AEP has previously been used for approved stormwater management plans and other studies in the Adelaide area including:

- Lockleys Stormwater Management Plan (2015) for the City of West Torrens
- Lefevre Peninsula SMP (2018)
- Port River East SMP (2019)
- Sturt River Urban Catchments SMP (in development)

A separate study of a large portion of the Brown Hill Lateral Drain Catchment was conducted to compare the costs involved with obtaining the 1% AEP flood standard compared to the 5% AEP. This is documented in Section 4.11.

An overview of all upgrades is presented in Figure 4.24. Each of the proposed upgrades has been assigned a Project ID for reference. A1 format floodplain depth and hazard maps have been prepared for each AEP event to demonstrate the performance of the flood mitigation strategies, and are presented in Appendix F.

Budget cost estimates have been prepared for the proposed flood mitigation works. The budget cost estimates are exclusive of GST and include allowances of:

- 10% for design;
- 5% for modification to existing services;
- 15% for construction preliminaries;
- 20% for contingencies on construction; and

These cost estimates are based upon historical cost information and experience, and do not allow for latent or market conditions (i.e. competition, escalation) or land acquisition.

It is expected that floor level survey will be undertaken to inform the design development phase and refine project scope to optimise the benefits associated with each upgrade element.

Latent conditions such as contaminated material and shallow groundwater has not been specifically allowed for in these cost estimates. Site investigations during the design development phase should be undertaken to assist in mitigating this risk.

The cost of ancillary landscaping works to be undertaken at the project sites has also not been considered, with the exception of re-seeding turf areas and the establishment of riparian plantings associated with WSUD elements.

Concept layouts of each proposed strategy are provided in the text. It is noted that these are high level concept plans and highlight the major drainage alignments. They do not show finer details such as the number/location of pits and smaller lateral pipes. Note that the cost estimates do account for all pits and smaller pipes. Proposed upgrade drains are coloured in red.



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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Proposed Stormwater Strategies]
NearMap [Aerial Photograph]

West Torrens
Stormwater Management Plan

Proposed Flood Mitigation Works - Overwiew Plan
Figure 4.24

4.8.2 River Torrens Pumping Station

The existing Halsey Pump Station Stormwater system does not meet a 5% AEP flood standard. Significant property inundation is seen in the low-lying areas in the upstream areas of the catchment, particularly along Ayton venue in Fulham. The current system runs from Henley Beach South to Fulham, crossing over from City of Charles Sturt (downstream end) to the City of West Torrens (upstream end). It is proposed to split the existing large system at the council boundary and construct a new pump station in the City of West Torrens boundary. This allows each Council to manage their own drainage and pump systems. See Section 7 for inter-council cost split information. The existing drainage of the Riverway Pump Station System is proposed to be upgraded to meet a 5% AEP standard.

Each of these proposals are described below. Figure 4.25 provides a flood comparison of the 5% AEP event for the area.

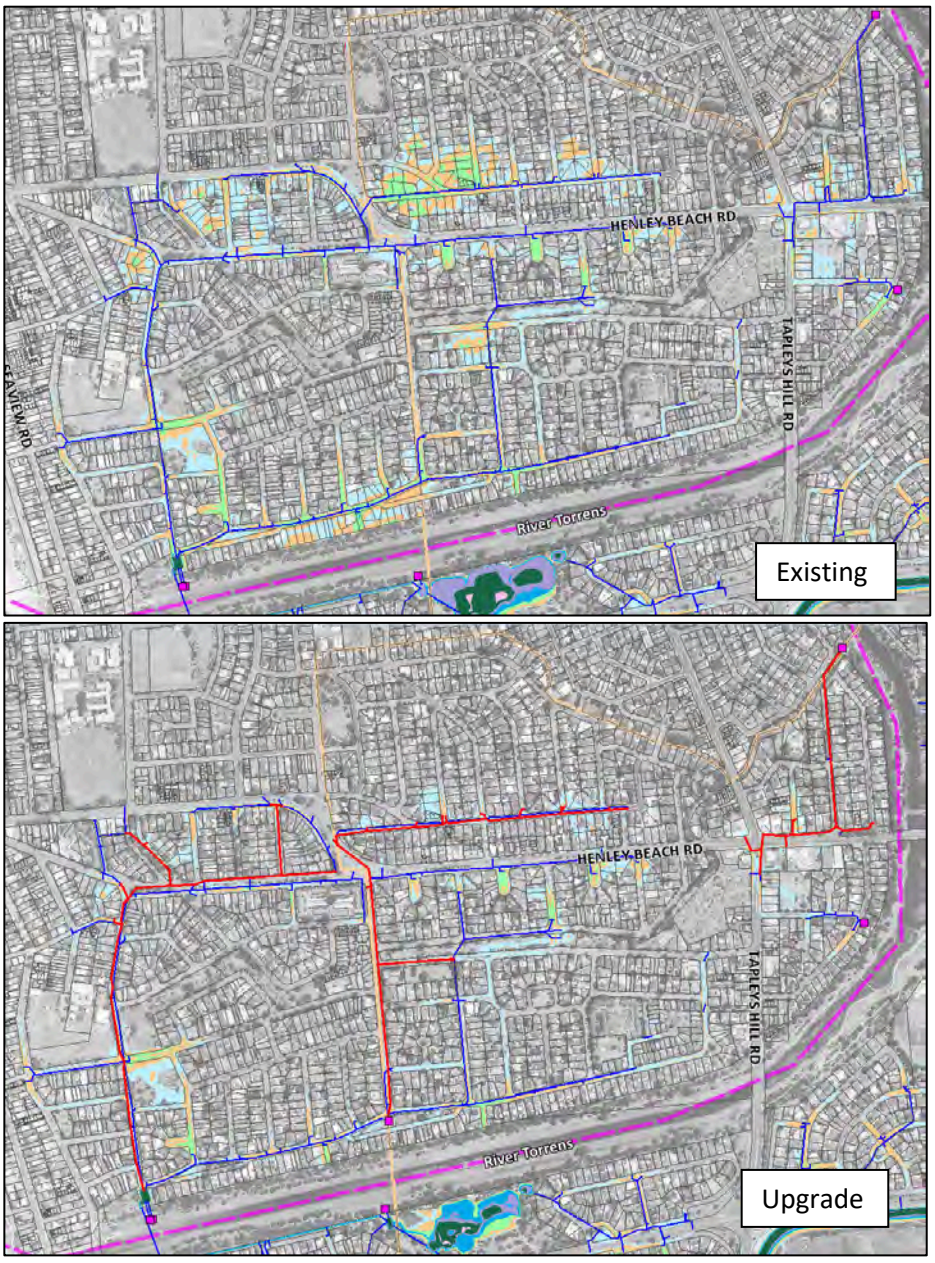


Figure 4.25 – 5% AEP floodplain comparison

D1 – Halsey Pump Station and Drainage

With the diversion of the upstream Fulham stormwater drainage into the new Burnley Street system, the Halsey Pump system did perform better, however did not meet a 5% AEP standard. Hence a new duplicate trunk drain, ranging in size from 1200mm to 675mm, is proposed to run along Waldron Street, Burford Road and Hmas Australia Road with lateral drains connecting the low-lying areas at Cudmore Terrace, Henley Beach Road and Gilmore Road. Please refer to Figure 4.26 for the concept plan. The existing pump station is also proposed to be upgraded to cater for the extra flows. There is also the potential to include a detention basin within William Atkin Reserve (Lexington Road, Henley Beach South). Options such as this would be assessed during the detailed design phase.

The existing Halsey Pump Station currently has two separate pump systems. The first consists of three horizontal dry mounted pumps with a total duty of 284 L/s at 8.76mTDH. The second consists of two submersible pumps with a total duty of 928 L/s at 8.6mTDH. It is proposed to increase the total combined capacity of the Halsey pump station to 1,900 L/s.

The total cost for the upgrades is estimated to be $4,326,000. This budget estimate assumes an allowance of $70,000 for the provision of an increased power supply to the proposed pump station upgrade. Added ongoing annual maintenance costs for the increased pump capacity are estimated to be in the order of $2,000/year including power/electrical usage, maintenance costs and monitoring costs.

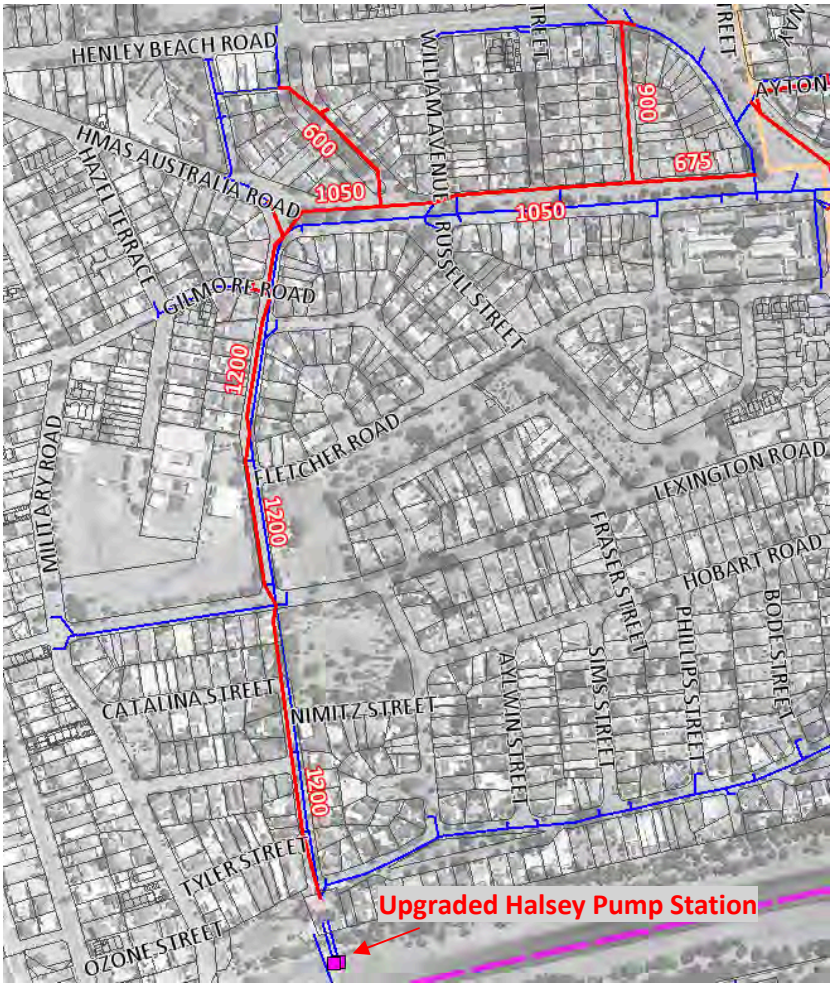


Figure 4.26 – Halsey Pump Station and Drainage Layout

D2 – Burnley Street Pump Station and Drainage

A maximum capacity of 3 m^3/s is proposed for the new Burnley Street Pump Station, requiring a new 1050 mm diameter rising main to be constructed to discharge to the River Torrens. The suggested location for the new pump station is at the reserve at the southern end of Burnley Street (intersection with Halsey Road). An underground storage of 1,000m^3 is proposed at the pump station. There is an existing reserve at Coral Sea Road where there is potential for further underground storage which would enable a reduction in the required pump flow rate and optimise the project cost.

A new trunk drain feeding into the pump station is proposed to run along Burnley Street, Henley Beach Road and Ayton Avenue. The proposed drain size ranges from a 2400mm x 900mm box culvert at the downstream end to 1800mm x 600 mm box culvert in Ayton Avenue. The exiting drain in Ayton Avenue is proposed to remain alongside the new trunk drain. A number of new and upgraded lateral systems have been proposed along the extent of the trunk drain. Existing stormwater lateral systems have been linked into the new system where feasible. Refer to Figure 4.27 for the proposed layout. There is also the potential to include a detention basin within Coast Watchers Park along Coral Sea Avenue, Fulham. Options such as this would be assessed during the detailed design phase.

The total cost for these works is estimated to be $16,140,000. Ongoing annual maintenance costs are estimated to be in the order of $8,000/year including power/electrical usage, maintenance costs and monitoring costs.



Figure 4.27 – Burnley Street Pump Station and Drainage Layout

D3 – Riverway Drainage

A new trunk drain ranging from a 1500mm RCP to 1800mm x 900 mm box culvert is recommended to run from the Riverway Pump Station, along Mickridy Street, to Henley Beach road. Larger new lateral drainage systems are proposed to replace the existing drainage, linking the trapped low points at Samuel Street, Murray Street and Tapleys Hill Road to the new trunk drain in Mackridy Street. Refer to Figure 4.28 for the proposed layout.

The proposed upgrade modelling indicates some residual roadway ponding occurs in the 5% AEP event. Increasing the pipes further will have little impact on increasing the flood protection. To obtain a higher flood standard the pump station, which currently has a capacity of up to 900 L/s, would need to be upgraded.

The total cost for these works is estimated to be $2,750,000.

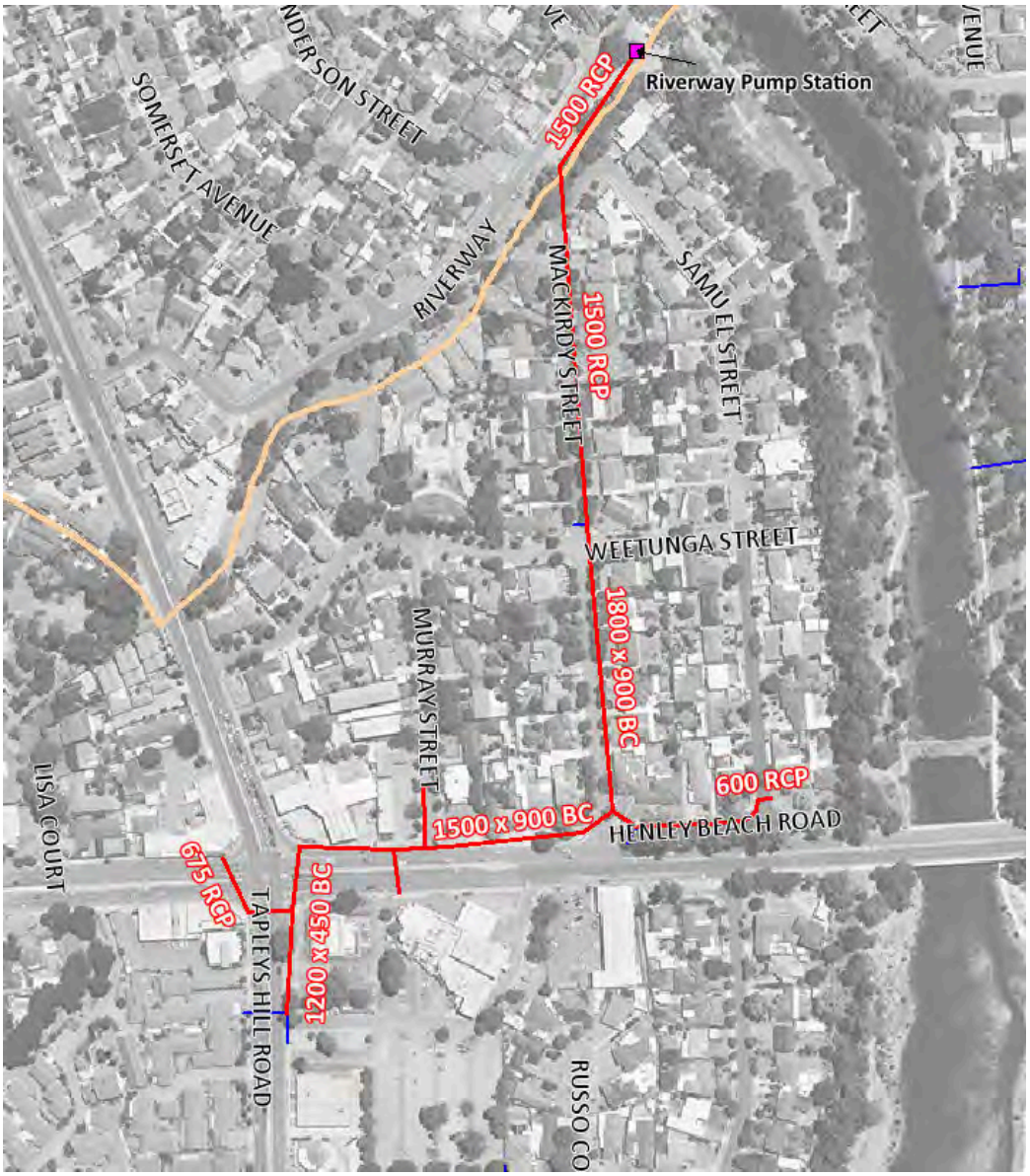


Figure 4.28 – River Drainage Layout

4.8.3 Lockleys

D4 – Frontage Road Drainage

A new system is proposed to discharge to the River Torrens at the northern end of Lockleys, picking up flows from Dathmor Street, Torrens Avenue and Sandilands Street. The pipes range in size from 900 mm to 375 mm. The system is to discharge from Frontage Road as shown in Figure 4.29. The proposed system will reduce the catchment area which drains into the existing, southwards draining, Lockley's system. Roadway ponding and property inundation is reduced in the larger AEP events along Acroona Avenue and Rutland Avenue as a result of the new system to the north (see Figure 4.30 comparing 5% AEP events). In addition, this option will provide significant drainage performance improvements in the minor events.

A gross pollutant trap and a flap gate/non-return valve on the pipe outlet would be required to prevent the 1% AEP River Torrens flood waters from surcharging into the catchment. The risk of a flap gate non-return value failure and mitigation measures should be assessed during the design development stage.

The total cost for these works is estimated to be $950,000.



Figure 4.29 – Frontage Road Drainage Layout

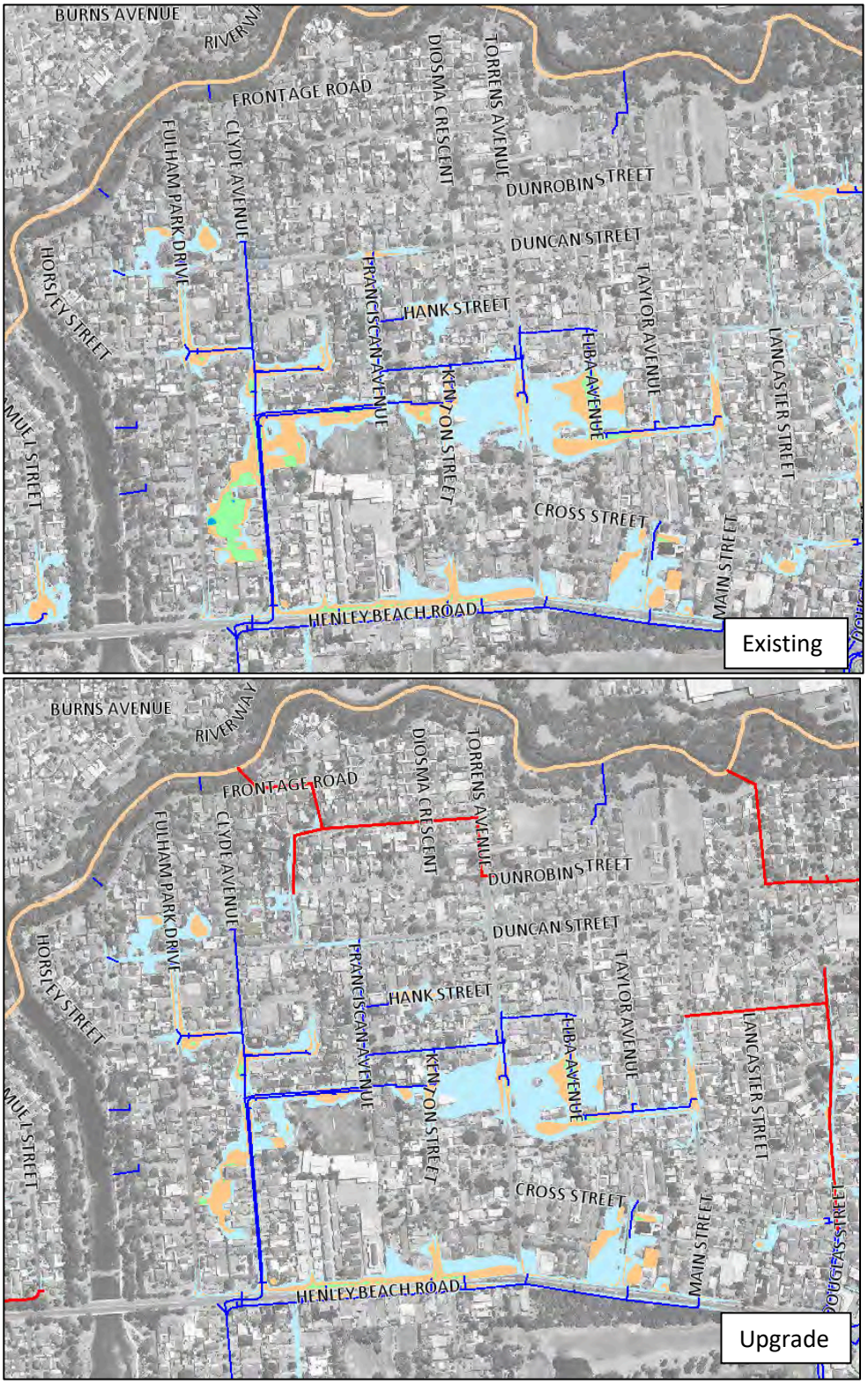


Figure 4.30 – 5% AEP floodplain comparison

D5 – Matt Street Drainage

A new system is proposed to connect into the northern end of the existing Rowells Road system and discharge northwards into the River Torrens (Figure 4.31). This would allow the existing northern Rowells Road system to be disconnected from the May Terrace system, thus improving the performance of the May Terrace system. Road ponding is reduced in the area and property inundation, especially at the Lockleys North Primary school, is significantly decreased for the 5% AEP event (Figure 4.32). The main trunk drain proposed ranges from a 1050 mm to 675 mm RCP, with a number of small laterals.

A gross pollutant trap and a flap gate/non-return valve on the pipe outlet would be required to prevent the 1% AEP River Torrens flood waters from surcharging into the catchment. The risk of a flap gate non-return value failure and mitigation measures should be assessed during the design development stage.

The total cost for these works is estimated to be $1,070,000.

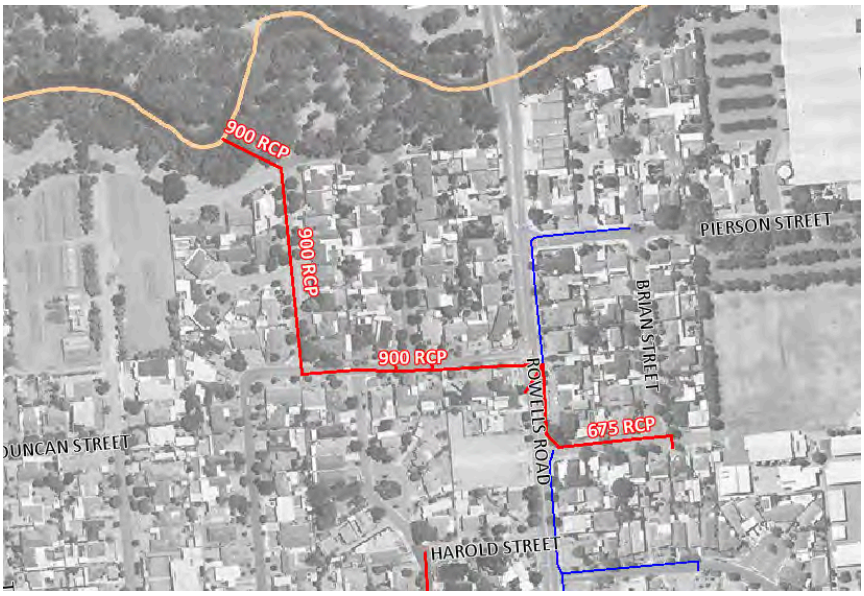


Figure 4.31 – Matt Street Drainage Layout

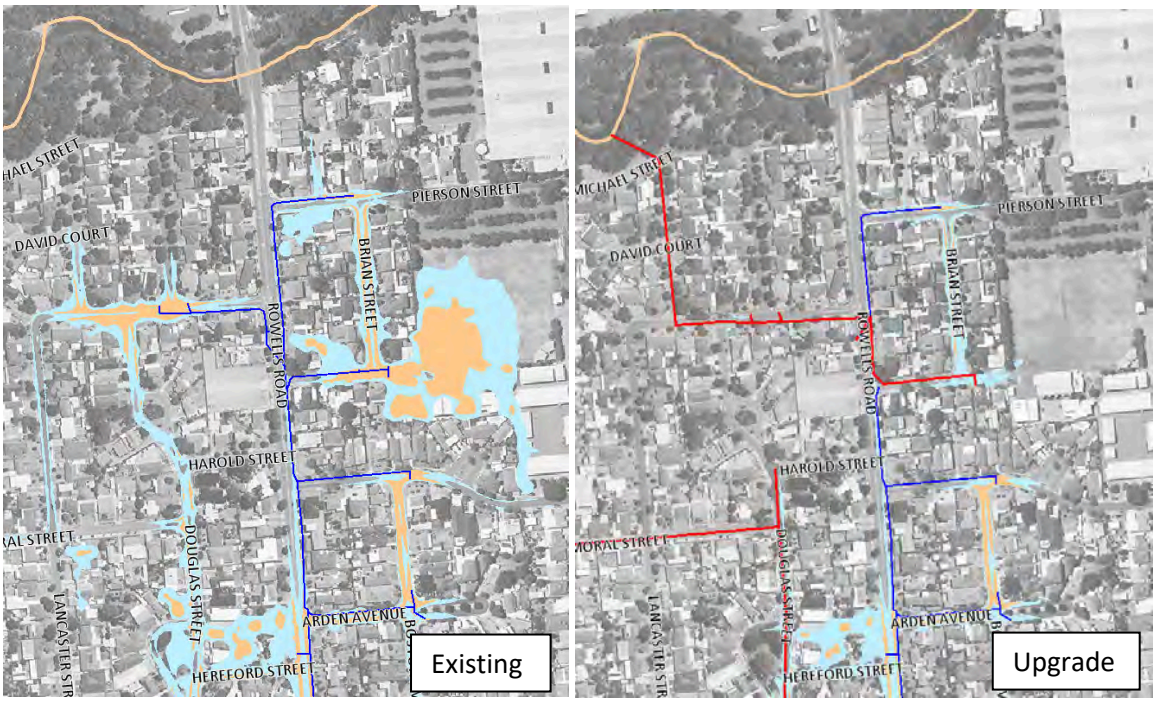


Figure 4.32 – 5% AEP floodplain comparison

D6 – Douglas Street Drainage

The proposed Douglas street drain extends form the recently upgraded May Terrace drainage system. The new 675mm to 450mm drain is to extend from Cross Street, down Douglas Street and then Balmoral Street. This upgrade provides significantly improved drainage performance in minor events and reduces roadway ponding. The proposed drain also provides some relief for the Rutland Avenue system as it picks up some subcatchments that currently drain to Rundle Avenue. A layout of the proposed drain is shown in Figure 4.33.

The total cost for the upgrades is estimated to be $730,000.

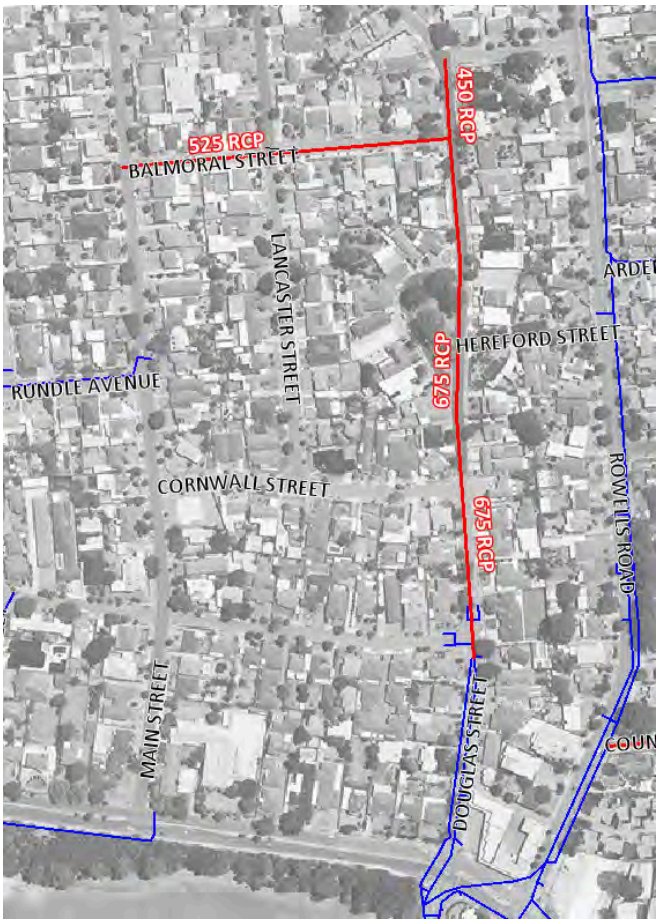


Figure 4.33 – Douglas Street Drainage Layout

D7 – Malurus Avenue Drainage

No existing underground drainage system services the pits along Malurus Avenue. The pits in the street surcharge and surface flows move down Counter Avenue to the pits connected to the Rowells Road system. It is proposed to connect the Malurus Avenue pits with a new underground 600mm to 450mm drain with new inlets (Figure 4.34). This proposal significantly reduces roadway ponding and property inundation up to the 5% AEP event (Figure 4.35).

The total cost for these works is estimated to be $460,000.



Figure 4.34 – Malurus Avenue Drainage Layout

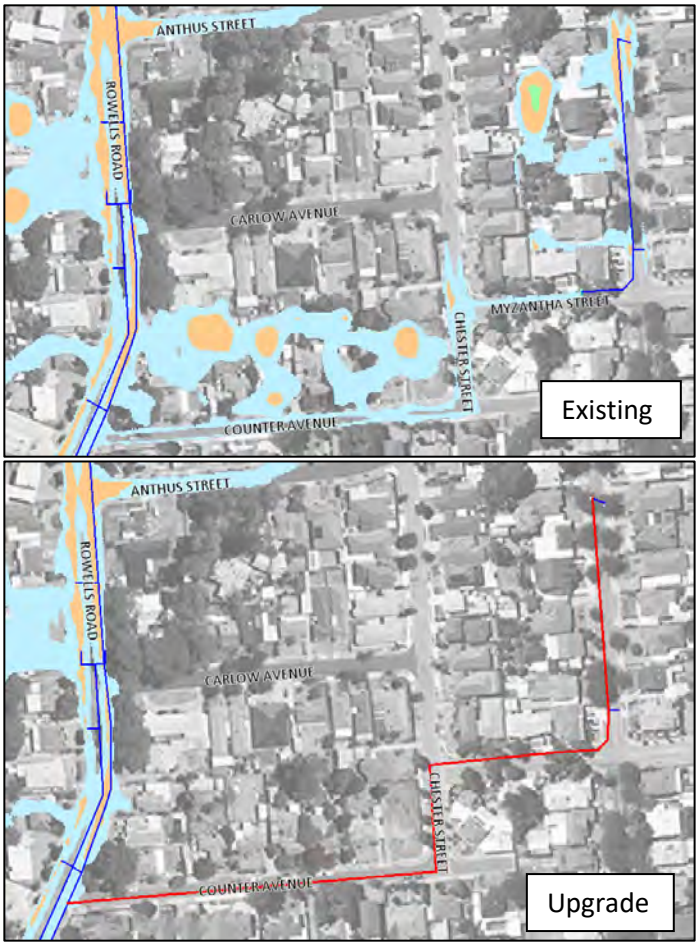


Figure 4.35 – 5% AEP floodplain comparison

D8 – Grant Avenue Drainage
A new drainage system is proposed to connect into the northern end of the existing White Avenue system and discharge northwards into the River Torrens via Grant Avenue (Figure 4.36). The main length of the drain ranges from 825mm to 525 RCP. This proposal reduces the catchment area draining into the existing southwards draining White Avenue system, which is to be disconnected, thus improving the existing system's performance. A reduction in minor property inundation towards the southern end of White Terrace for the 5% AEP event is seen.

A gross pollutant trap and a flap gate/non-return valve on the pipe outlet would be required to prevent the 1% AEP River Torrens flood waters from surcharging into the catchment. The risk of a flap gate non-return value failure and mitigation measures has not been assessed and should be assessed during the design development stage.

The total cost for these works is estimated to be $900,000.

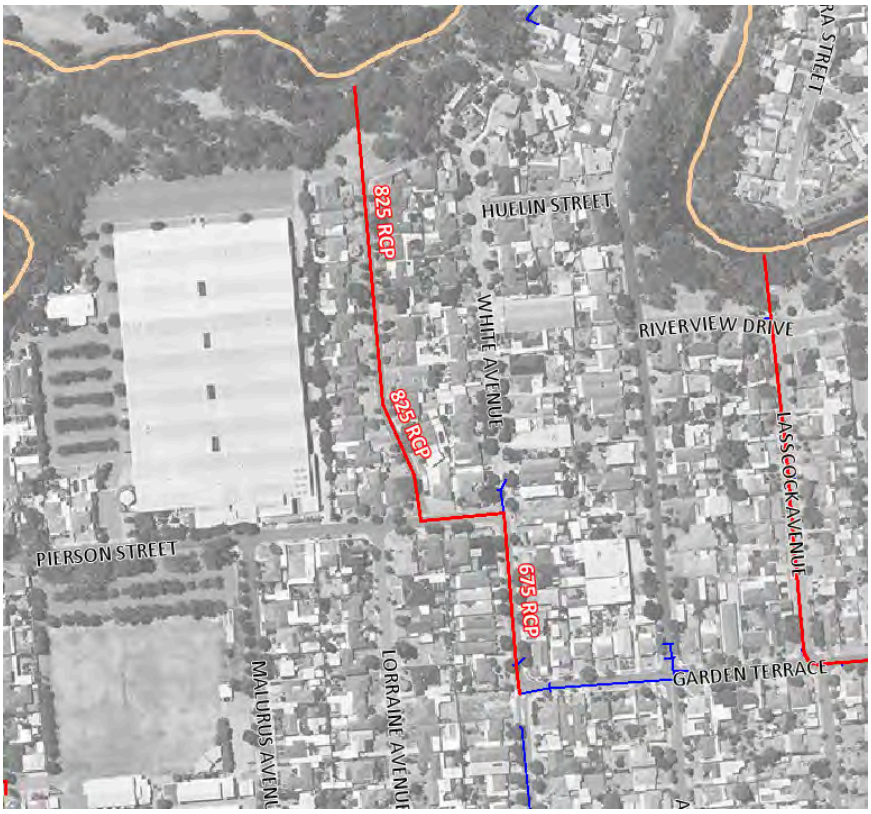


Figure 4.36 – Grant Avenue Drainage Layout

4.8.4 River Torrens

D9 – Lasscock Avenue Drainage
Property inundation occurs along the southern side of Garden Terrace in all existing AEP events, including the 0.5 EY event. A new parallel 750mm RCP is proposed to run down Lasscock Avenue and Garden Terrace, connecting with the existing system which is to remain (Figure 4.37). The upstream end of the existing system at Howard Street is to be disconnected. A new system draining southwards down Airport Road is proposed to pick up flows from Howard Street and is described in the Cowandilla Mile End proposed strategies.

The new duplicate 750mm drain discharges into the River Torrens and provides the properties along garden terrace with a 5% AEP standard (Figure 4.38). A gross pollutant trap and a flap gate/non-return valve on the pipe outlet would be required to prevent the 1% AEP River Torrens flood waters from surcharging into the catchment. It is noted that the existing system discharges into the River Torrens here. Any outlets into the River Torrens should be designed or retrofitted to reduce erosion of the bed and banks of the watercourse. This also applies for other proposed upgrades discharging into the River in the following sections.

The total cost for these works is estimated to be $1,130,000.



Figure 4.37 – Lasscock Avenue Drainage Layout

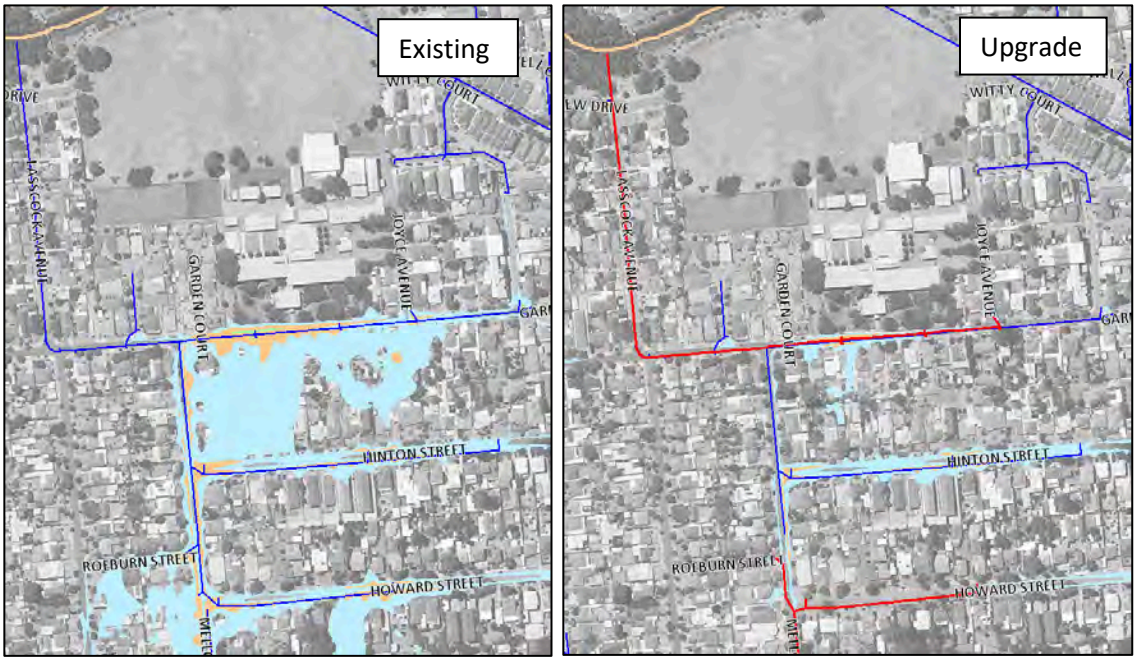


Figure 4.38 – 5% AEP floodplain comparison

D10 – Sheriff Street South Drainage + Raingarden – Detailed Design Completed
Detailed design for the Sheriff Street drain has been issued for construction. The general design includes a new 900mm RCP connecting the existing system from Ashley Street to Golden Glow Avenue. The design included new pit inlets and raingardens.

D11 – Sheriff Street North Drainage
A new system draining north into the River Torrens along Sherriff Street has been proposed to further alleviate the road ponding and property inundation experienced along this system, especially at the intersection with Ashley Street. The new system ranges from a 750mm drain at the downstream end to 375 at the upstream ends (Figure 4.39). The existing subcatchments feeding into the northern end of the existing Sherriff Street system are large and this proposed drain will break up the existing subcatchments and reduce road flows and ponding.

The existing system currently drains into the River Torrens via the existing drain running under Underdale High School Oval. The proposed system discharges at the northern end of Sheriff Street and requires a gross pollutant trap and a flap gate/non-return valve. The risk of a flap gate non-return value failure here has not been assessed and should be investigated during the design development stage.

The total cost for these works is estimated to be $910,000.

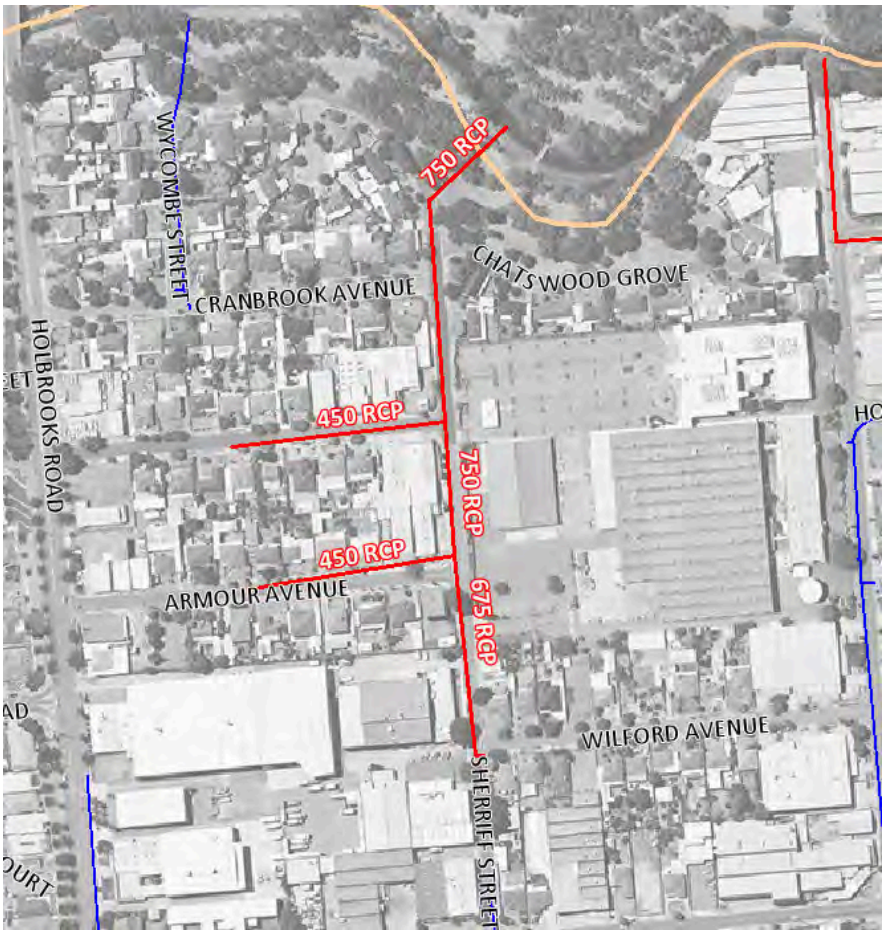


Figure 4.39 – Sheriff Street North Drainage Layout

D12 – Ashwin Parade Drainage

Significant inundation occurs in industrial / commercial properties at the western end of Ashwin Parade. Currently these large catchments are drained into an existing system which runs south down Hardys Road. Significant overflows also run south from Ashwin Parade, down Stephens Ave, resulting in residential property inundation at Ashley Street. It is proposed to cut off these large catchments with a new drain which discharges into the River Torrens at the northern end of Hardys Road, as shown in Figure 4.40. The new trunk drain ranges from 1800mm to 600mm RCP with several laterals and increases to pit inlet capacity. The new drain provides a 5% AEP flood standard to the industrial properties and provides relief to the existing system running south down Hardys Road (Figure 4.41 – also shows Stephens Avenue Drainage upgrade). A gross pollutant trap and a flap gate/non-return valve are required at the new drain outlet.

The total cost for these works is estimated to be $2,010,000.



Figure 4.40 – Ashwin Parade Drainage Layout

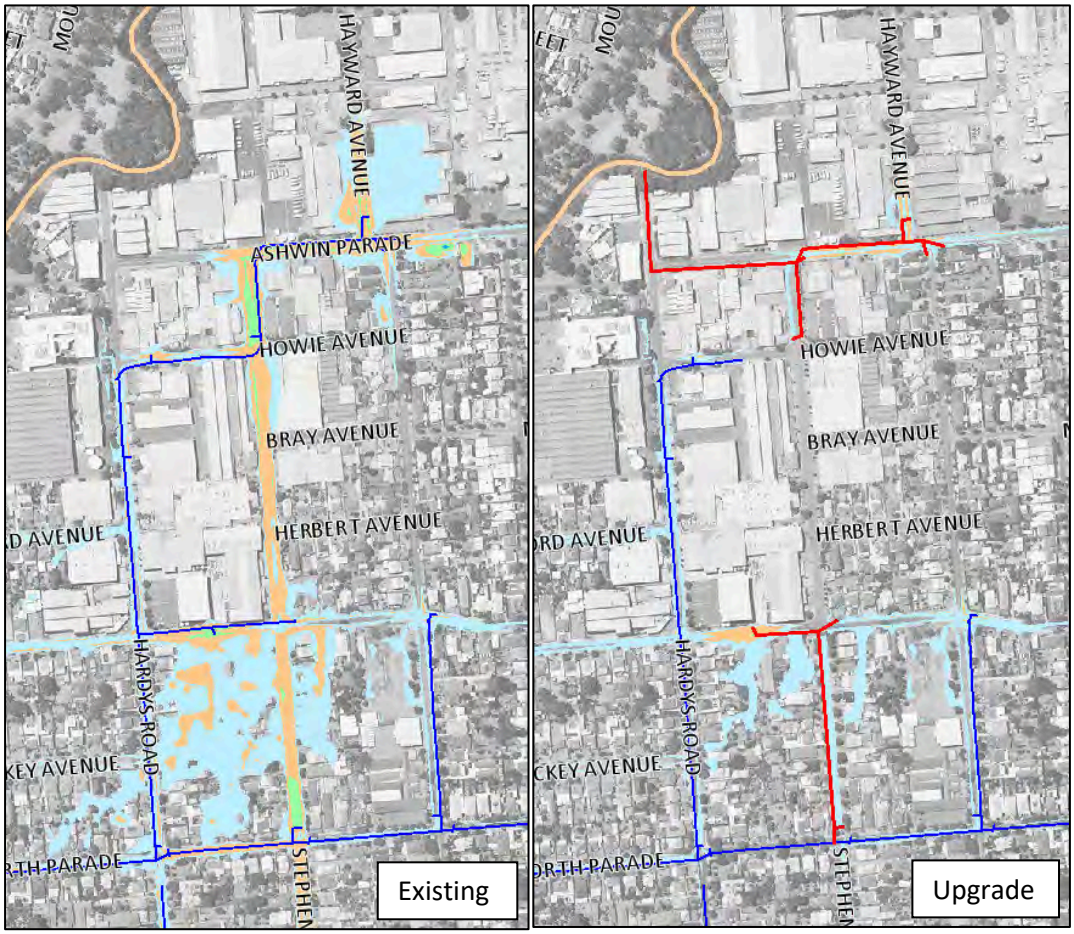


Figure 4.41 – 5% AEP floodplain comparison

D13 – Stephens Avenue Drainage

The existing lateral system on Ashley Street that connects into the drain on Hardys Road is undersized and significant property inundation occurs in this area for all AEP events. A new system is proposed to pick up these subcatchments and run down Stephens Avenue to N Parade and connect into the existing 2100mm RCP which has greater capacity. This proposal provides further relief for the Hardys Road system and achieves a 5% AEP flood protection standard for the properties at the Ashley St and Stephens Avenue intersection. The new drain down Stephen Avenue is proposed to be a 900mm RCP with lateral systems at Ashley street connecting to new pit inlets (Figure 4.42).

The construction cost for these works is estimated at $630,000.



Figure 4.42 – Stephens Avenue Drainage Layout

D14 – Ann Nelson Drive to Light Terrace Drainage and Detention Basin

A new drain ranging in size from 1200mm to 525mm is proposed to run down Neville Road, Lowe Street and Ann Nelson Drive before discharging into the River Torrens. This system breaks up the large subcatchments that drain west towards the existing system in South Road. The new system extends east from Neville Road down Dove Street. An online detention basin is proposed in the Dove Street Reserve with a capacity of 2,500 m^3 (see Figure 4.44). The basin works are to be integrated into the reserve such that the impact (both visually and for usability) is minimised. Basin side slopes are to be gentle (maximum 1V:8H) with a maximum depth of 1.5 metres below natural surface. A bioretention component is to be included with the basin, along with a GPT before the basin inlet. Roadway ponding and property inundation along the lateral roads connecting to South Road is alleviated and a 5% AEP flood standard is provided (Figure 4.45). A gross pollutant trap and a flap gate/non-return valve are required at the new drain outlet to the River Torrens. The risk of a flap gate non-return value failure has not been assessed and should be investigated during the design development stage.

From the detention basin, the new system is to extend east along Dove Street to Dew Street and then Light Terrace. Roadway ponding along Light Terrace is an existing issue and this new drain will decrease this ponding significantly. The existing system at the western end of Light Terrace which drains south down Dew Street is to be disconnected. Refer to Figure 4.43 for the proposed layout of the new drainage system from light Terrace to Ann Melrose Drive.

A balance pipe in South Road is also proposed. The existing western drain has more capacity, and the balance pipe provides some reduction to roadway ponding at Ballantyne Street and Walter Street.

The total cost for these works is estimated to be $3,140,000.

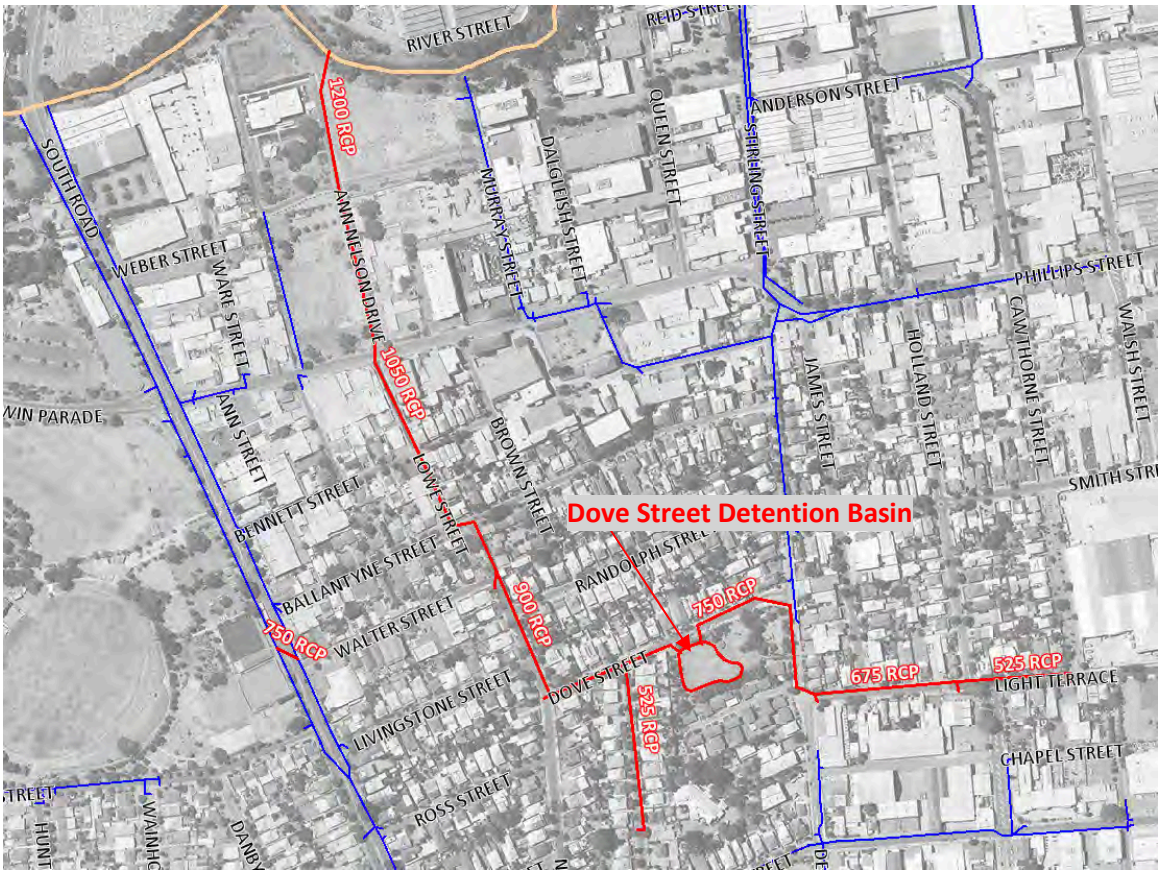


Figure 4.43 – Ann Nelson Drive to Light Terrace Drainage and Detention Basin Layout



Figure 4.44 – Dove Street Reserve, Detention Basin Location

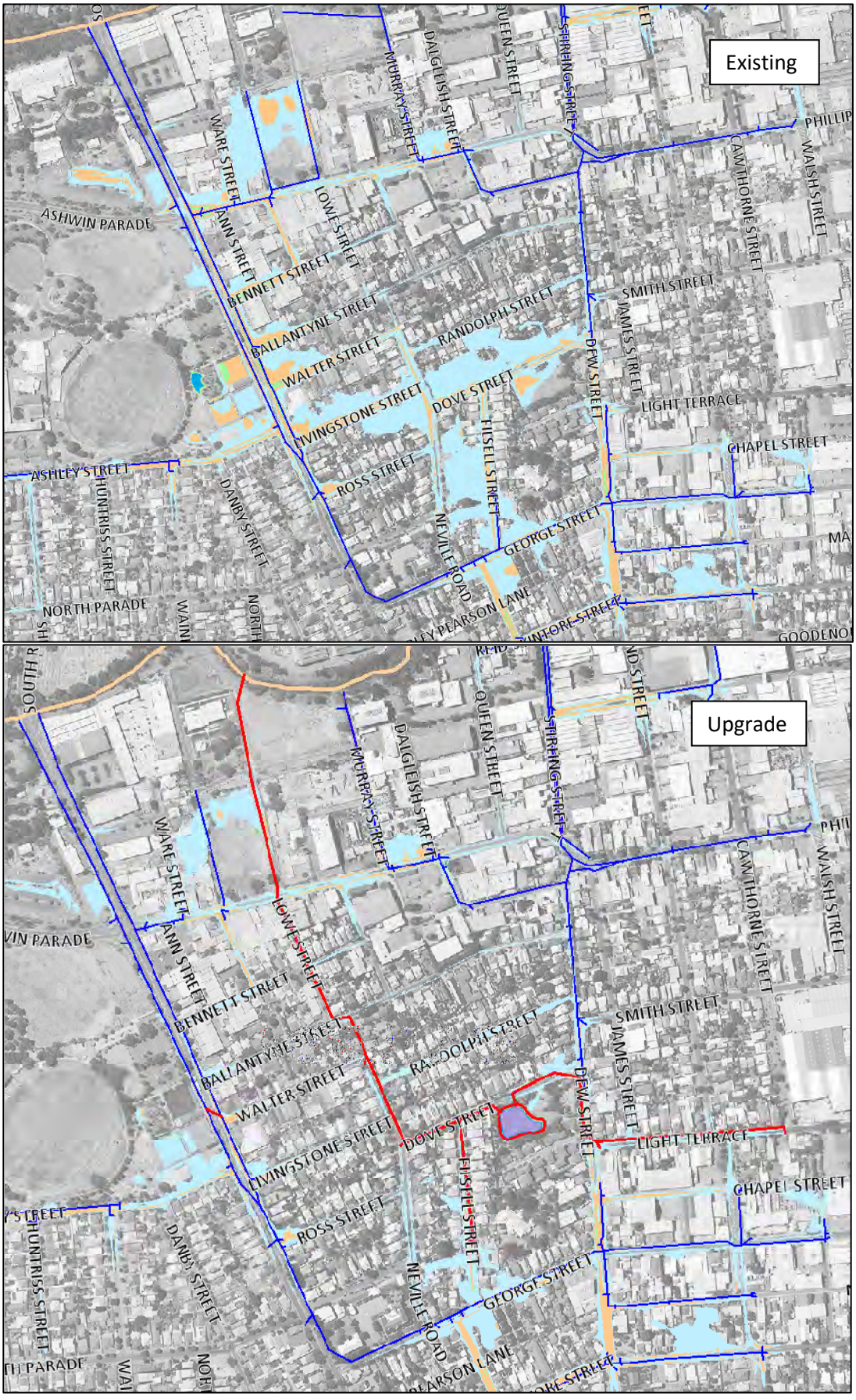


Figure 4.45 – 5% AEP floodplain comparison

4.8.5 Cowandilla Mile End

D15 – Cowandilla, Mile End to Keswick Creek Trunk Drain
Significant residential property inundation occurs throughout Cowandilla and Mile End in larger AEP events. As previously mentioned, the existing system which drains west to the northern airport channel has been designed to provide a 10% AEP standard. It is proposed that a large gravity trunk drain is constructed to service the two large trapped low points in the region and discharge into the Keswick Creek.

The new trunk consists of drains which range in size from two parallel 3000mm x 900mm box culverts (downstream), to two 2700mm x 900mm box culverts, two 2100mm x 750mm box culverts and finally a single 2100mm x 750mm box culvert (upstream). The new drain discharges into Keswick creek at Carnarvon Avenue. It is proposed to run east along Jenkins Street before 'zig-zagging' to the north east to Cowra Street, connecting to existing systems within the large trapped low point in Mile End. See Figure 4.46 below for the concept layout of the new trunk drain. The new system is to connect into the existing system at multiple locations and allows the existing system to be disconnected from upstream drains, providing relief.

A second drain connects into the new system at the intersection of Marion Road and Press Road. This system consists of two parallel 2700mm x 600mm box culverts which connect to the large trapped low point at Neill Road, Cowandilla.

The 1% AEP peak outflow to Keswick Creek for the proposed upgrade is 8.2 m^3/s.

It is recognised that the drains proposed are exceptionally large and, in some cases, could take up the whole road width, resulting in costly, unavoidable service re-locations. Further investigation and optimisation are required to assess whether these large drains could be split into multiple smaller drains with multiple outlets to Keswick Creek.

The total cost for these works is estimated to be $23,040,000.

The proposed trunk drains to Keswick Creek provide close to a 5% AEP flood standard in the area (Figure 4.47). This upgrade is reaching the practical limit of what is possible to construct in this area. Providing upgrades to reach a 1% AEP standard would incur extremely large costs and would likely not be possible to construct given the space limitations.

A significant increase in flows will enter Keswick Creek as a result of this upgrade. Hence, Keswick creek may require an increase in capacity. This is discussed further in Section 4.8.9., where it is proposed the overall impact on design peak flows in the creek channels should be the subject of a specific assessment to determine the feasibility of the major trunk drain upgrades (such as the above proposal) that discharge into the creek channels.



Figure 4.46 – Cowandilla, Mile End to Keswick Creek Trunk Drain Layout

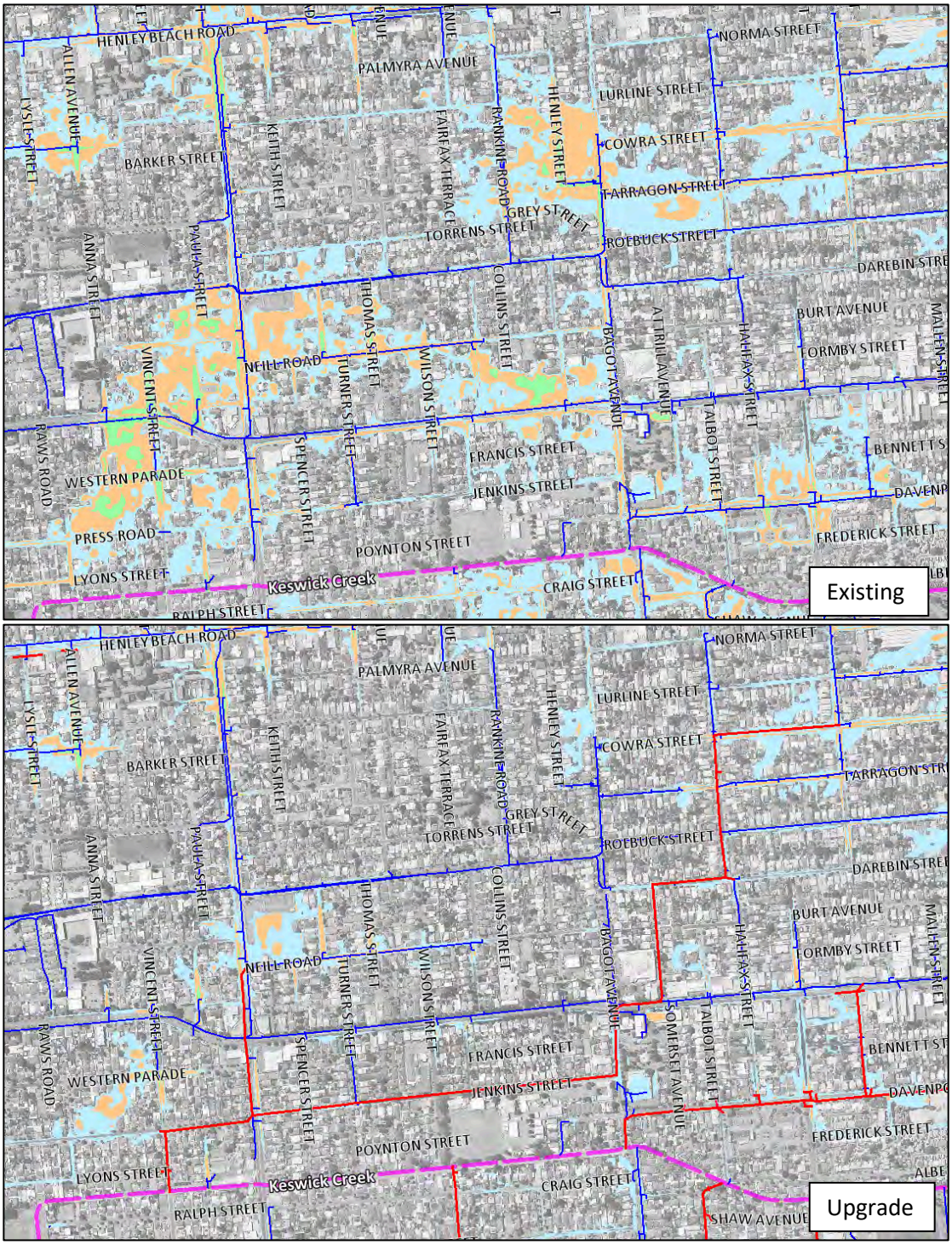


Figure 4.47 – 5% AEP floodplain comparison

D16 – Airport Road, Mellor Avenue Drainage

A new drain along Airport Road from Marshall Terrace to Henley Beach road is proposed (ranging in size from 2100mm x 1500mm box culvert to a 1500mm RCP). The new drain is to provide greater flow capacity by creating another route for flows in the existing Henley Beach Road box culvert trunk drain to reach the large existing trunk drain in Airport Road (Figure 4.48). This upgrade provides a significant reduction to property inundation and roadway ponding depths in streets connecting to Airport Road (Figure 4.49).

A further new 900mm drain is to extend along Mellor Avenue from the new drain connection in Henley Beach Road. This system is proposed to service the subcatchments along Arnold Street where existing property inundation occurs in the 5% AEP event and significant road ponding in smaller events.

The total cost for these works is estimated to be $3,150,000.

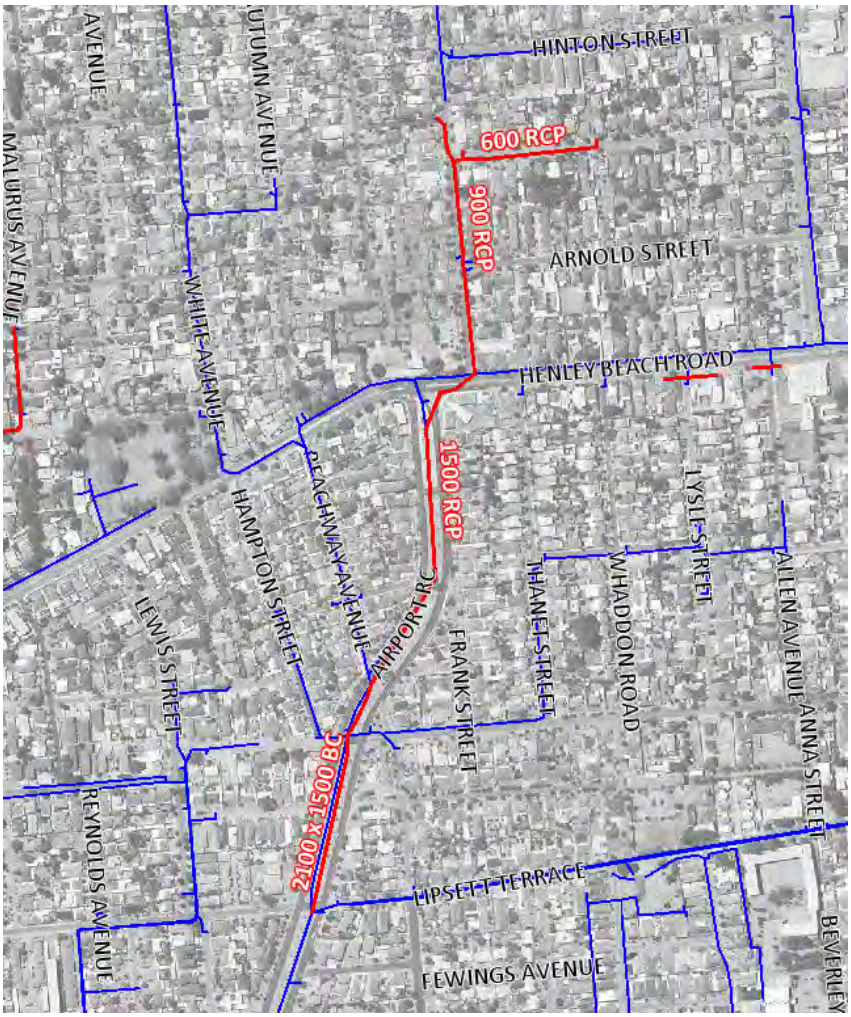


Figure 4.48 – Airport Road, Mellor Avenue Drainage Layout

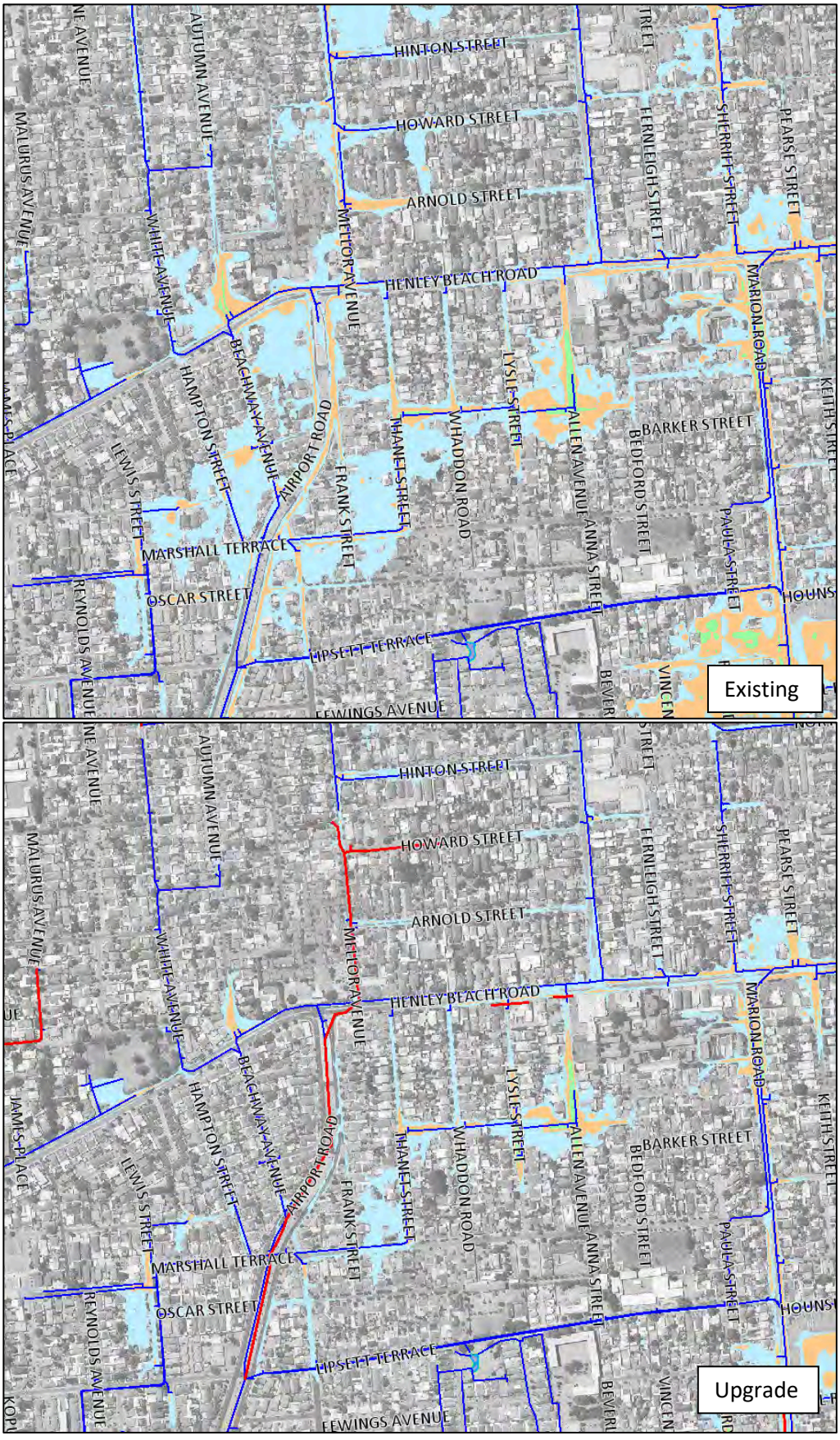


Figure 4.49 – 5% AEP floodplain comparison

D17 – Allen Avenue, Lysle Street Road Bunds
Road bunds and spoon drains are proposed to be constructed at the northern ends of Allen Avenue and Lysle Street. Currently overflows from Henley Beach Road run south down these roads to the trapped low points at Pine Street. This section of existing system in Pine Street does not have the capacity for these additional overflows. Refer to Figure 4.50 for the proposed locations of the construction works.

The total cost for these works is estimated to be $32,000.



Figure 4.50 – Allen Avenue, Lysle Street Road Bunds Locations

4.8.6 Keswick Creek Lateral Drains

D18 – Davenport Terrace Drainage
The existing drain along Davenport Terrace that discharges into Keswick Creek at Brooker Terrace is to be replaced with an upgraded drain which is to run until South Road. This new drain ranges in size from 2100mm x 1200mm box culvert to 750mm RCP (Figure 4.51). A new 900mm lateral drain is to run along Verran Avenue and connect into the existing system at Sir Donald Bradman Drive. This proposed upgrade provides a 5% AEP flood protection along Davenport Terrace, whereas in the existing scenario, many properties along the street are shown to be inundated (Figure 4.52). The lateral connection along Verran Avenue provides some relief to the existing undersized drain along Sir Donald Bradman Drive.

The total cost for these works is estimated to be $3,040,000.



Figure 4.51 – Davenport Terrace Drainage Layout

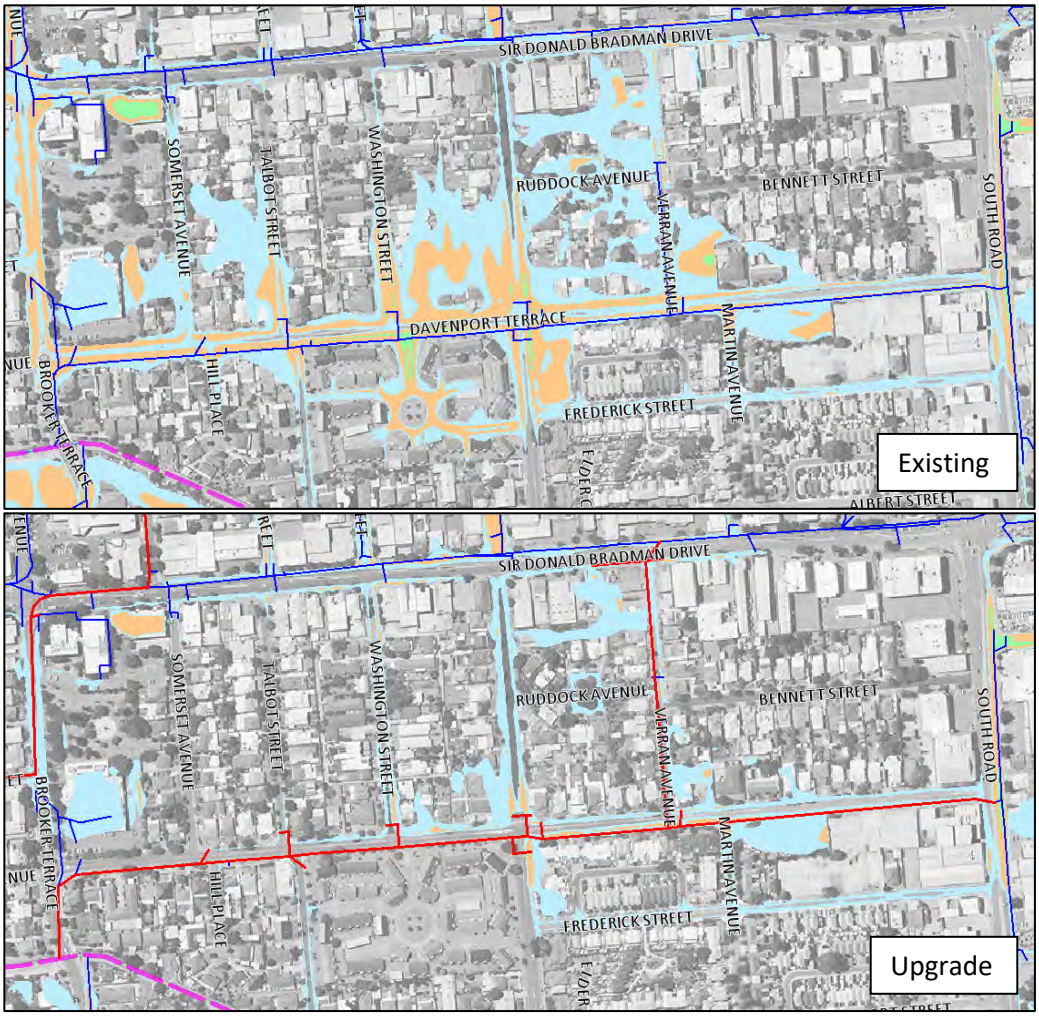


Figure 4.52 – 5% AEP floodplain comparison

D19 – South Road, Mile End Drainage and Storage

The existing stormwater system along South Road, south of Keswick Creek, does not have a 0.5 EY standard. Significant road ponding and overflows to the west occur in all AEP events. With property inundation shown to occur to areas along the western side of South Road in larger AEP events. A floodplain comparison is shown in Figure 4.55 which includes the proposed Milner Road and Arthur Street upgrades (described later).

A new drain is proposed to run down the middle of South Road between the two existing drains. The drain size ranges from 2100mm x 900mm box culvert to 900mm RCP (Figure 4.53). The new drain is to be connected to the existing systems at a number of locations, increasing the capacity of the total system.

Prior to discharging into Keswick Creek, the new system is to connect into a new detention basin located in the empty patch of land on the north eastern corner of the South Road and James Congdon Drive intersection (Figure 4.54). The basin provides storage and a reduced peak outflow into Keswick Creek. The 800m^3 volume basin can either be constructed as underground tanks or an exposed basin. This option will depend on a number of factors such as existing services and maximum allowable basin depth.

This section of South Road has been flagged to be upgraded as part of the DIT Torrens Road to River Torrens Project (T2T). Drainage upgrade items such as this may be able to benefit from funding as a part of the future upgrade of South Road. Noting that construction of an additional or upgraded drain in South Road may not be practically feasible, an alternative whereby the South Road drain is diverted into Deacon Avenue and combined with the proposed Milner Road system may be possible. Note this has not been modelled or cost estimated. This proposed upgrade should be provided to the T2T Project for consideration.

The total cost for these works is estimated to be $1,560,000.

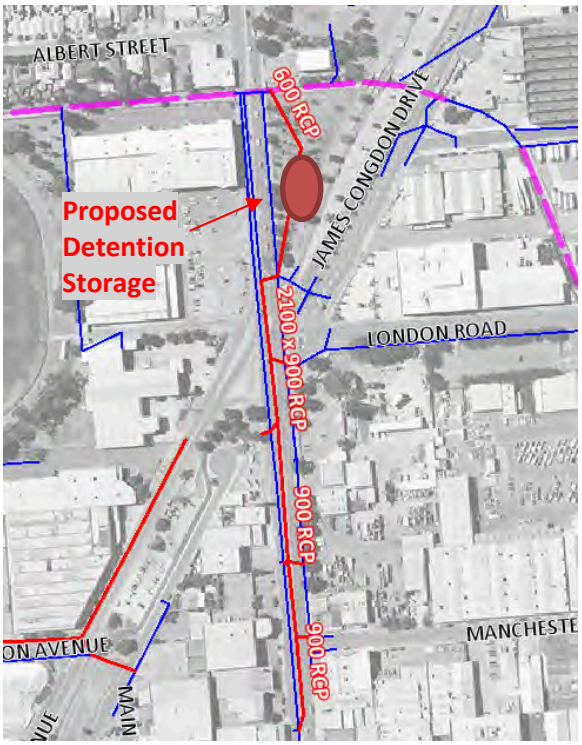


Figure 4.53 – South Road, Mile End Drainage and Storage Layout



Figure 4.54 – Detention Basin / Underground Tanks Location

D20 – Milner Road Drainage and Storage

The existing system that runs down Kingston Avenue and Brooker Terrace before discharging into Keswick Creek is severely undersized, with property inundation occurring in the 0.5 EY event. Severe inundation occurs in the larger storm events on both the eastern and western sides of Brooker Terrace. It is proposed to relieve this existing system by constructing two new outlet drains down Milner Road and Arthur Street, and disconnecting the existing system at the intersection of Apollo Court. The two new Milner Road and Arthur Street systems can be constructed as separate works. The new systems provide a 5% AEP flood protection to the area as shown in Figure 4.55 (along with the South Road upgrade).

The Milner Road trunk drain ranges in size from 2100 x 1200mm box culvert at the downstream end to a 900mm RCP at Deacon Avenue (Figure 4.56). A number of new lateral systems are to be included and connect into existing drainage where possible.

A detention storage basin, or underground tank, is proposed for the linear reserve adjacent to Deacon Avenue. This storage is proposed to have a volume of 390m^3 and service the drainage of subcatchments along Fleet Street. The proposed location of the storage is shown in Figure 4.57.

The total cost for these upgrades is estimated to be $2,060,000.

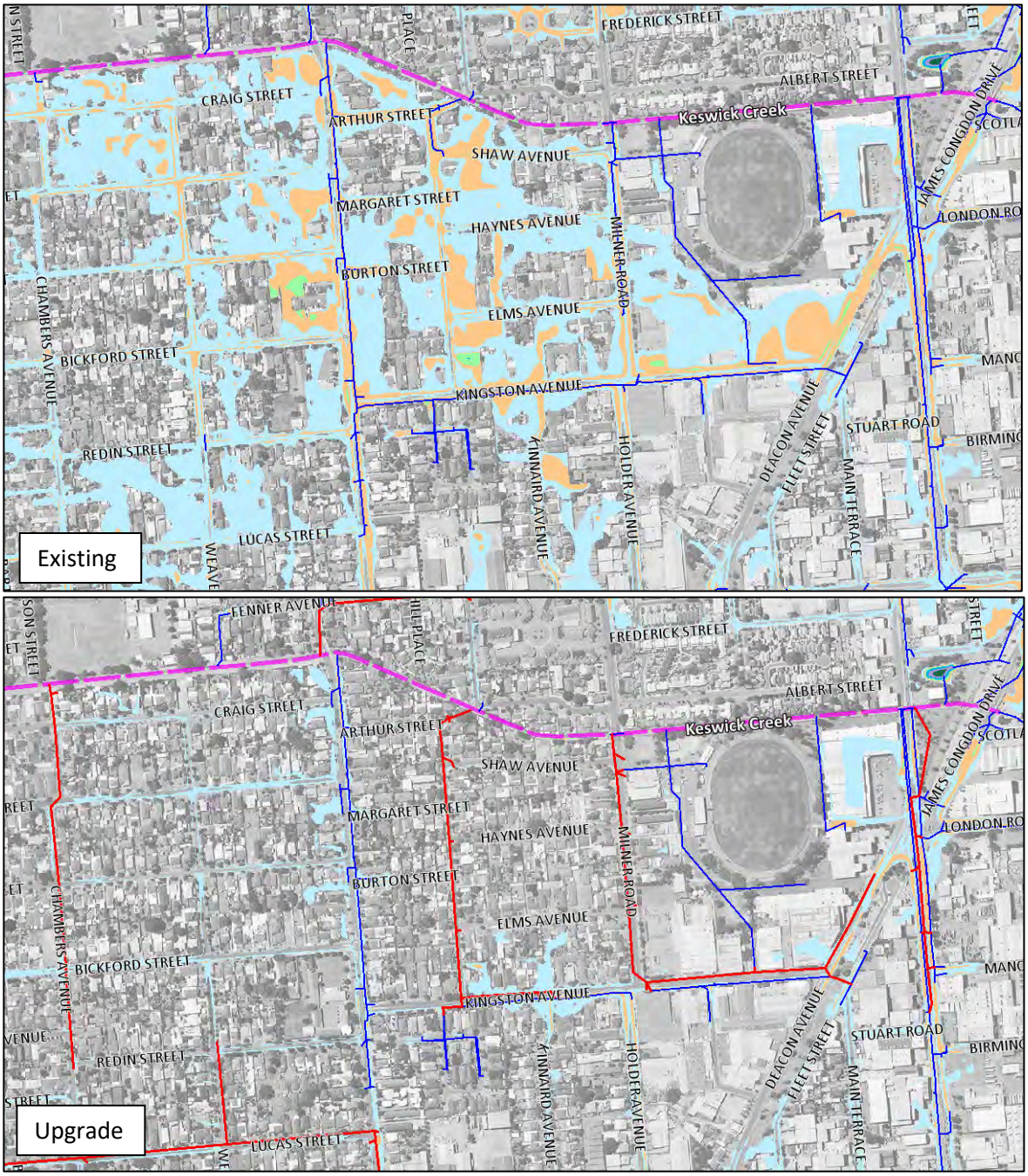


Figure 4.55 – 5% AEP floodplain comparison

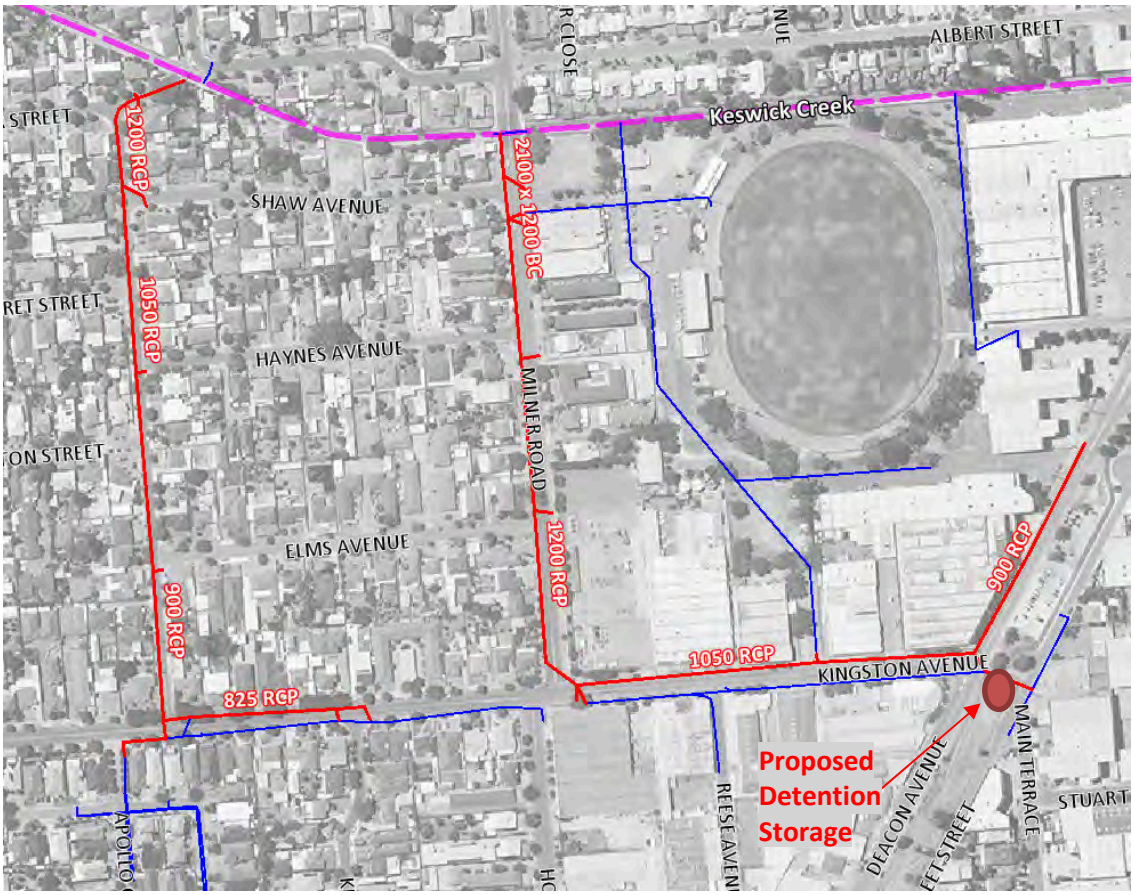


Figure 4.56 – Milner Road and Arthur Street Drainage Layout



Figure 4.57 – Detention Basin / Underground Tanks Location

D21 – Arthur Street Drainage
The proposed new trunk drain that runs down Arthur Street ranges in size from 1500mm RCP to 675mm at Kingston Avenue (refer Figure 4.56 in section above). As stated above this new system significantly reduces property inundation, providing a 5% AEP standard to the area. Small lateral systems are proposed to connect into existing drainage at the upstream end of the system. Additional later drains and pits along Shaw Avenue, Haynes Ave and Elms Avenue are also proposed to increase the system inlet capacity. This new system also breaks up the existing large subcatchments which currently drain west to Brooker Terrace, improving the performance of the existing Brooker Terrace system.

The total cost for these upgrades is estimated to be $1,410,000.

D22 – Chambers Avenue Drainage
The residential area to the east of Marion Road, in Richmond, currently has no underground drainage, with existing subcatchments draining west and reaching the stormwater system in Marion Road. A new trunk drain is proposed along Chambers Avenue with the outlet at the northern end to Keswick Creek (Figure 4.58). This new system will break up the existing large residential subcatchments and provide relief for the Marion Road system.

The grade in this area is from south-east to north-west which is why this system is proposed to drain northwards to Keswick Creek. Smaller lateral systems are proposed at each of the crossroads to the new drain along Chamber Avenue.

This new system will reduce nuisance flows in the area and provides a 5% AEP flood standard.

The total cost for the new stormwater system is estimated to be $930,000.



Figure 4.58 – Chambers Avenue Drainage Layout

D23 – Knight Street Drainage

The existing system down Passmore Street is severely undersized, with property inundation occurring in events as small as the 0.5 EY, according to the existing floodplain mapping. It is proposed for the existing system to remain and construct a parallel system down Knight Street. The system is to extend to Marion Road to pick up the existing drainage here and disconnect this from the system running down Passmore Street. The new drain is proposed to range in size from 1200mm at the outlet, to 900mm at Marion Road, with a number of smaller lateral systems (Figure 4.59). This upgrade provides the area with a 5% AEP flood protection as shown in Figure 4.60.

The total cost for the new stormwater system is estimated to be $1,350,0000.



Figure 4.59 – Knight Street Drainage Layout

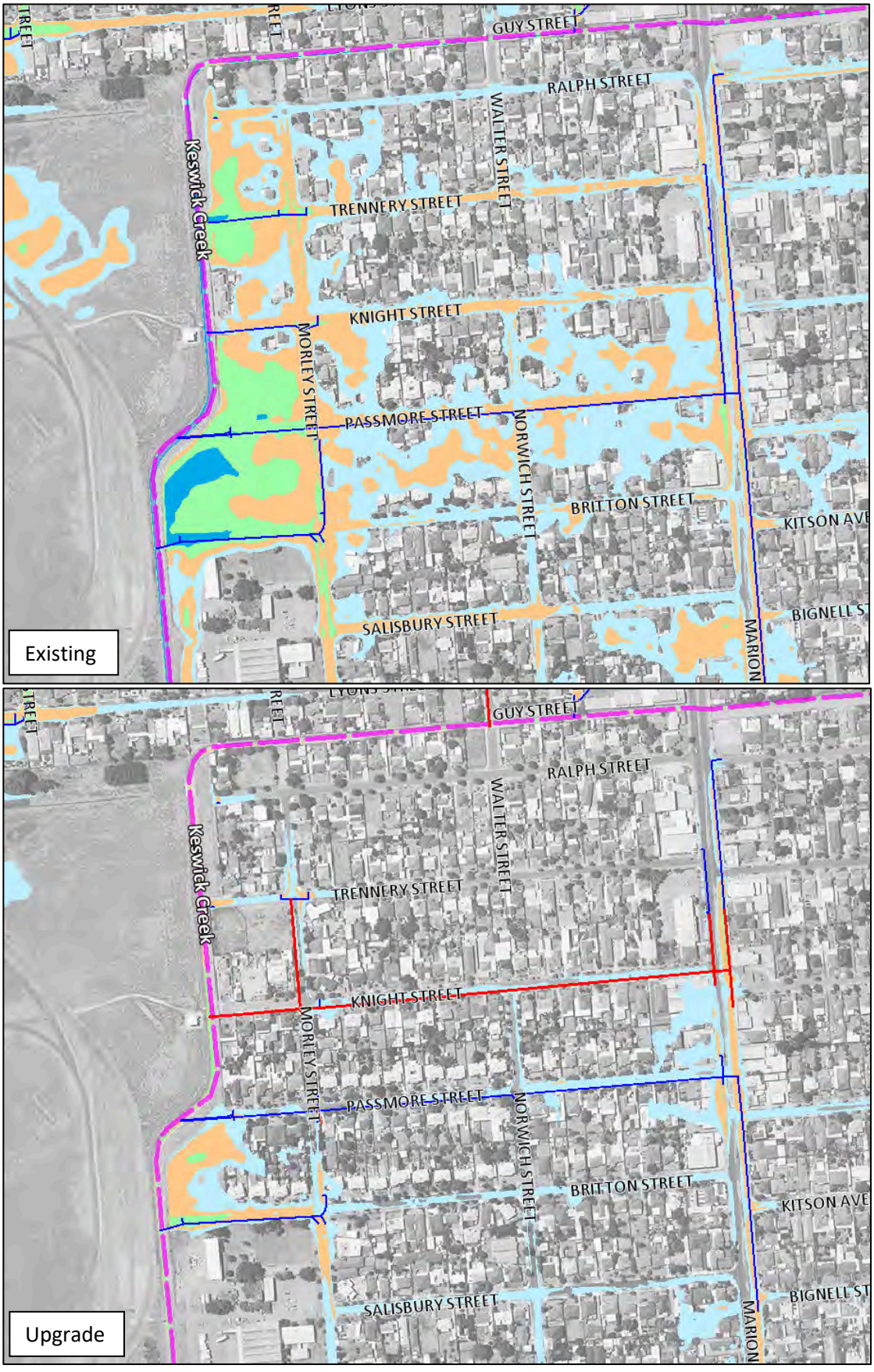


Figure 4.60 – 5% AEP floodplain comparison

D24 – Marleston to West Richmond Trunk Drain + Laterals

A large new trunk drain with several lateral systems is proposed to run from Marleston to West Richmond, before discharging into the Keswick Creek. Extensive road ponding and property flooding is shown to occur throughout a number of pockets of industrial, commercial and residential properties along Richmond Road and its surrounds. Observed overflows from the undersized existing South Road system create further road ponding and property inundation to areas of Marleston. Property inundation is severe in the larger AEP events at the downstream end of Richmond Road and further east at Marleston in the residential area. The new system has been designed to pick up each of these flooding hotspots to provide a 5% AEP flood standard (Figure 4.62).

The main trunk drain is proposed to run along Leicester Street and Lucas Street, parallel with the existing Richmond Road system, which is to remain. From Lucas Street, the new trunk drain runs south along Brooker Terrace and the Grove Avenue, connecting with the existing system in Richmond Road. The drain continues down Grove to Barwell Avenue. The drain runs along Barwell Avenue, connecting with the existing system in South Road. The main trunk drain ranges in size from a 3600mm x 1200mm box culvert along Lucas street to a 1200mm RCP connecting to the existing system at South Road (see Figure 4.61 for layout). Several lateral systems are proposed which connect into adjacent existing systems where flooding has been identified. These lateral systems include:

- 900mm RCP along Morley Street connecting the existing Richmond Road system to the new Leicester Street system.
- A new system ranging from 2100mm x 1200mm box culvert to 900mm RCP along Marion Road from Lucas Street connecting to the existing system at Desmond Street.
- 750mm RCP along Bartholomew Street connecting the existing Richmond Road system to the new Lucas Street system.
- A new 450mm RCP system along Weaver Avenue to Redin Street, breaking up the large existing subcatchment.
- A new 1050mm RCP system along Commercial Street then branching down both Coneybeer Street and Richire Terrace picking up existing flooding hotspots. A detention storage of 200m^3 is proposed for the linear reserve adjacent to Richie Terrace (Figure 4.63).

The 1% AEP peak outflow to Keswick Creek for the proposed upgrade is 13.7 m^3/s. This is a significant flow entering Keswick Creek, again justifying the proposed investigation into the Keswick Creek upgrade feasibility discussed in Section 4.8.9.

The total cost for the new trunk main and multiple lateral systems is estimated to be $18,370,000.

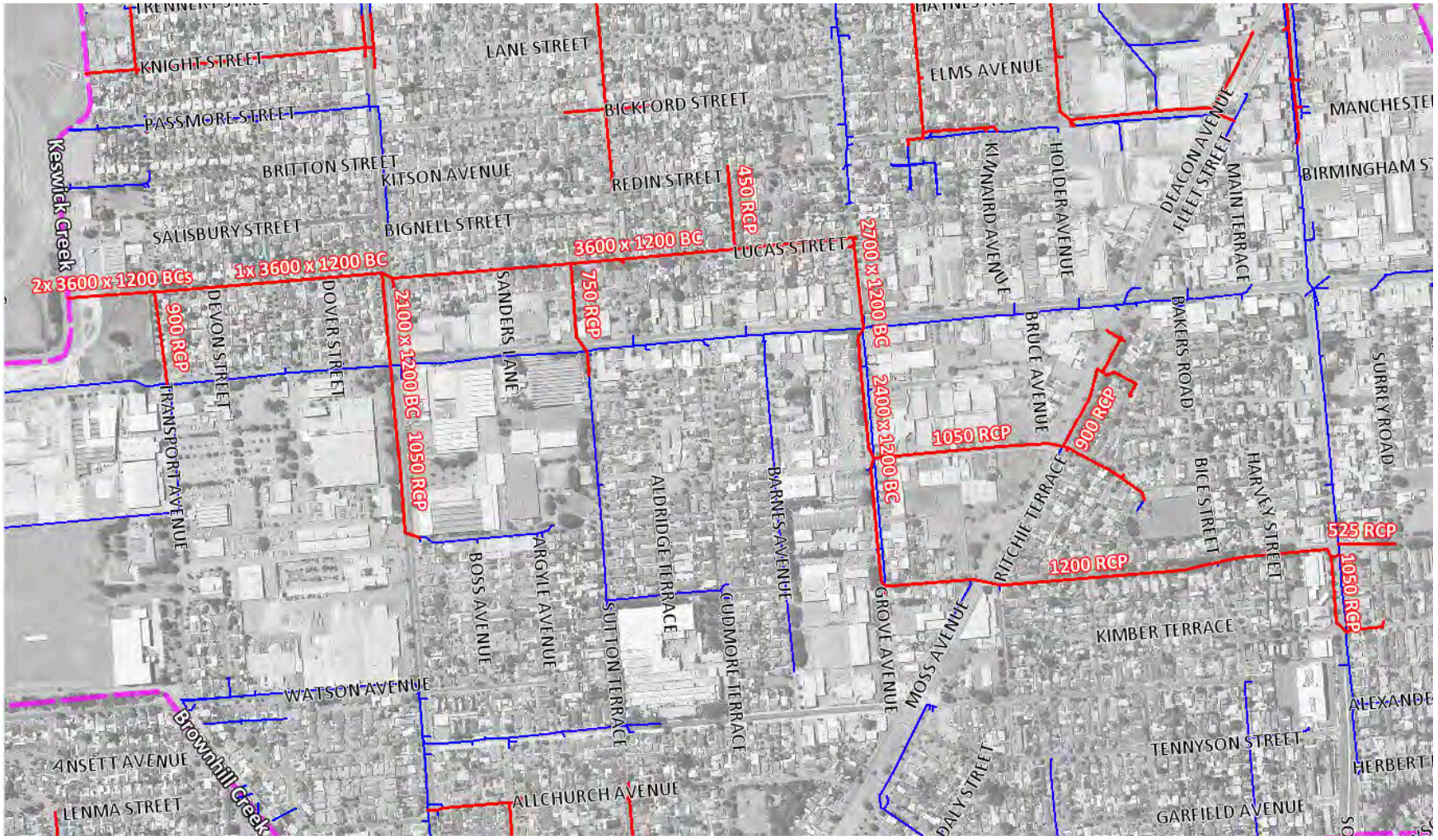


Figure 4.61 – Marleston to West Richmond Trunk Drain + Laterals Layout

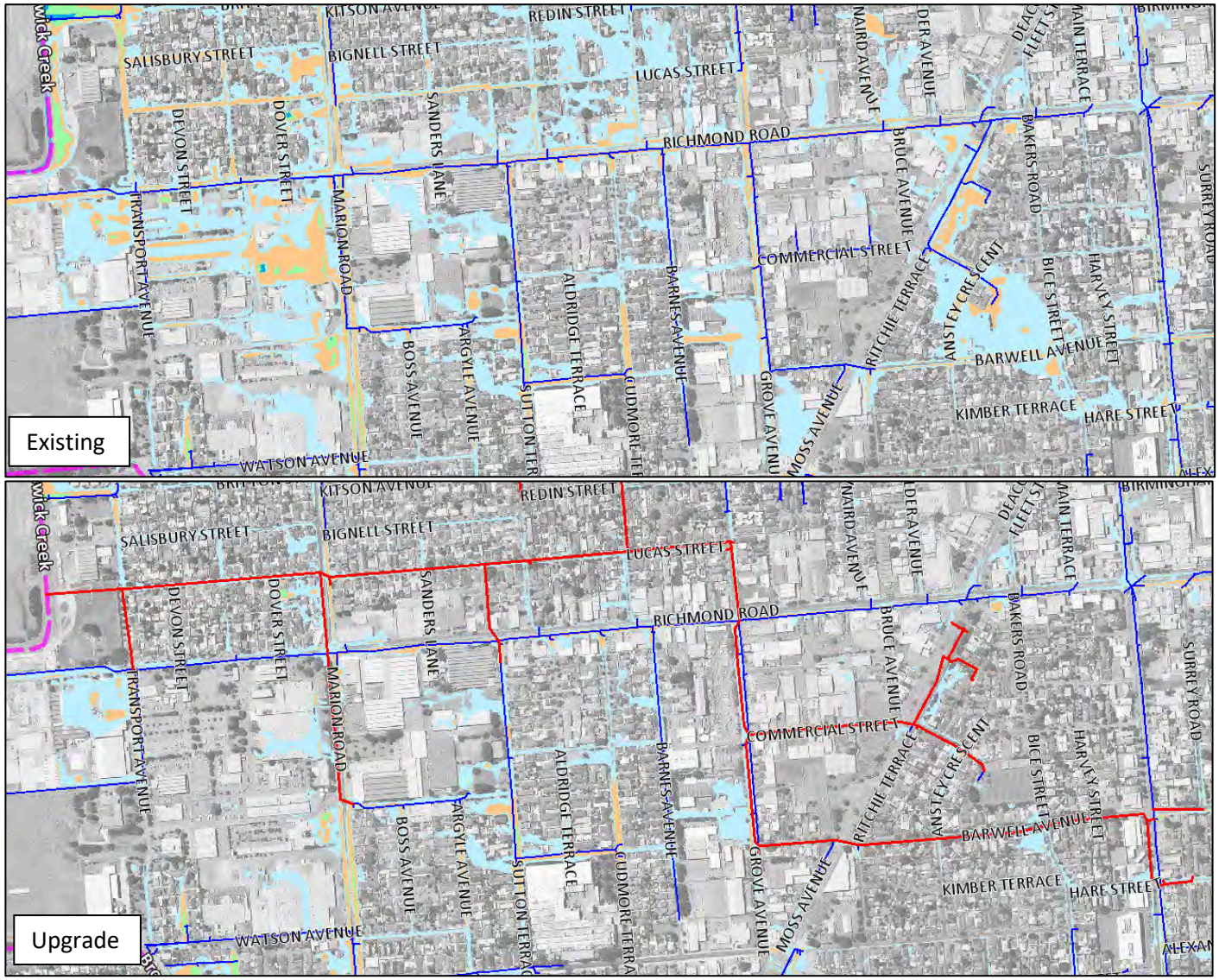


Figure 4.62 – 5% AEP floodplain comparison



Figure 4.63 – Detention Basin / Underground Tanks Location

4.8.7 Brown Hill Creek Lateral Drains

D25 – Warwick Avenue Drainage

A new system is proposed to pick up the existing systems to the south of Brown Hill Creek in Kurralta Park. Property inundation and significant road ponding occurs in this area for all events, including the 0.5 EY event. Substantial increases in inundation depths are seen in the 5% AEP events and higher. There are four existing small lateral systems discharging into Brown Hill Creek; all are undersized. The new system is to run from Daphne, Warwick Avenue, Cross Terrace and discharge into Brown Hill creek at Daly Street. Each existing system it to be connected to the new drain and the existing outlets to the creek removed. The new system ranges in size from 1200mm RCP at the downstream end to 375mm at the upstream ends (Figure 4.64 in Gray Street discussion). The upgrade provides significant reductions to roadway ponding and a 5% AEP flood standard to the residential properties (Figure 4.65 in Gray Street discussion).

The total cost for the new stormwater system is estimated to be $1,590,000.

D26 – Gray Street Drainage

The new system along Gray Street provides the same benefit as the Warwick system, by connecting to existing systems to the south of Brown Hill Creek that are shown to be undersized. Property inundation and significant road ponding occurs in the 0.2 EY event in this area and considerable increases in inundation depths are seen in the 5% AEP events and higher. The new system has two main branches: one connecting to the existing system at James Street, and the other running down Gray Street before connecting to the existing system in Mortimer Street. The existing systems can be disconnected at the upstream ends, resulting in better performance as they are now servicing smaller catchments. The new outlet at Gray street is a 1500mm RCP and the two separate laterals that branch off are 900mm to 600mm RCPs (Figure 4.64). The upgrade provides significant reductions to roadway ponding and a 5% AEP flood standard to the residential properties (Figure 4.65).

The total cost for the new stormwater system is estimated to be $1,770,000.



Figure 4.64 – Warwick Avenue and Gray Street Drainage Layouts

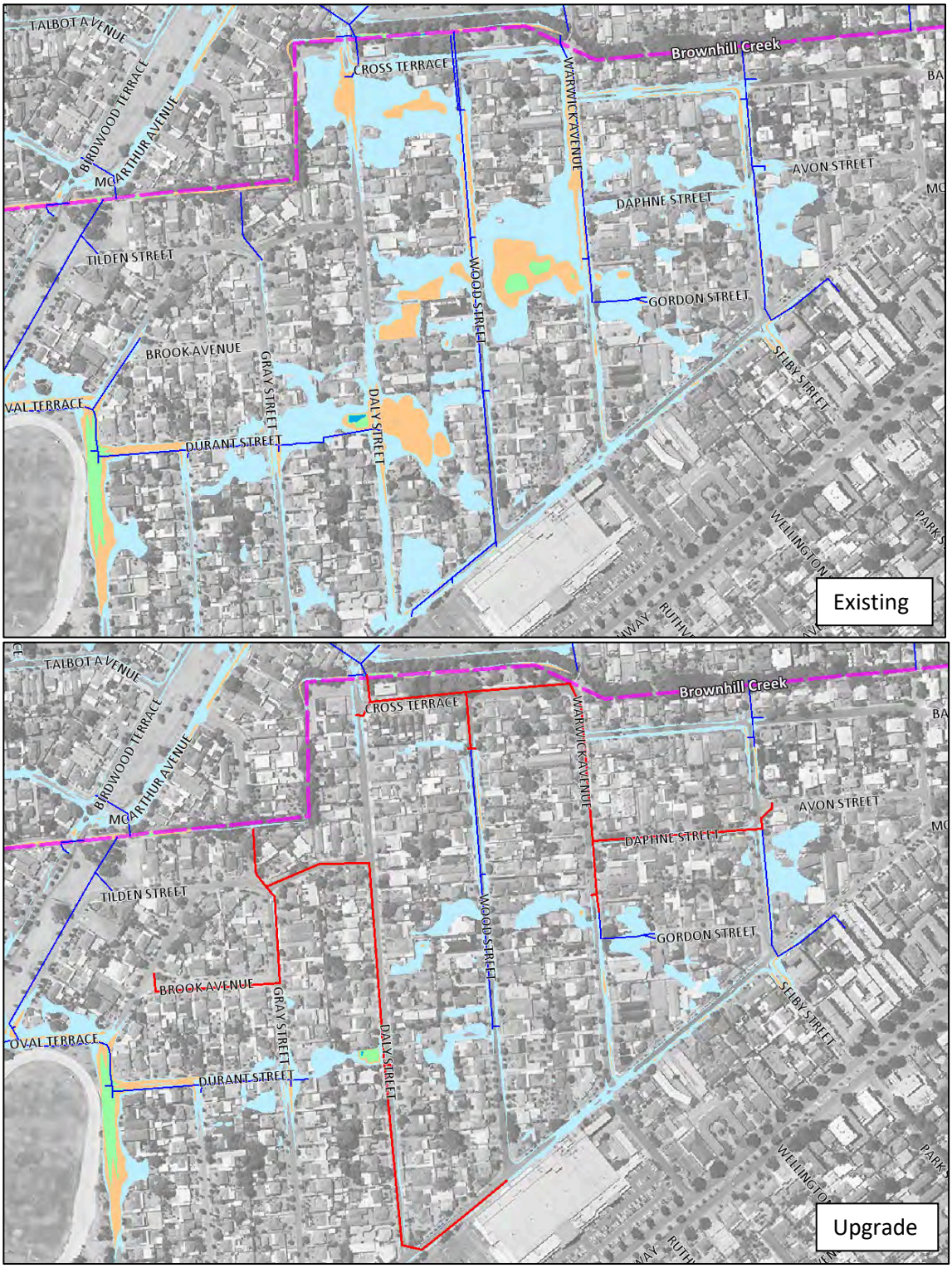


Figure 4.65 – 5% AEP floodplain comparison

D27 – Harvey Avenue Drainage

There is very little underground drainage in the southern residential half of Netley. A new stormwater system is proposed in the area to break up the existing large subcatchments. This system will provide substantial reductions to nuisance flows and relieve the smaller existing systems to the north- and south-west of the area. Residential inundation is shown to occur in the existing scenario in the larger AEP events to the west of this area along Brown Hill Creek. The new system provides a 5% AEP standard to the area (Figure 4.67).

The new drain ranges in size from 900mm RCP to 450mm at the upstream ends with multiple smaller lateral systems (Figure 4.66).

There is an opportunity to construct a detention or upwell basin in Baroda Avenue Reserve prior to the proposed outlet. A WUSD element could also be incorporated. This opportunity would be analysed further in the detailed design phase.

The total cost for the new stormwater system is estimated to be $1,790,000 (this estimate does not include the basin).

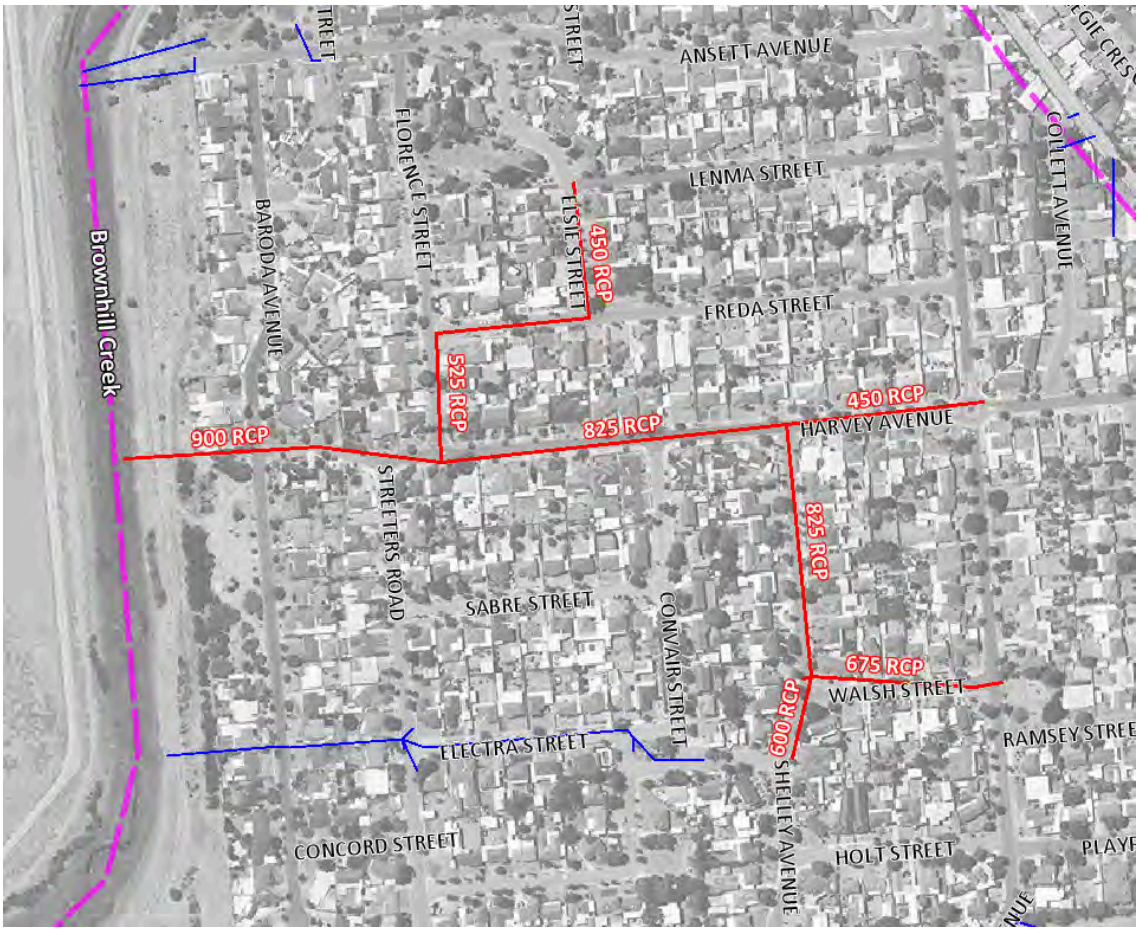


Figure 4.66 – Harvey Avenue Drainage Layout

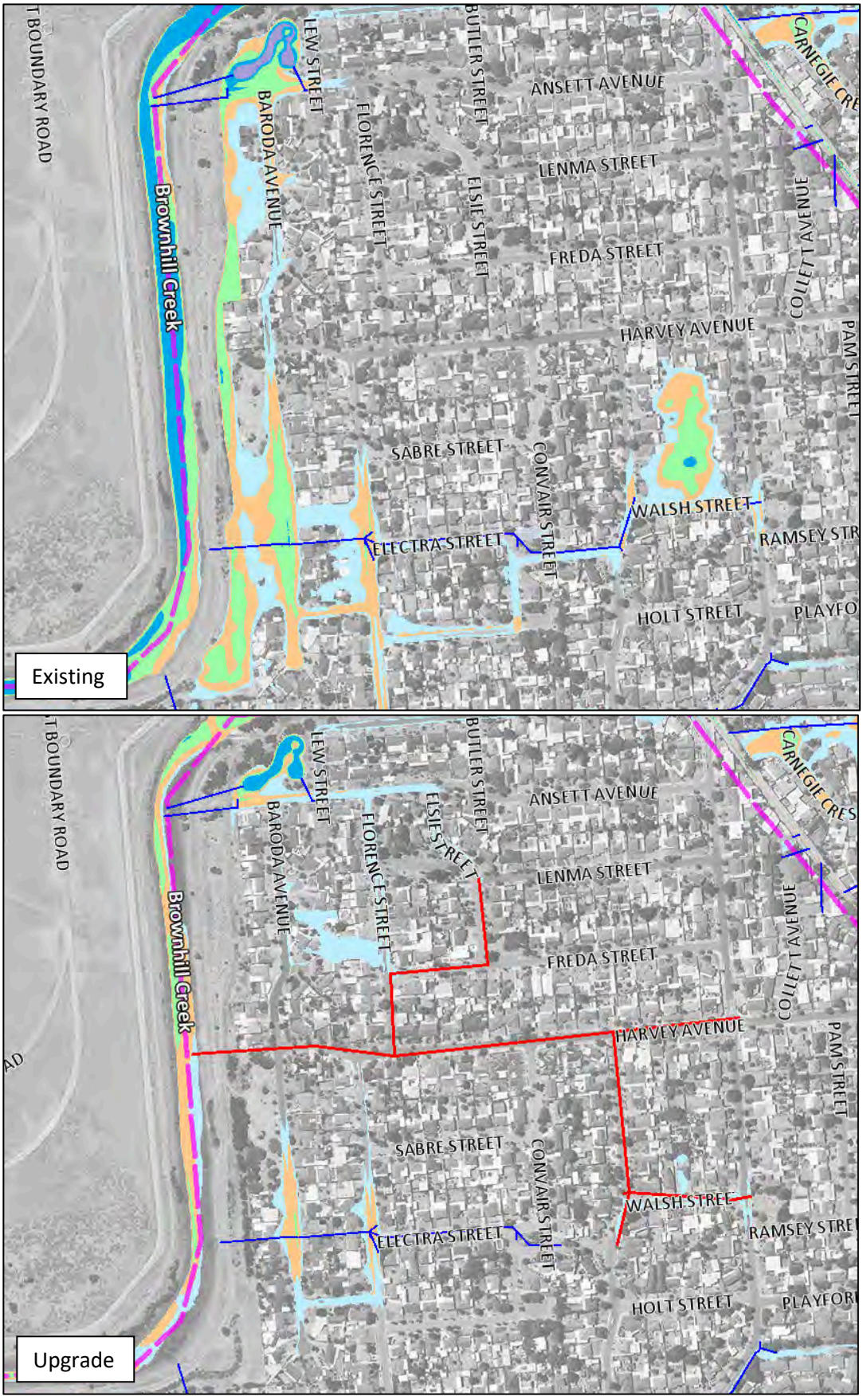


Figure 4.67 – 5% AEP floodplain comparison

D28 – Packard Street Drainage – Detailed Design Completed

The Packard Street Drainage upgrade involves two separate systems which have been designed to break up the large residential subcatchments in the north eastern end of North Plympton. The new system alleviates capacity pressure on the existing Marion Road system and significantly reduces nuisance flows in the area. The detailed design for this proposal has already been completed. The general layout is shown in Figure 4.68 below.

The construction cost of this upgrade is estimated to be $1,090,000.

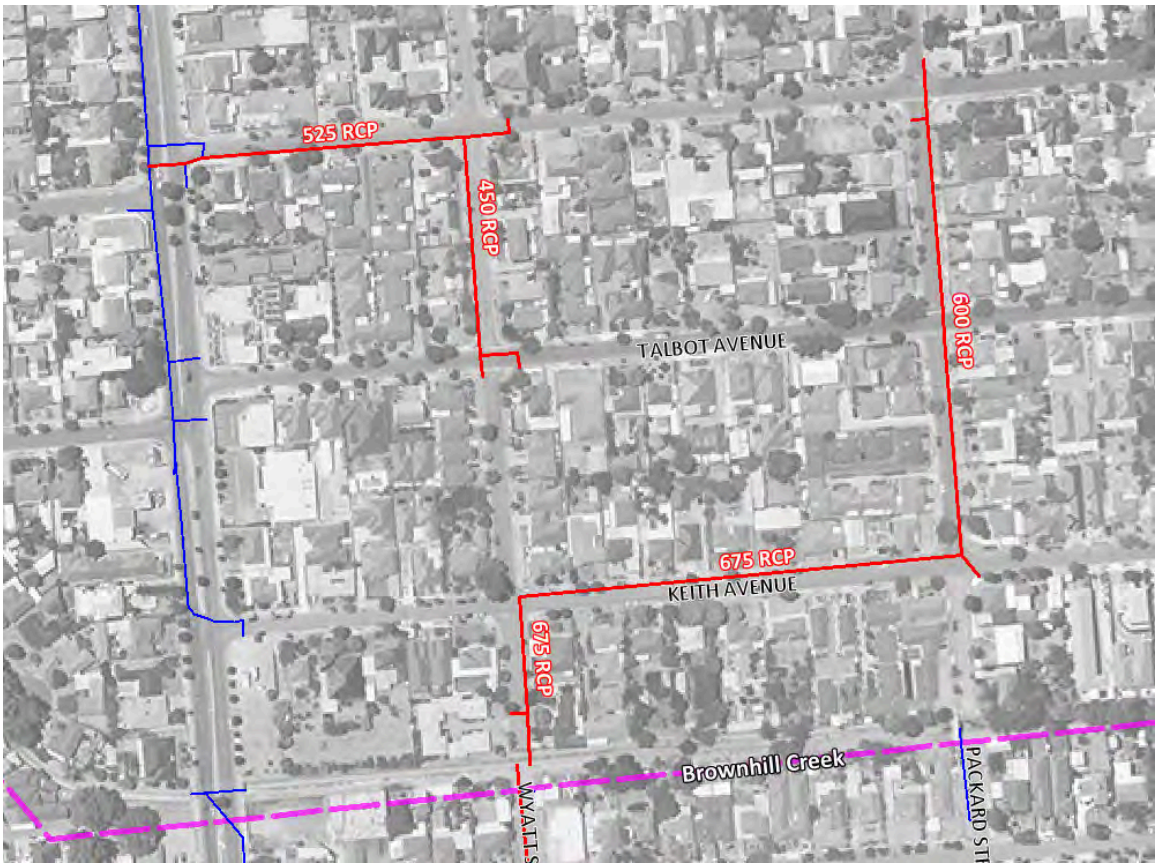


Figure 4.68 – Packard Street Drainage Layout

D29 – Edward Davies Street Drainage

Significant roadway ponding and property inundation is shown to occur in the larger AEP events along the existing Marion Road system, from Murdoch Avenue to Brown Hill Creek. The residential catchments that feed this system from the east are relatively large and so a new system is proposed to break up these catchments and provide relief to the existing Marion Road system. The new system is also proposed to pick up the existing pits in MacKay Avenue where road ponding occurs in storm events as small as the 0.5 EY. The existing system in MacKay Avenue runs south to the existing Laverack Road / Hawson Avenue system. The proposal allows these pits to be disconnected and drained north to Brown Hill Creek via a new outlet at Wyatt Street. Pipe sizes range from 1200mm RCP to 450mm RCP. Figure 4.69 provides a layout of the proposed design.

The total cost for this upgrade is estimated to be $800,000.



Figure 4.69 – Edward Davies Street Drainage Layout

D30 – Glenburnie Terrace Drainage and Detention Basin

Significant roadway ponding and property minor property inundation occurs along Glenburnie Terrace in the existing 5% AEP event. It is proposed to replace the existing undersized drain in Glenburnie Terrace with a new system ranging from 1050 mm to 450mm RCP with a lateral system connecting to the existing system at Long Street. This new system is to connect into a new detention basin in the linear reserve alongside McArther Avenue (Figure 4.71). There is available space for the basin to have a storage of up to 5,000m^3. A smaller 525mm RCP outlet pipe from the basin reduces the peak flow entering the downstream system. Figure 4.70 provides the proposed layout.

The basin works are to be integrated into the reserve such that the impact (both visually and for usability) is minimised. Basin side slopes are to be gentle (maximum 1V:8H) with a maximum depth of 1.5 metres below natural surface. A bioretention component is to be considered with the basin along with a GPT at the primary basin inlet.

The total cost for the new stormwater system and basin is estimated to be $2,160,000.

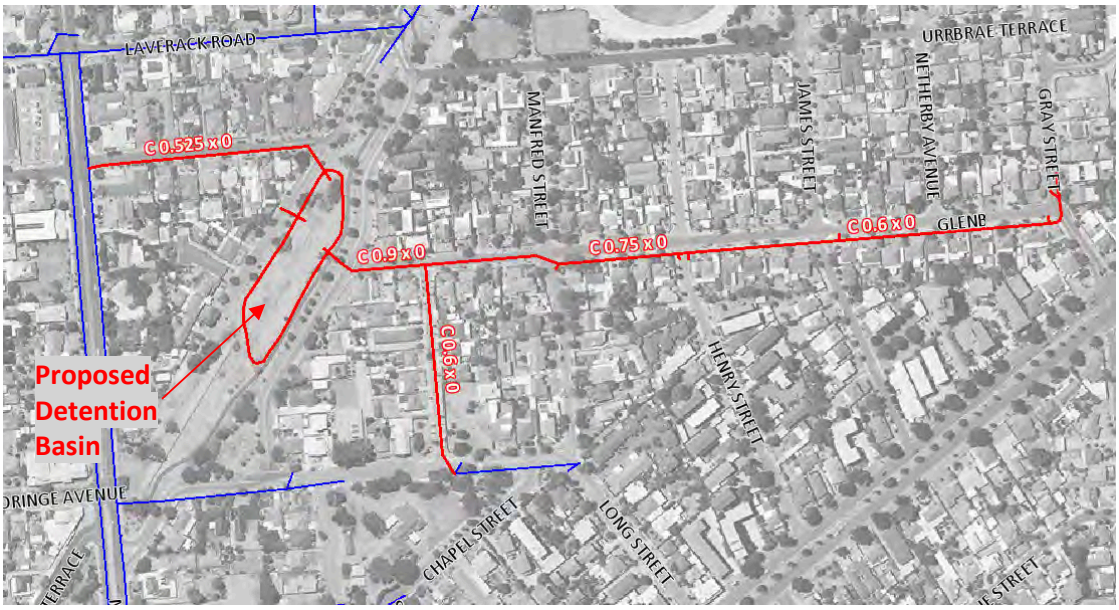


Figure 4.70 – Glenburnie Terrace Drainage and Detention Basin Layout



Figure 4.71 – McArther Ave, Detention Basin Location

D31 – Spring Street Drainage

The existing lateral system along Spring Street, west of Streeters Road, is undersized with roadway ponding shown to occur in all existing scenario AEP events. Overflows from the upstream end of the existing system spill south down Beare Avenue, resulting in minor property inundation in the 0.2 EY event, with more severe inundation in the larger events. To improve the flood standard in this area, it is proposed to replace the existing 450mm drain with a 900mm / 825mm RCP drain. The inlet capacity at the upstream end of the system is to be significantly increased to prevent large overflows running down Beare Avenue. The following North Plympton upgrade section includes the Spring Street upgrade figures (concept layout and the comparison flooding).

The total cost for the new lateral system is estimated to be $670,000.

D32 – North Plympton Trunk Drain + Laterals

Substantial industrial, commercial, and residential inundation is shown to occur throughout North Plympton in the larger AEP events, with minor property inundation occurring in the 0.5 EY event. Many of the subcatchments in this area have high impervious proportions and the existing drainage systems is not able to cope with the large runoff volumes. A large trunk drain with a number of lateral systems is proposed to connect to each flooding hotspot along North Plympton, significantly increasing the available flow capacity and providing a 5% AEP flood standard to the area.

The main trunk drain is to discharge into the concrete channel off James Melrose Road before entering Brown Hill Creek. The concrete channel is to be upgraded to account for the increased flow.

The layout of the proposed upgrades is shown in Figure 4.72 and the flood comparison maps are provided in Figure 4.73. The details of the total proposed works are summarised below:

- A new outlet drain from the downstream end of the concrete channel consisting of 4 2400mm x 1500 box culverts
- An increased channel capacity – 7m wide and 2m deep with 1:0.5 batter slopes
- Two parallel 2700mm x 1200mm box culverts connecting into the upstream end of the channel and running along James Melrose Road and Morphett Road to Kinkaid Ave. the existing 2300mm x 1000mm box culvert running along the eastern edge of the Glenelg Golf course is to connect with the new system under James Melrose Road at the upstream end of the concrete channel.
- From the Kinkaid Avenue intersection with Morphett Road, the trunk drain is to run east along Kinkaid Avenue to Streeters Road. The drain size here ranges from a single 3000mm x 900mm box culvert to a 2700mm x 900mm box culvert.
- From Streeters Road the proposed system branches north and south connecting into existing undersized systems and flood hotspots along Hawson Avenue, Dingera Avenue and Lewis Crescent to the north, and Inverell Avenue, Whelan Avenue and Gardner Street to the South.
- Additional lateral systems are proposed for Deeds Road, both north and South of Kinkaid Avenue, connecting to the respective existing systems in these areas.
- Another lateral system running south from Kinkaid down Morphett Road provides additional capacity to the existing system along Morphett Road.
- The Morphett Road existing system, north of Kinkaid Avenue, is io be disconnected. A new drain (2100mm x 900 mm box culvert to 900mm RCP) is proposed to pick up these large industrial / commercial catchments and discharge into Brown Hill Creek to the north. This system will not be connected to the main trunk drain running down Kinkaid Avenue / James Melrose road.

The 1% AEP peak outflow to Brown Hill Creek for the proposed upgrade is 14 m^3/s.

The total cost for the new trunk main and multiple lateral systems to reach a 5% AEP flood standard is estimated to be $14,970,000. Section 4.11 details what is required to reach the 1% AEP standard in this area and the costs involved.

During further design development of this strategy, inflows from the adjoining Sturt Urban Catchments SMP, as highlighted in Section 4.3.7, should be considered to ensure the strategy provides the desired performance standard for the area.

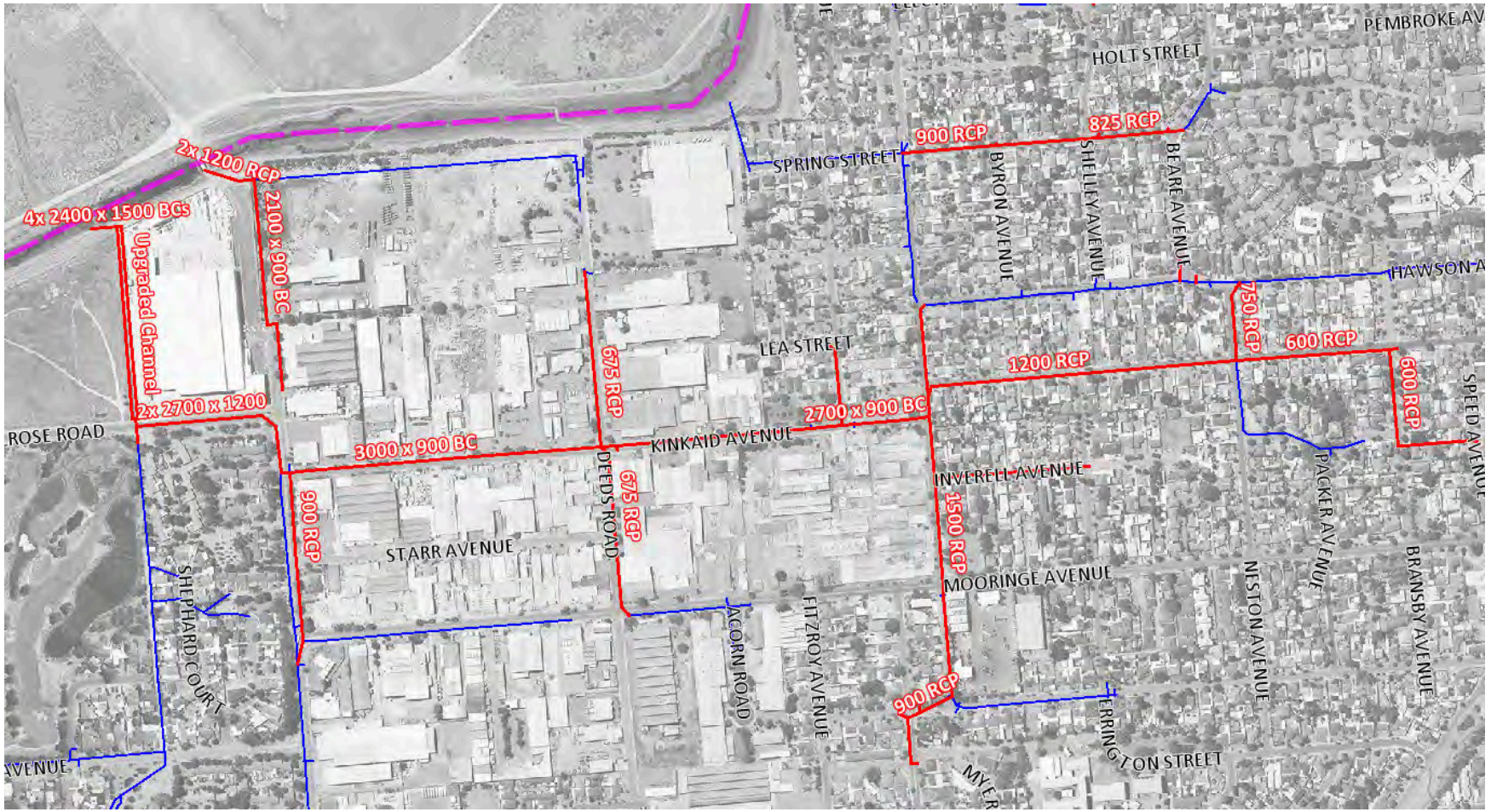


Figure 4.72 – North Plympton Trunk Drain + Laterals Layout (includes Spring Street Upgrade)

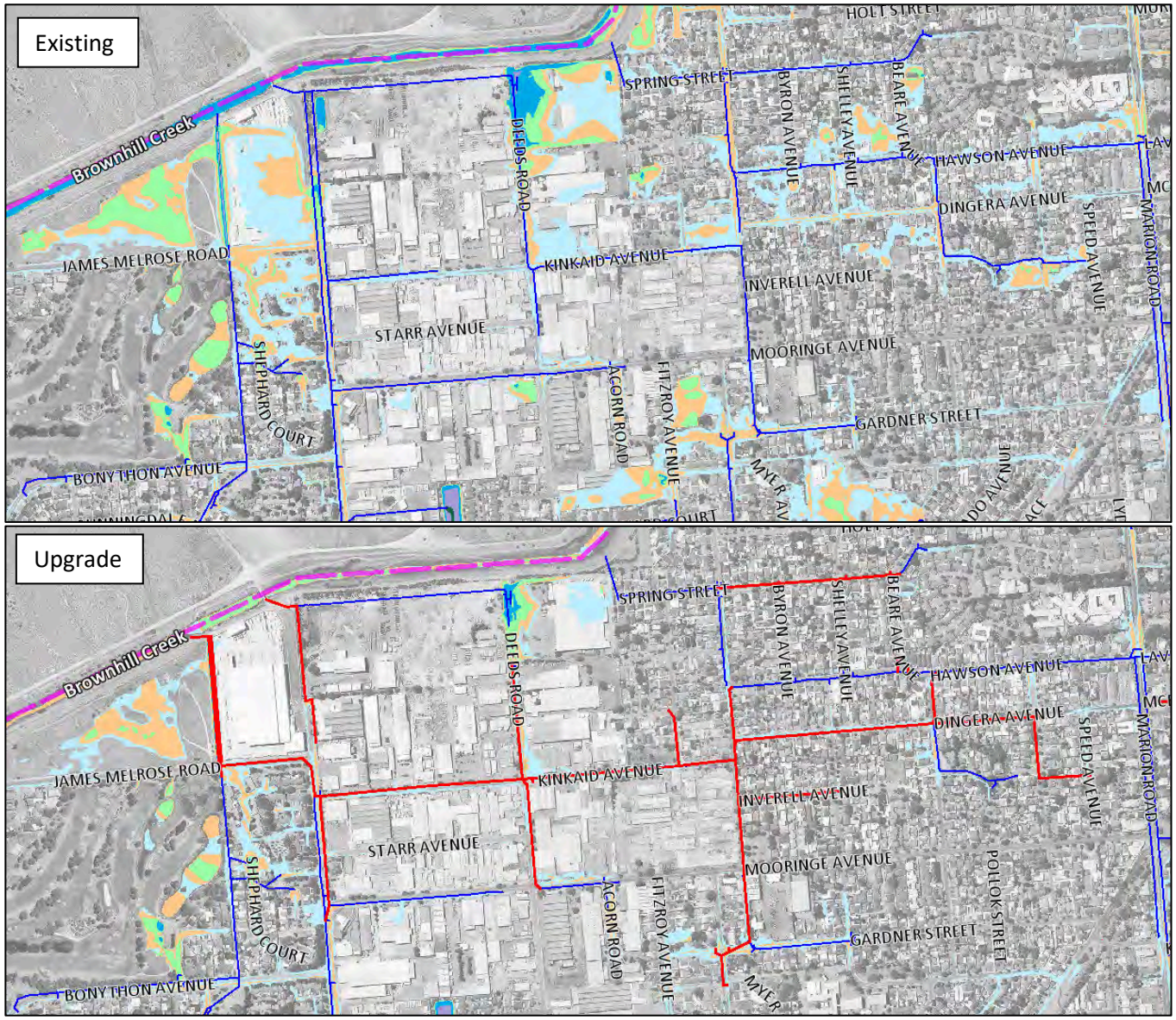


Figure 4.73 – 5% AEP floodplain comparison

D33 – Emma Place Surcharge Basin Re-shape
Currently significant road ponding is known to occur in the smaller AEP events at Emma Place the Plympton Green Reserve. The existing basin in the reserve and drainage system is undersized. In larger AEP events, the floodplain maps indicate overflows from the basin run north along the western edge of the Plympton International College Oval with minor residential property inundation also occurring.

It is suggested that the basin capacity could increase, however, more importantly, that the overflow route is adjusted so that overflows stay within the reserve and spill onto Myer Avenue. The adjustment to the overflow route eliminates the minor inundation to properties along the eastern edge of Myer Road. The overflows remain in Myer road until reaching the Penong Avenue Drainage system. Figure 4.75 in the following section demonstrates the impact of the adjusted overflow route.

The total cost for the basin earthworks is estimated to be $100,000.

D34 – Penong Avenue Drainage
The existing system from Raffles Crescent, through the Plympton International College, to Penong Avenue, is significantly undersized. Residential and school building inundation is shown to occur in all AEP events, increasing in severity for larger storms.

It is proposed the existing system is replaced along Penong Avenue, from Cromer Street to Raffle Crescent. This will involve construction through the International College, where it is assumed, an existing easement is in place for the existing stormwater drain. The existing 1200mm RCP in Penong Avenue at Cromer Street is to be extended to Whelan Avenue. From there, a new 900mm RCP will run to the College, and a 750mm RCP through the College to Raffles Crescent. Additional laterals and inlet capacity will be provided at Raffles Crescent.

At the downstream end of the upgrade, a new lateral system along Cromer is recommended to replace the existing undersized drain where significant overflows and minor property inundation occur along Patricia Avenue. The proposed upgrades provide a 5% AEP standard as shown in Figure 4.75. Refer to Figure 4.74 for the concept layout.

The total cost for these upgrades is estimated to be $1,150,000.

During further design development of this strategy, inflows from the adjoining Sturt Urban Catchments SMP, as highlighted in Section 4.3.7, should be considered to ensure the strategy provides the desired performance standard for the area.



Figure 4.74 – Penong Avenue Drainage Layout

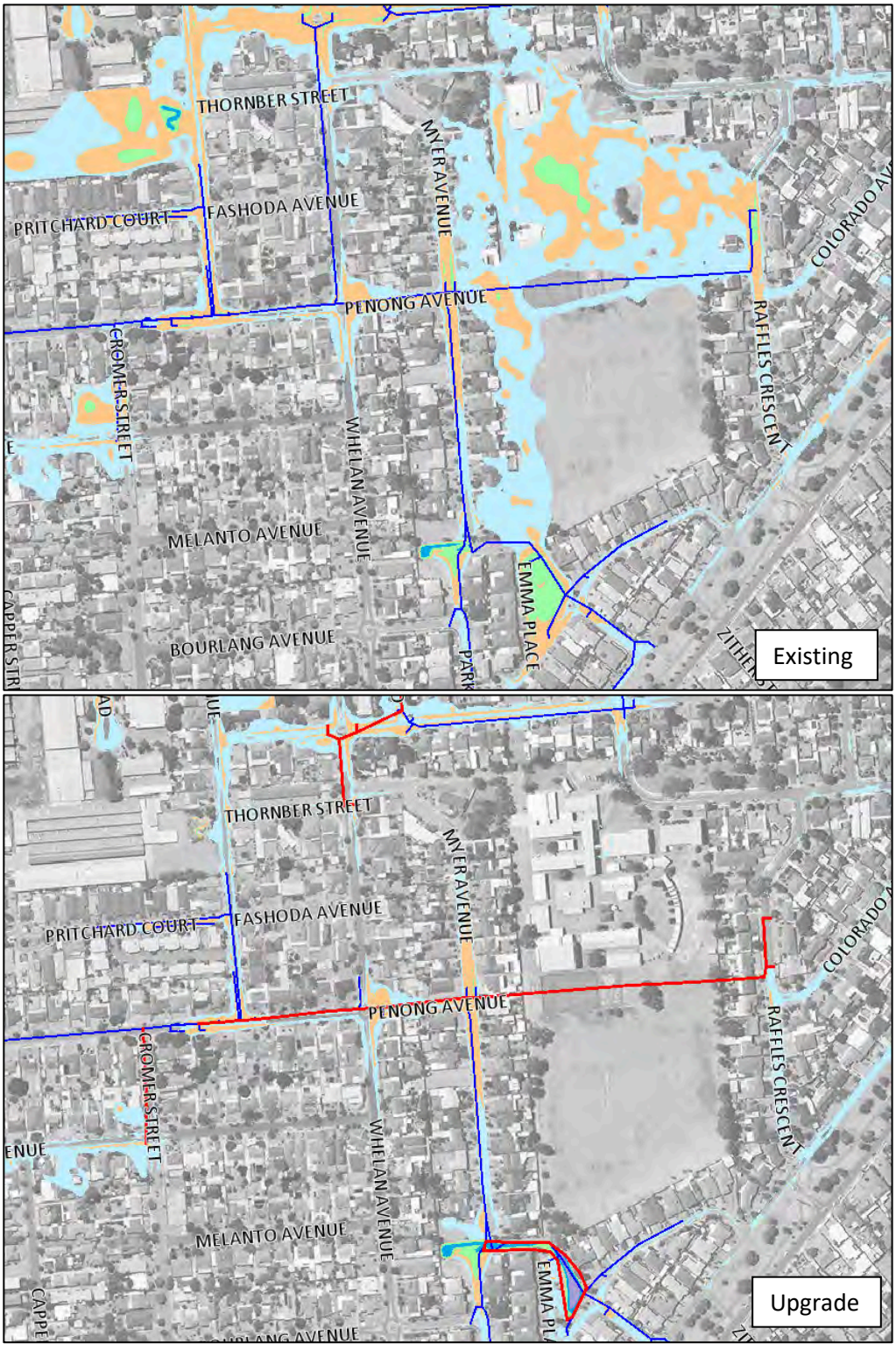


Figure 4.75 – 5% AEP floodplain comparison

D35 – Hoylake Street / Albert Avenue Drainage
Considerable roadway ponding is shown to occur in Albert Avenue, with significant inundation of the SA Health Distribution Centre and Camden Park Fire Station occurring in larger AEP events. The existing system that services these subcatchments runs down Morphett Road and is shown to be undersized.

It is proposed to construct a parallel 825mm / 750mm RCP drain in Albert Avenue, with several new pit inlets. This new drain is then to run north along Morphett Road and the west down Hoylake Street as a 1050mm RCP. It is to connect into the large existing system that runs north along St Andrews Crescent. See Figure 4.76 for the concept layout.

This proposed upgrade significantly reduces roadway ponding in the 10% AEP and smaller events along Albert Avenue and provides a 5% AEP flood protection to the area (Figure 4.77).

The total cost for this upgrade is estimated to be $1,720,000.

During further design development of this strategy, inflows from the adjoining Sturt Urban Catchments SMP, as highlighted in Section 4.3.7, should be considered to ensure the strategy provides the desired performance standard for the area.

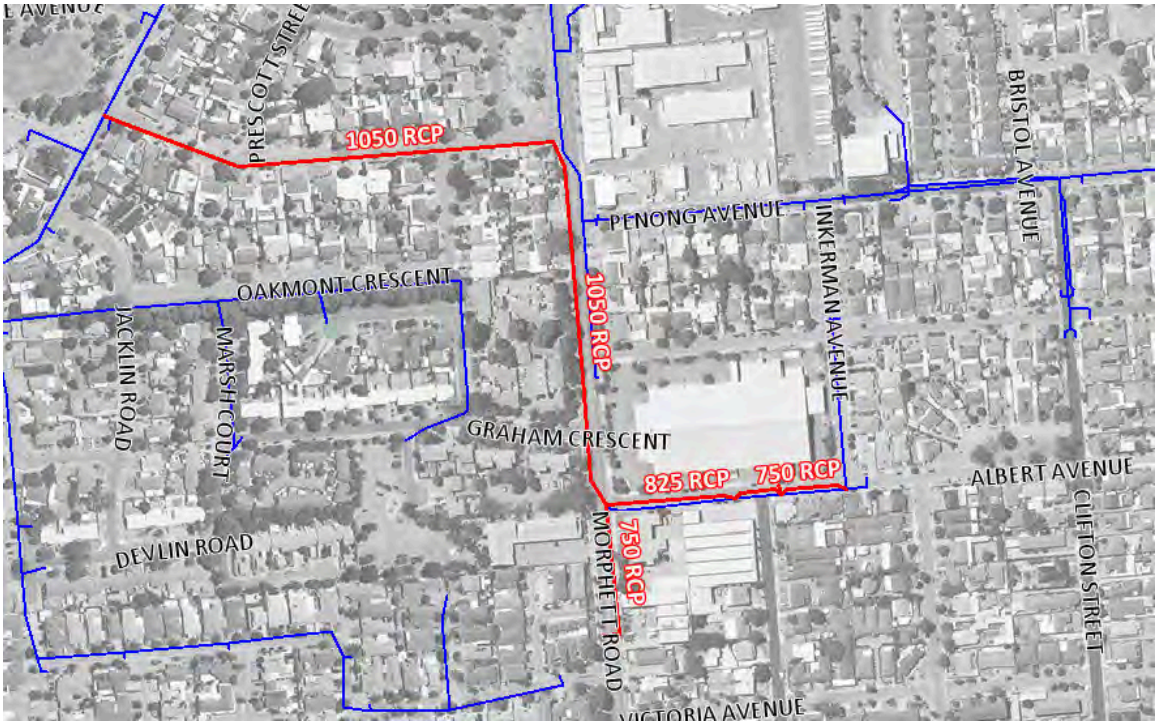


Figure 4.76 – Hoylake Street / Albert Avenue Drainage Layout

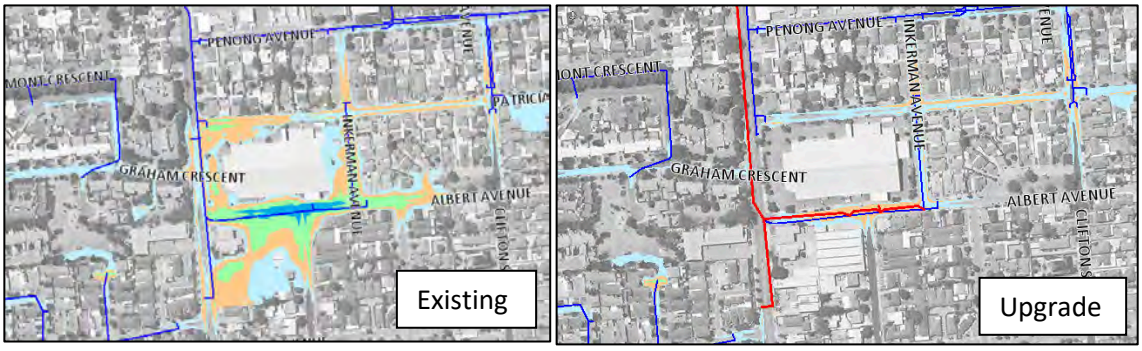


Figure 4.77 – 5% AEP floodplain comparison

4.8.8 Feasibility and Optimisation

Some of the major proposed upgrades such as the Cowandilla, Mile End to Keswick Creek Trunk Drain and North Plympton Trunk Drain + Laterals include duplicate large pipes and/or box culverts running in parallel. The trench width for laying such large systems would in many cases take up nearly the entire width of road. To avoid service clashes, the drains could be split between two or three parallel streets.

There is clearly scope for further design development to optimise design routes, and the scope of the proposed trunk drain upgrades, to achieve the most optimal (cost effective) outcome in each area. It is recommended that a comprehensive preliminary design development be undertaken prior to proceeding with any of the proposed major upgrade schemes (>$10,000,000) which include large duplicate parallel drains. This would include consideration of underground services, outfall arrangements, drain size sensitivity supported by flood plain modelling, and refined budget cost estimation.

4.8.9 D36 – Keswick Creek, Brown Hill Creek – Keswick Channel Implications

The proposed upgrade works comprise a number of new trunk drains that will discharge greater total rates of flow locally into the Keswick Creek concrete channel and downstream Brown Hill – Keswick Creek channel. The total impact on peak flows in the channels are unclear and may be offset due to the West Torrens drainage systems being at the downstream end of the creek catchments, such that local peak flows can be passed prior to the arrival of the total creek catchment peak flow. Detention storage has been proposed in some of the upgrades where opportunities are apparent. Further detention (in the form of underground storage in roadways) could be considered should this prove to be of merit in achieving an appropriate balance between local drainage and creek channel performance standards.

The overall impact on design peak flows in the creek channels should be the subject of a specific assessment to determine the feasibility of the major trunk drain upgrades that discharge into the creek channels. Should such an assessment identify that channel works are required and of merit, a preliminary design should be undertaken in collaboration with the channel asset owner (SA Water) to confirm overall project feasibility, prior to proceeding with any local trunk drain system upgrade. This initial assessment and preliminary design have been included as a non-structural strategy action (D36).

More specifically the assessment recommended of the interaction between the floodplain drainage upgrades and Keswick Creek capacity should consider the following:

- Existing peak flow capacity of the Brown Hill and Keswick Creeks

- Joint probability of flows from the local drainage network coinciding with flows from further upstream and the impact on the Creek capacity and local drainage network performance.
- Assessment of the need for, and impact of, further detention in the local drainage network on the Creeks' capacity.
- Preliminary design of any proposed upgrades to Brown Hill or Keswick Creeks.
- Expected performance of the proposed local drainage upgrades if Keswick and Brown Hill Creek are not upgraded.

4.8.10 Non-Structural Flood Mitigation Measures

To complement the proposed structural options described in the sections above, a number of non-structural flood mitigation options have been considered. Non-structural options are typically low cost (relative to structural measures) and hence are extremely cost effective with respect to the flood damage reductions that they achieve.

D37 – Community Flood Response and Preparedness
The State Emergency Service (SES) deliver their FloodSafe and StormSafe program in schools and the community throughout the area, to help build community resilience and understanding about flood risk. Community FloodSafe is a partnership between local Councils and State and Federal governments The FloodSafe program uses existing State Emergency Service volunteers, as well as new community volunteers with good presentation skills, to reach into communities to raise awareness in flood-prone areas. Initiatives include articles in Council newsletters, street corner meetings, community group meetings, internet sites, brochures, and school education.

The volunteers talk to community groups, local residents, businesses and schools about what they can do reduce the risk of flood damage and improve the resilience of their community if a flood should occur. FloodSafe volunteers typically address communities on:

- Local risks and historic flooding in the area;
- Having a flood plan to reduce the risk to business equipment, stock and staff;
- Protecting family and property;
- Understanding BOM Flood Watch and Flood warnings;
- Having a home emergency kit; and
- How to call for SES response.

Since its inception in 2009, many metropolitan and regional South Australian councils have joined the FloodSafe program. It is recommended that the catchment Councils facilitate the delivery of this program throughout the catchment area.

D38 – Community Flood Response and Preparedness – Council's Community Emergency Management Plan
The City of West Torrens has produced Community Emergency Management Plan, with the purpose of collectively developing skills which provide the community with:

- Knowledge of the emergency risks that exist in the local area;
- Information to support the role that each member of the community can have in an emergency;

- A platform to connect with each other and council before, during and after an emergency; and
- The ability to support each to become resilient in an emergency event or disaster.

The Community Emergency Management documents are currently available on the Council website. The sections of the documents focussed on flooding provide information on how the community should prepare for a flood emergency arising. Council may also elect to make the floodplain mapping for the West Torrens SMP publicly available via their website, along with advice to residents on measures they can take to reduce their flood risk and steps to take to prepare a Personal Flood Action Plan. Flood maps can also be shared with DEW for use in flood hazard management including the Flood Awareness Site.

D39 – Development Controls – Floor Levels
It is recommended that all catchment Councils ensure that all new development has a floor level that provides at least 300 mm freeboard above the 1% AEP floodplain, as depicted on the floodplain maps of the area.

D40 – Development Controls – On-site Detention and Retention
The consistent application of stormwater detention as a development requirement has previously been identified as an option to mitigate against the impacts of intensification of future development. The City of West Torrens now falls under the jurisdiction on the new state-wide Planning and Design Code, 2021.

The new code sets out the stormwater detention and retention requirements for new residential developments. New developments are to incorporate a rainwater tank as per Table 4.17 below.

Table 4.17 – Rainwater Tank Requirement by allotment size (Planning and Design Code - 19 March - Version 2021.2)

Allotment Size (m^2)	Minimum Rainwater Tank Volume (L)	Minimum detention volume (L)
<200	1,000	1000
200 – 400	2,000	Site perviousness <30%: 1,000 Site perviousness >30%: N/A
>401 – 500	4,000	Site perviousness <35%: 1,000 Site perviousness >35%: N/A

Based minimum site perviousness – see planning code document for details.

It is recommended that Council uphold these requirements as a part of their development application approval process.

D41: Ongoing Maintenance and Monitoring of Council Assets
Councils have developed various Asset Management Plans for managing their stormwater infrastructure. The goal of these plans is to ensure processes are in place for the required maintenance, monitoring and capital renewal of Council assets and to ensure it is done in a financially sustainable way. The Councils also keep records of all their stormwater assets in GIS form. It is recommended that the Councils maintain the Asset Management Plans as live documents, continually updating them when required as issues are identified. It is also recommended that the Councils' GIS systems are continually updated with any new infrastructure as it is constructed and filled in where gaps may exist.

4.9 Flood Mitigation Benefits Evaluation

4.9.1 Damages Comparison

The residual flood damages associated with the ultimate development scenario and proposed upgrades have been evaluated, consistent with the methodology outlined in Section 4.7, as summarised in the tables below.

Table 4.18 – Residential Damages, Ultimate Development / Upgraded Drainage / Climate Change RCP 8.5

AEP	No. of Residential Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	43	3	0	0	0	0	$200,000
0.2 EY	93	6	3	0	0	0	$580,000
10% AEP	227	8	5	1	0	0	$1,310,000
5% AEP	591	25	13	1	0	0	$3,340,000
2% AEP	1385	142	72	20	0	0	$11,740,000
1% AEP	2086	320	198	76	2	0	$26,340,000

Table 4.19 – Commercial - Office Damages, Ultimate Development / Upgraded Drainage / Climate Change RCP 8.5

AEP	No. of Office Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	22	0	1	0	0	0	$2,120,000
0.2 EY	32	2	1	0	0	0	$3,260,000
10% AEP	40	5	3	0	0	0	$4,560,000
5% AEP	69	3	6	1	0	0	$7,450,000
2% AEP	134	11	13	1	1	0	$15,260,000
1% AEP	185	24	14	10	1	0	$22,750,000

Table 4.20 – Commercial - Retail Damages, Ultimate Development / Upgraded Drainage / Climate Change RCP 8.5

AEP	No. of Retail Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	10	0	0	0	0	0	$1,450,000
0.2 EY	14	0	0	0	0	0	$2,030,000
10% AEP	18	0	0	0	0	0	$2,610,000
5% AEP	32	1	0	0	0	0	$4,820,000
2% AEP	73	4	1	0	0	0	$11,480,000
1% AEP	96	13	3	1	0	0	$17,440,000

Table 4.21 – Industrial Damages, Ultimate Development / Upgraded Drainage / Climate Change RCP 8.5

AEP	No. of Industrial Properties Inundated at each Depth Range						Damage Estimate
	0 – 0.1	0.1 – 0.15	0.15 – 0.25	0.25 – 0.5	0.5 – 1.0	1.0 – 1.5	
0.5 EY	8	0	1	0	0	0	$2,110,000
0.2 EY	18	0	1	0	0	0	$4,380,000
10% AEP	23	2	2	0	0	0	$6,420,000
5% AEP	34	4	3	0	0	0	$9,820,000
2% AEP	58	9	6	4	0	0	$20,280,000
1% AEP	77	15	6	7	1	0	$29,270,000

Table 4.22 – Total Damages, Ultimate Development / Upgraded Drainage / Climate Change RCP 8.5

AEP	Residential	Commercial – Office	Commercial – Retail	Industrial	Total
0.5 EY	$200,000	$2,120,000	$1,450,000	$2,110,000	$5,870,000
0.2 EY	$580,000	$3,260,000	$2,030,000	$4,380,000	$10,240,000
10% AEP	$1,310,000	$4,560,000	$2,610,000	$6,420,000	$14,900,000
5% AEP	$3,340,000	$7,450,000	$4,820,000	$9,820,000	$25,430,000
2% AEP	$11,740,000	$15,260,000	$11,480,000	$20,280,000	$58,760,000
1% AEP	$26,340,000	$22,750,000	$17,440,000	$29,270,000	$95,800,000

The total reduction in direct tangible damages when comparing the upgraded drainage scenario to the existing drainage scenario is shown in Table 4.23.

Table 4.23 – Potential Reduction to Damages

AEP	Existing Damages	Upgraded Damages	Reduction in Damages	Reduction in Damages (%)
0.5 EY	$19,000,000	$5,870,000	$13,120,000	69%
0.2 EY	$31,490,000	$10,240,000	$21,250,000	67%
10% AEP	$45,560,000	$14,900,000	$30,670,000	67%
5% AEP	$70,100,000	$25,430,000	$44,680,000	64%
2% AEP	$118,360,000	$58,760,000	$59,600,000	50%
1% AEP	$160,320,000	$95,800,000	$64,520,000	40%

A breakdown of the reduction in damages by catchment is shown in Table 4.24.

Table 4.24 – Reduction in Damages by Catchment

Catchment	Total Damages Estimate and Reduction per Catchment ($000)											
	0.5 EY		0.2 EY		10% AEP		5% AEP		2% AEP		1% AEP	
	Est.	Red.	Est.	Red.	Est.	Red.	Est.	Red.	Est.	Red.	Est.	Red.
West Beach	$8	$230	$30	$320	$90	$310	$750	$90	$1,410	$4	$2,590	$50
River Torrens Pumping Stations	$0	$670	$20	$1,610	$70	$2,360	$580	$3,010	$2,030	$3,290	$3,700	$3,350
Lockleys	$400	$130	$580	$220	$730	$380	$1,060	$1,010	$3,050	$1,810	$5,740	$1,490
River Torrens	$230	$1,260	$2,080	$2,550	$2,910	$3,140	$4,440	$5,210	$9,640	$5,550	$15,490	$5,030
Cowandilla Mile-End	$380	$880	$610	$1,660	$1,570	$3,180	$3,250	$8,340	$8,170	$17,360	$17,290	$22,670
Keswick Creek Lateral Drains	$2,960	$5,110	$4,400	$8,830	$5,640	$13,180	$9,160	$16,520	$20,340	$17,620	$28,910	$17,320
Keswick - Western Adelaide	$1,370	$0	$1,850	$0	$2,580	$0	$3,750	$0	$7,450	$0	$9,760	-$190[1]
Brown Hill Creek Lateral Drains	$530	$4,850	$680	$6,060	$1,090	$8,120	$1,980	$10,280	$5,770	$13,140	$10,890	$13,550
Adelaide Airport	$0	$0	$0	$0	$230	$0	$450	$230	$910	$840	$1,440	$1,270

[1]Proposed upgrades in the Brown Hill Creek Lateral Drains Catchment reduce damages by $13,550,000 for this catchment. There is a slight impact on a small number of properties within the adjacent Keswick - Western Adelaide Catchment in the 1% AEP event. Further design development of the proposed upgrades will ensure existing flooding is not made worse for these properties. Overall, there is a significant reduction in flood damages for the wider area.

The number of properties shown to experience inundation of more than 50 mm in the upgrade scenario is presented by catchment in Table 4.25. A direct comparison with the existing drainage scenario can be made by catchment in Section 4.6, demonstrating the benefits of the proposed works in terms of property inundation. Floor level survey of properties that have been identified as vulnerable to stormwater ingress in the upgrade scenario would be required to confirm that the minimum performance standard has been achieved for flooding up to and including the 5% AEP storm event.

Table 4.25 – Property Inundation by Catchment, Ultimate Development / Upgraded Drainage / Climate Change RCP 8.5

Catchment	Number of Properties Inundated > 50 mm					
	0.5 EY	0.2 EY	10% AEP	5% AEP	2% AEP	1% AEP
West Beach	1	2	5	17	35	48
River Torrens Pumping Stations	0	0	3	19	64	132
Lockleys	5	11	17	44	127	188
River Torrens	3	8	12	16	35	82
Cowandilla Mile-End	0	6	19	52	238	484
Keswick Creek Lateral Drains	6	13	26	40	131	253
Keswick - Western Adelaide	1	2	4	12	15	20
Brown Hill Creek Lateral Drains	5	9	15	23	84	186
Adelaide Airport	0	0	0	0	1	5
Total (Upgrade) (% Reduction)	**21 (88%)**	**51 (86%)**	**101 (85%)**	**223 (81%)**	**730 (63%)**	**1,398 (49%)**
Total (Existing Sc. 4)	**172**	**375**	**659**	**1,152**	**1,967**	**2,735**

The annual average damages (AAD) were again calculated for the upgrade scenario. The total annual average damage value for the upgrade scenario is $8,747,000, a breakdown of annual average damages by drain catchment is shown in Table 4.26.

Table 4.26 – Reduction to AAD

Catchment	Existing AAD	Upgrade AAD	Reduction
West Beach	$280,000	$150,000	$130,000
River Torrens Pumping Stations	$1,030,000	$200,000	$830,000
Lockleys	$670,000	$480,000	$190,000
River Torrens	$2,760,000	$1,440,000	$1,320,000
Cowandilla Mile-End	$2,850,000	$1,160,000	$1,690,000

Catchment	Existing AAD	Upgrade AAD	Reduction
Keswick Creek Lateral Drains	$7,960,000	$3,190,000	$4,760,000
Keswick - Western Adelaide	$1,230,000	$1,230,000	0
Brown Hill Creek Lateral Drains	$4,190,000	$800,000	$3,390,000
Adelaide Airport	$130,000	$80,000	$40,000
Total	$21,090,000	$8,750,000	$12,340,000

4.9.2 Benefit Cost Ration (BCR)

Average Annual Damages (AAD) were determined for all major upgrade catchments for the existing infrastructure scenario and the upgrade scenario, refer to Section 4.7 for details.

Catchments that contain no proposed upgrades have not been considered in this analysis, though, in some cases they do benefit to some degree from the proposed works.

The total existing AAD for all catchments that contain upgrade works is $8.75M. The total AAD reduction for all catchments with proposed upgrade works was determined to be $12.34M.

The catchment AAD values were applied to the capital costs of the projects over a 50 year accounting period with a discount rate of 4.1% (IPART NSW Local Government Discount Rate). The majority of proposed upgrades are pit and pipe based and hence do not have an associated ongoing maintenance costs that need to be included in the analysis. For catchments with pump station upgrades an annual cost was included.

The resulting Net Present Value (NPV), Internal Rate of Return (IRR) and the BCR are shown in Table 4.27.

Table 4.27 – Benefit Cost Ratio Summary

Catchment	Reduction in AAD	Capital Costs	Annual Costs	IRR	NPV	BCR
River Torrens Pumping Stations	$960,000*	$23,210,000	$10,000	3%	-$3,400,000	0.82
Lockleys	$190,000	$4,100,000	-	4%	-$260,000	0.93
River Torrens	$1,320,000	$8,080,000	-	16%	$17,620,000	3.28
Cowandilla Mile-End	$1,730,000*	$26,230,000	-	6%	$8,150,000	1.32

Catchment	Reduction in AAD	Capital Costs	Annual Costs	IRR	NPV	BCR
Keswick Creek Lateral Drains	$4,760,000*	$28,730,000	-	17%	$64,060,000	3.33
Brown Hill Creek Lateral Drains	$3,390,000	$27,750,000	-	12%	$38,620,000	2.45

*Note:

- The River Torrens Pumping Stations reduction in AAD has been combined with the West Beach AAD as the upgrades impact properties within the West Beach Catchment.
- The Cowandilla Mile End reduction in AAD has been combined with the Adelaide Airport AAD as the upgrades impact properties within the airport catchment (north eastern are which connects into Cowandilla system)
- The Keswick Creek reduction in AAD has been combined with the Keswick – Western Adelaide AAD as the upgrades impact properties within the Keswick – Western Adelaide Catchment.

The River Torrens, Cowandilla Mile End, Keswick Creek Lateral Drains and Brown Hill creek lateral Drains catchment all have a BCR above 1, suggesting that in financial terms the benefits do outweigh the costs of the upgrades. The proposed upgrades significantly reduce the depth and extent of flooding in the larger AEP events and the number of properties impacted is significantly reduced.

The River Torrens Pumping Station and Lockleys catchments have a BCR just slightly less than 1. BCR values less than 1 are not unusual for flood mitigation proposals, particularly where benefits are only measured based on floor inundation direct damages.

4.10 Flood Mitigation Strategy Action Summary

A consolidated summary of flood mitigation strategies across the Study Area is presented in Table 4.28. Each of the strategies listed below were developed in order to address the flooding issues identified in Section 4. The objectives addressed (as outlined in Table 3.3) column identifies the objective(s) for which the proposed works is addressing.

Table 4.28 – Flood Mitigation Strategy Action Summary

Project ID	Project Location / Type of Works	Catchment	LGA	Related WSUD Action	Budget Estimate	Priority	Design AEP	Objectives Addressed
D1	Henley Beach Sth Pump Station Upgrade + Drainage	River Torrens Pumping Station	WT, CCS	Nil	$4,330,000 ($2,000 annual cost)	20 - 30 years	5% AEP	O1, O2, O3
D2	Burnley Pump Station + Drainage	River Torrens Pumping Station	WT, CCS	Multi-objective WSUD	$16,140,000 ($8,000 annual cost)	20 - 30 years	5% AEP	O1, O2, O3
D3	Riverway Drainage Upgrade	River Torrens Pumping Station	WT	Nil	$2,750,000	30 - 40 years	5% AEP	O1, O2
D4	Frontage Rd Drainage	Lockleys	WT	Multi-objective WSUD	$950,000	20 - 30 years	5% AEP	O1, O2, O3
D5	Matt St Drainage	Lockleys	WT	Multi-objective WSUD	$1,070,000	10 - 20 years	5% AEP	O1, O2, O3
D6	Douglas St Drainage	Lockleys	WT	Nil	$730,000	20 - 30 years	5% AEP	O1, O2
D7	Malurus Ave Drainage	Lockleys	WT	Nil	$460,000	20 - 30 years	5% AEP	O1, O2
D8	Grant Ave Drainage	Lockleys	WT	Multi-objective WSUD	$900,000	20 - 30 years	5% AEP	O1, O2, O3

Project ID	Project Location / Type of Works	Catchment	LGA	Related WSUD Action	Budget Estimate	Priority	Design AEP	Objectives Addressed
D9	Lasscock Ave Drainage	River Torrens	WT	Multi-objective WSUD	$1,130,000	0 - 10 years	5% AEP	O1, O2, O3
D10	Sheriff South Drainage + Raingardens	River Torrens	WT	Multi-objective WSUD	$280,000	Complete	5% AEP	O1, O2
D11	Sherriff North Drainage	River Torrens	WT	Nil	$910,000	20 - 30 years	5% AEP	O1, O2, O3
D12	Ashwin Parade Drainage	River Torrens	WT	Multi-objective WSUD	$2,010,000	0 - 10 years	5% AEP	O1, O2, O3
D13	Stephens Ave Drainage	River Torrens	WT	Nil	$630,000	10 - 20 years	5% AEP	O1, O2
D14	Ann Nelson Dr to Light Terrace Drainage and Detention Basin with Biofilter	River Torrens	WT	Multi-objective WSUD	$3,140,000	0 - 10 years	5% AEP	O1, O2, O3, O5, O9
D15	Cowandilla, Mile End to Keswick Creek Drainage	Cowandilla Mile End	WT	Nil	$23,040,000	20 - 30 years	5% AEP	O1, O2
D16	Airport Rd, Mellor Ave Drainage	Cowandilla Mile End	WT	Nil	$3,150,000	20 - 30 years	5% AEP	O1, O2
D17	Allen Ave, Lysle St Road Bunds	Cowandilla Mile End	WT	Nil	$32,000	0 - 10 years	5% AEP	O1, O2

Project ID	Project Location / Type of Works	Catchment	LGA	Related WSUD Action	Budget Estimate	Priority	Design AEP	Objectives Addressed
D18	Davenport Terrace Drainage	Keswick Creek Lateral Drains	WT	Nil	$3,040,000	10 - 20 years	5% AEP	O1, O2
D19	South Rd Mile End Drainage and Detention Storage	Keswick Creek Lateral Drains	WT	Nil	$1,560,000	10 - 20 years	5% AEP	O1, O2, O9
D20	Milner Rd Drainage and Detention Storage	Keswick Creek Lateral Drains	WT	Nil	$2,060,000	0 - 10 years	5% AEP	O1, O2, O9
D21	Arthur St Drainage	Keswick Creek Lateral Drains	WT	Nil	$1,410,000	0 - 10 years	5% AEP	O1, O2
D22	Chambers Ave Drainage	Keswick Creek Lateral Drains	WT	Nil	$930,000	0 - 10 years	5% AEP	O1, O2
D23	Knight St Drainage	Keswick Creek Lateral Drains	WT	Nil	$1,350,000	0 - 10 years	5% AEP	O1, O2
D24	Marleston to West Richmond Drainage and Detention Storage	Keswick Creek Lateral Drains	WT	Nil	$18,370,000	10 - 20 years	5% AEP	O1, O2, O9

Project ID	Project Location / Type of Works	Catchment	LGA	Related WSUD Action	Budget Estimate	Priority	Design AEP	Objectives Addressed
D25	Warwick Ave Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$1,590,000	0 - 10 years	5% AEP	O1, O2
D26	Gray St Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$1,770,000	0 - 10 years	5% AEP	O1, O2
D27	Harvey Ave Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$1,790,000	0 - 10 years	5% AEP	O1, O2
D28	Packard St Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$1,090,000	Complete	5% AEP	O1, O2
D29	Edward Davies St Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$800,000	0 - 10 years	5% AEP	O1, O2
D30	Glenburnie Tce Drain and Detention Basin with Biofilter	Brown Hill Creek Lateral Drains	WT	Multi-objective WSUD	$2,160,000	10 - 20 years	5% AEP	O1, O2, O3, O5, O9
D31	Spring St Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$670,000	10 - 20 years	5% AEP	O1, O2

Project ID	Project Location / Type of Works	Catchment	LGA	Related WSUD Action	Budget Estimate	Priority	Design AEP	Objectives Addressed
D32	North Plympton Trunk Drain + Laterals	Brown Hill Creek Lateral Drains	WT	Nil	$14,970,000	0 - 10 years	5% AEP	O1, O2
D33	Emma Pl Surcharge Basin Re-shape	Brown Hill Creek Lateral Drains	WT	Nil	$100,000	0 - 10 years	5% AEP	O1, O2
D34	Penong Ave Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$1,150,000	10 - 20 years	5% AEP	O1, O2
D35	Hoylake St / Albert Ave Drainage	Brown Hill Creek Lateral Drains	WT	Nil	$1,720,000	0 - 10 years	5% AEP	O1, O2
D36	Keswick Creek Channel Investigation and Prelim Design	Various	Various	N/A	$200,000	0-10 years	N/A	O2
D37	Community Flood Response and Preparedness	N/A	All	N/A	($10,000 annually)	0-10 years	N/A	O8
D38	Community Flood Response and Preparedness – Council's Community Emergency Management Plan	N/A	All	N/A	N/A	0-10 years	N/A	O8
D39	Development Controls – Floor Levels	N/A	All	N/A	N/A	0-10 years	N/A	O7

Project ID	Project Location / Type of Works	Catchment	LGA	Related WSUD Action	Budget Estimate	Priority	Design AEP	Objectives Addressed
D40	Development Controls – On-site Detention / Retention	N/A	All	N/A	N/A	0-10 years	N/A	O7
D41	Ongoing Maintenance and Monitoring of Council Assets	N/A	N/A	N/A	N/A	N/A	N/A	O6
				TOTAL	**$118,380,000**			

4.11 1% AEP Flood Standard Upgrade Comparison

To achieve a 5% AEP standard, many of the proposed upgrades are reaching the practical maximums when considering construction feasibility and costs involved. To build a better understanding of what it is involved to achieve a 1% AEP flood standard, the proposed upgrades in the North Plympton and Camden Park areas were extended and increased to attempt to reach a 1% AEP standard. The area considered consists of the three upgrades listed below.

- D32 – North Plympton Trunk Drain + Laterals
- D34 – Penong Avenue Drainage
- D35 – Hoylake Street / Albert Avenue Drainage

The key differences between the 5% AEP upgrade and 1% AEP upgrade are listed below:

- The main trunk drain along Kinkaid Avenue is two duplicate box culverts rather than one.
- Instead of an open channel upstream of the outlet, a larger system was required and so the channel was replaced with three underground parallel 3600mm wide box culverts.
- All proposed lateral systems have had their pipe sizes increased and additional lateral systems have been required along Morphett Road, Shepard Court, Fitzroy Avenue and parallel to Brown Hill Creek from the Northern end of Deeds Road.
- Many more large junction boxes are required.
- Greater pit inlet capacity resulting in many more side entry pits.

Figure 4.78 provides the layout of the 1% AEP proposed upgrade with the 1% AEP floodplain. Table 4.29 lists the difference in amounts of construction materials and Table 4.30 shows cost differences between the two upgrades. As shown the 1% AEP upgrade solution would cost nearly double that of the 5% AEP design. Extrapolating this increase to the whole of West Torrens to achieve a 1% flood protection standard results in a total cost of $232,110,000, compared to $118,380,000 for the 5% AEP standard.

Table 4.29 – Comparison of construction materials required

Item	5% Standard, Amount	1% Standard, Amount
Large box culverts (> 900mm width)	1,672 metres	3,851 metres
Large RCP (> 750mm)	2,141 metres	4,552 metres
Small RCP (<= 750mm)	2,155 metres	2,436 metres
Large drainage structures	64 structures	104 structures
Small drainage structures	190 structures	290 structures

Table 4.30 – Cost Comparison, 5% AEP vs 1% AEP Standard

Upgrade Scheme	5% AEP Standard Cost	1% AEP Standard Cost	% increase
North Plympton Trunk Drain + laterals	$14,966,960	$30,237,831	102%
Penong Ave	$1,148,800	$2,121,452	85%
Graham Cres / Albert Ave	$1,717,131	$2,606,495	52%
Total Camden Park, North Plympton Upgrades	**$17,832,890**	**$34,965,778**	**96%**
Total West Torrens Flood Mitigation Upgrades	***$118,380,000***	***$232,110,000*** *(extrapolated)*	***96%***

The damages for the 1% AEP event were calculated for the 1% AEP standard upgrades and compared to the damages for the same event with the 5% AEP standard upgrades. The total damages for the area of concern for the 5% AEP standard was $8,840,000 (see Table 4.26). The damages for the 1% standard upgrades were calculated to be $2,940,000, resulting in a 67% decrease in damages for the area.

To provide an approximate estimate of the BCR for the 1% AEP standard upgrades, the 67% decrease in damages was applied to the 5% AEP standard upgrade ADD for each catchment as shown below in Table 4.31. This provides a new reduction in ADD for each catchment. Using the updated capital costs and reduction in ADD, the Net Present Value (NPV), Internal Rate of Return (IRR) and the BCR were estimated (Table 4.32 below). As can be seen, constructing upgrades that provide a 1% AEP flood standard does produce a BCR above 1 for the majority of catchments. This suggests that in financial terms the benefits do outweigh the costs of the upgrades. When comparing the BCR to 5% standard upgrades (see Table 4.32), the only catchment that performs better is the Lockleys Catchment. This suggests that the 5% standard upgrades predominantly provide a better long term financial outcome.

However, the question remains whether constructing drainage upgrades to reach the 1% standard is physically possible given the number and size of new infrastructure required. Further design development and feasibility investigations are required (in particular, considering other existing underground services).

Table 4.31 – AAD Comparison, 5% AEP vs 1% AEP Standard

Catchment	Existing AAD	5% AEP Upgrade AAD	1% AEP Upgrade AAD
West Beach	$280,000	$150,000	$50,000
River Torrens Pumping Stations	$1,030,000	$200,000	$70,000

Catchment	Existing AAD	5% AEP Upgrade AAD	1% AEP Upgrade AAD
Lockleys	$670,000	$480,000	$160,000
River Torrens	$2,760,000	$1,440,000	$480,000
Cowandilla Mile-End	$2,850,000	$1,160,000	$380,000
Keswick Creek Lateral Drains	$7,960,000	$3,190,000	$1,050,000
Keswick - Western Adelaide	$1,230,000	$1,230,000	$410,000
Brown Hill Creek Lateral Drains	$4,190,000	$800,000	$260,000
Adelaide Airport	$130,000	$80,000	$30,000
Total	$21,090,000	$8,750,000	$2,890,000

Table 4.32 – Benefit Cost Ratio Summary

Catchment	Reduction in AAD		IRR		NPV		BCR	
	5% AEP standard	1% AEP standard	5% AEP standard	1% AEP standard	5% AEP standard	1% AEP standard	5% AEP standard	1% AEP standard
River Torrens Pumping Stations	$960,000	$1,200,000	3%	1%	-$3,400,000	-$20,760,000	0.82	0.52
Lockleys	$190,000	$510,000	4%	6%	-$260,000	$2,100,000	0.93	1.27
River Torrens	$1,320,000	$2,280,000	16%	14%	$17,620,000	$28,790,000	3.28	2.90
Cowandilla Mile-End	$1,730,000	$2,560,000	6%	4%	$8,150,000	$70,000	1.32	1.00
Keswick Creek Lateral Drains	$4,760,000	$7,730,000	17%	14%	$64,060,000	$94,730,000	3.33	2.76
Brown Hill Creek Lateral Drains	$3,390,000	$3,930,000	12%	7%	$38,620,000	$23,430,000	2.45	1.45

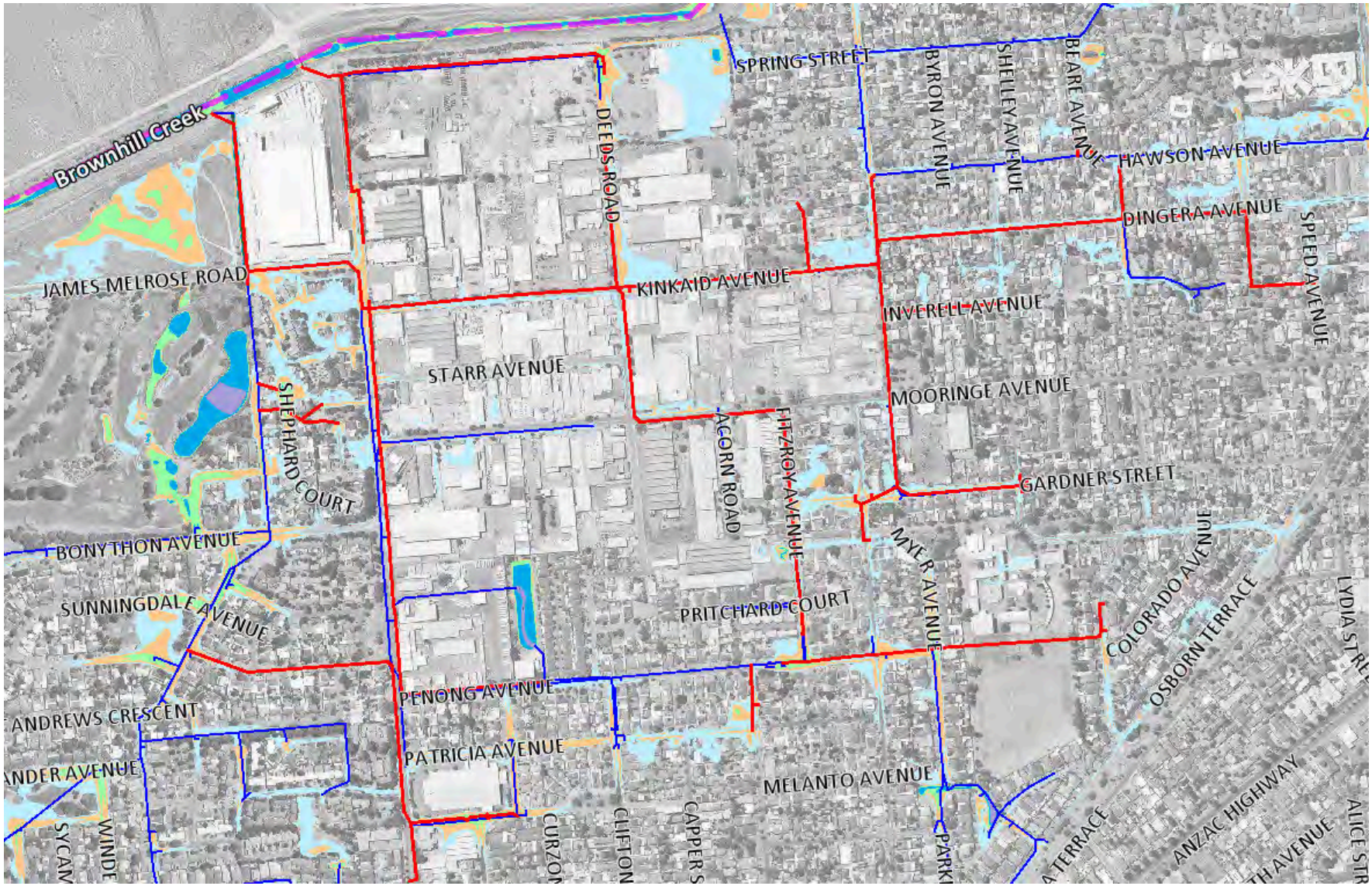


Figure 4.78 – 1% Standard Upgrade Floodplain

5 Water Sensitive Urban Design

5.1 Receiving Waters

The majority of stormwater runoff from the West Torrens catchment discharges into the Patawalonga Lake/Barcoo Outlet before entering the Gulf St Vincent. Stormwater flows reach the Barcoo Outlet via the Brown Hill Creek/Keswick Creek channels, the Patawalonga Creek and the Adelaide Airport channels. The northern major catchments of West Torrens discharge directly into the River Torrens before entering the Gulf.

The habitats most likely to be impacted by stormwater discharges are those along the River Torrens and marine environments located downstream of stormwater outlets (Barcoo Outlet). Stormwater dilution away from outfalls will vary greatly over the area due to hydrodynamics, also affecting the load and concentration of contaminants reaching different areas.

5.2 Potential Risks from Stormwater Outflows

Potential risks from stormwater are increased suspended sediments, which have impacts through light reduction (turbidity) and sedimentation, nutrients, other contaminants such as metals, pesticides, hydrocarbons, and emerging organic contaminants, and reduced salinity due to freshwater inputs (Gaylard 2009b). The ACWS and other investigations on the Adelaide coast have demonstrated negative impacts to reef and seagrass habitats, particularly from sediments and nutrients (Gorgula and Connell 2004; Turner 2004; Fox *et al.* 2007; Gorman *et al.* 2009).

5.2.1 Risks to habitats in the vicinity of stormwater outfalls

In addition to contributing to chronic nutrient effects on a wider scale, local impacts from stormwater nutrients, such as blooms of harmful dinoflagellates (red tides), or increased growth of opportunistic (*Ulva* spp.) or invasive (*Caulerpa* and *Codium* spp) green algae, could occur in the vicinity of outfalls to the Barcoo Outlet and River Torrens mouth more generally if nutrient levels are too high. The expansion of *Zostera* seagrass in the Gulf could be threatened or potentially reversed by elevated nutrients from the West Torrens catchment. Although phosphorus is not noted as being of concern currently in Adelaide waters, phosphorus inputs can promote algal blooms where nitrogen is not limiting (EPA 2008; McDowell and Pfennig 2011).

Stormwater is likely to be major contributor to local turbidity, and, given the correlation between TSS and other contaminants (Mills and Williamson 2008), habitats surrounding outfalls could be at risk of impacts from these pollutants, particularly metals. *Zostera* seagrass would be at risk from turbidity and sedimentation.

The River Torrens provides habitat to a number of species of native flora and fauna. There are several outfalls from the West Torrens Catchment that directly discharge into the River with minimal treatment measures in place. The river habitat could be at risk from the impacts of pollutants being directly discharged into the system.

5.2.2 Community Health and Social Impacts

Stormwater outflows also create risks to community health and other social issues that are relevant for local governments. Poor water quality being discharged into coastal environments can create an unsafe swimming environment for the public. Beaches can be closed due to

increased pollutant concentration, resulting in a lack of access to an important social open space for the community.

5.3 Water Quality Modelling Approach

An estimation of the pollutant loads and concentrations within stormwater discharges from the urban catchment to the receiving waterbodies has been undertaken. The MUSIC (Model for Urban Stormwater Improvement Conceptualisation) computer software package developed by the Cooperative Research Centre for Catchment Hydrology has been used for this purpose.

MUSIC can be used to simulate the quantity and quality of runoff from stormwater catchments, and predict the performance of stormwater quality management systems. The MUSIC model requires user defined meteorological and catchment data to estimate the quantity and quality of stormwater runoff for a given catchment, as described below.

5.3.1 Meteorological Data

Water Sensitive SA provides meteorological data for different regions in SA as recommended by the South Australian MUSIC Guidelines. 'Adelaide Dry' data has been used for the SMP MUSIC modelling as shown in Figure 5.1 (average annual rainfall of 450 mm). Table 5.1 provides the key data for each region.

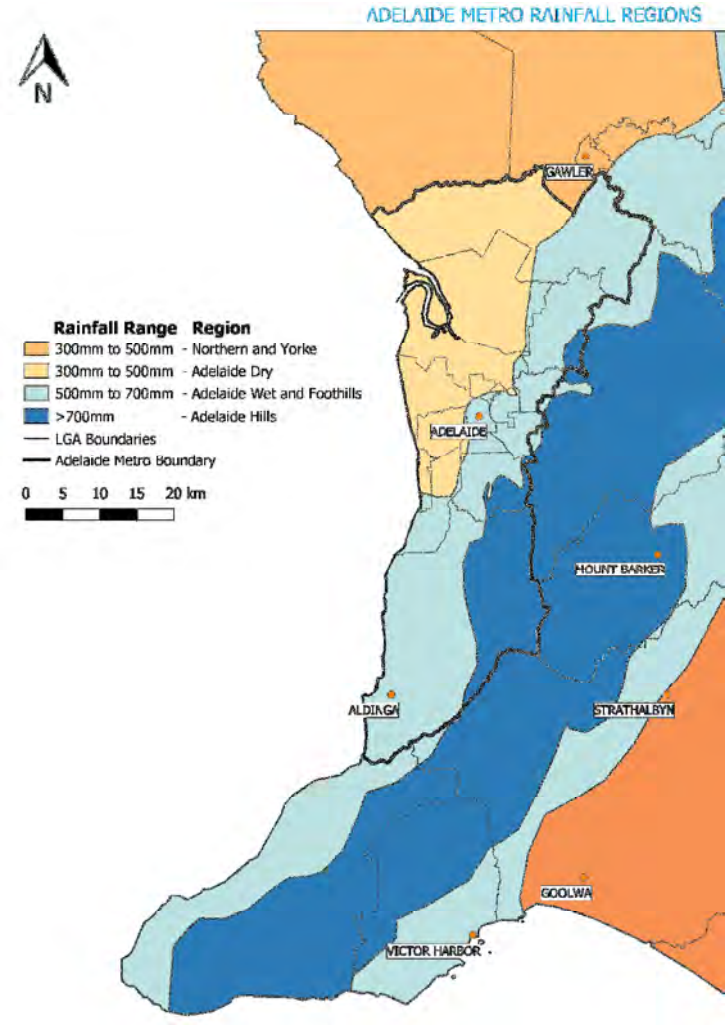


Figure 5.1 – Adelaide Metro rainfall Regions (South Australian MUSIC Guidelines)

Table 5.1 – Adelaide Metro rainfall Regions (South Australian MUSIC Guidelines)

Region	Rainfall band (mm)	Rainfall station	Period	Period mean annual rainfall (mm)	Mean annual PET (mm)
Adelaide Dry	300-500	23013 Parafield Airport	1979-1988	450	1159
Adelaide Wet & Foothills	500-700	23090 Adelaide-Kent Town	1983-1992	585	1143
Adelaide Hills	700+	23875 Parawa (Second Valley AWS)	2001-2010	866	1132
Northern Yorke	300-500	23122 Roseworthy AWS	2001-2010	404	1145

For the climate change scenario, a period of data was selected from the Adelaide Airport gauge that equated to a 15% reduction in annual average rainfall of the 'Adelaide Dry' region. 6 minute rainfall data for the years 2001-2009 was selected which provided an average annual rainfall of 390 mm (approximately 15% reduction of 450 mm).

5.3.2 Catchment Area and 'Effective Impervious' Fraction

The 'effective impervious' fraction adopted in MUSIC should correspond to the 'directly connected paved' (DCP) portion of the catchment area. The stormwater runoff volumes estimated by MUSIC are highly sensitive to this value.

The MUSIC models compiled for the West Torrens catchments are based on the ultimate development scenario, and the typical 'effective impervious' fractions for development in the Study Area were estimated to be:

- 0.2 to 0.3 for low density residential development;
- 0.4 to 0.6 for high density residential development; and
- 0.6 to 0.8 for high density commercial and industrial developments.

These values were adjusted for individual subcatchments based on the relative proportions of urban development and open space within the subcatchment area under the ultimate development scenario; hence the 'effective impervious' fractions for the MUSIC subcatchments varied from 0.01 to 0.9.

5.3.3 Rainfall-runoff Parameters

A 'rainfall threshold' of 1 mm has been adopted for the impervious areas (commonly referred to as the initial loss), which is consistent with the industry standard approach to hydrological modelling of urban catchments.

A 'soil storage capacity' of 40 mm and 'field capacity' of 30 mm have been adopted for the pervious areas, which is consistent with MUSIC's recommended values for the Adelaide region. The stormwater runoff volumes estimated by MUSIC are not sensitive to variation in parameters defining the pervious area response to rainfall (except where impervious fractions are low).

5.3.4 Pollutant Load Parameters

MUSIC's default pollutant load parameters have been adopted for Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP), which are based on a comprehensive review of worldwide stormwater quality in urban catchments undertaken by Duncan (1999), supplemented by local data specific to regional applications.

MUSIC's default pollutant load parameters have also been adopted for Gross Pollutants (GP), which are based on field monitoring data of Allison et al (1997) for 12 storm events in an inner city suburb.

The above parameters are consistent with those recommended for use in *Chapter 15 - Modelling Process and Tools, Water Sensitive Urban Design Technical Manual for the Greater Adelaide Region* (Department of Planning and Local Government, 2010).

5.3.5 Model Structure and Output

The individual pit level subcatchments from the DRAINS model described in Section 4.2 were aggregated into larger catchments, based on areas of similar land use and/or to reflect the contributing area to specific points of interest in the stormwater management system (i.e. outfalls, location of treatment measures). This approach enables estimates to be obtained of the quantity and quality of runoff at these points of interest and guides the development of the water quality improvement strategy for the catchment.

MUSIC can provide summary results for each point of interest as follows:

- Sources – the annual pollutant loadings and quantity of water that arrive at outlet under no treatment;
- Residual – the annual pollutant loadings and quantity of water that arrive at outlet with the included treatment devices; and
- Percent reduction – the percentage reduction in pollutant loadings as a result of the included treatment devices (ie. between the Sources and Residual loadings).

The MUSIC models for the West Torrens catchments have been structured to enable results to be reported for each major catchment discharging into their respective receiving water body as shown in Table 5.2.

The major Lockleys, and Cowandilla Mile End catchments have been combined into one larger catchment for the purposes of water quality modelling because there are significant, downstream WSUD elements that treat the combined runoff from each separate catchment.

The other major catchments have not been combined because the receiving water bodies are fed by much larger catchments which are not fully contained within the model area. Significant WSUD elements towards the downstream ends of the River Torrens and Brown Hill/Keswick Creek (trash racks, basins, wetlands) have not been modelled as they are designed to treat much larger catchment areas and the amount of pollutants entering these channels from upstream of the West Torrens area is not known. If these WSUD elements were to be modelled, then pollutant reductions would be significantly overstated for these catchments. Hence, the River Torrens and Brown Hill/Keswick Creek are also seen as receiving water bodies.

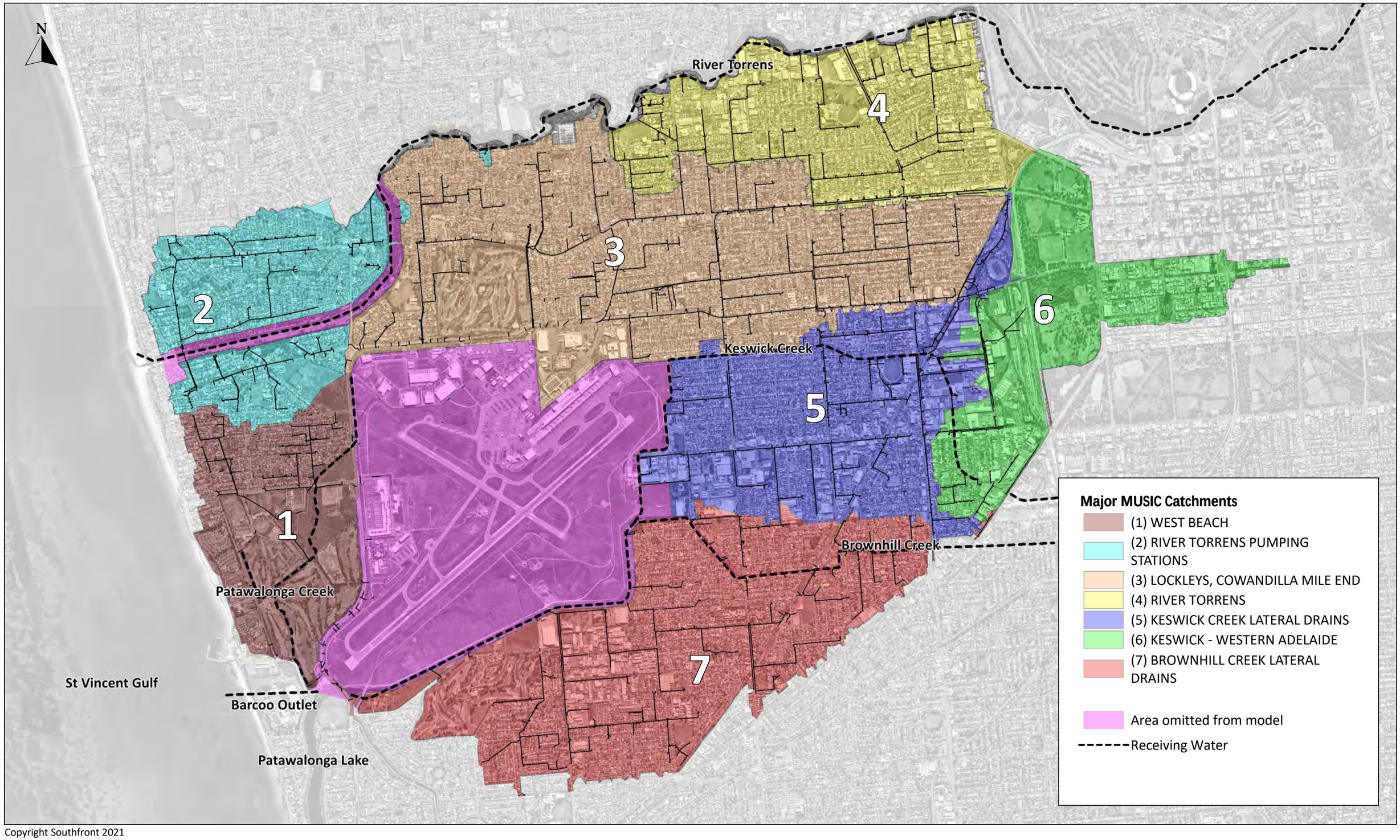
The majority of the Adelaide Airport catchment has not been included in the MUSIC model. The airport internal drainage system is not part of the Council owned network. The airport system is

a separate system discharging into the Patawalonga Creek (receiving water body) and should be assessed for water quality separately.

Figure 5.2 provides a graphical representation of the major catchments used for water quality modelling.

Table 5.2 – Major Catchments for MUSIC Modelling Output Reporting

Reference	Major Catchments	Receiving Water Body
1	West Beach	Patawalonga Creek
2	River Torrens Pumping Stations	River Torrens
3	Lockleys + Cowandilla Mile End	Patawalonga Creek
4	River Torrens	River Torrens
5	Keswick Creek Lateral Drains	Keswick Creek
6	Keswick – Western Adelaide	Keswick Creek
7	Brown Hill Creek Lateral Drains	Brown Hill Creek



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Data Sources:
City of West Torrens [Existing Stormwater Network]
NearMap [Aerial Photograph]

southfront

West Torrens
Stormwater Management Plan

Water Quality Major Catchments
Figure 5.2

5.4 Baseline Scenario MUSIC Model

A MUSIC model was compiled for the West Torrens catchments using the input parameters described above, to represent the 'baseline' scenario, whereby all stormwater runoff generated within the Study Area is discharged to the receiving environment with no pre-treatment. Three separate 'baseline' models were produced each representing a difference scenario; existing development (Scenario 1), future development (Scenario 2), and future development with reduced annual rainfall due to climate change (Scenario 3 & 4) as described in Section 2.5.3.

The purpose of the baseline MUSIC models is to estimate the pollutant loads generated by the catchment under the different scenario conditions and to facilitate an assessment of the water quality improvement performance of existing and proposed treatment measures. The whole baseline scenario MUSIC model layout is shown in Appendix G.

A summary of the average annual pollutant loadings and quantity of stormwater runoff generated by the whole Study Area and individual catchments under each scenario are provided in the following tables.

Table 5.3 – MUSIC Model Results; Baseline Scenario, Total West Torrens Study Area discharging into various receiving waters (ultimately Gulf St Vincent)

Parameter	Source Load		
	Scenario 1 (Existing Development)	Scenario 2 (Future Development)	Scenario 3 & 4 (Climate Change)
Flow (ML/yr)	6,380	6,840	5,120
Total Suspended Solids (kg/yr)	1,210,000	1,310,000	1,000,000
Total Phosphorous (kg/yr)	2,510	2,730	2,070
Total Nitrogen (kg/yr)	18,000	19,400	14,600
Gross Pollutants (kg/yr)	255,000	279,000	226,000

Table 5.4 – MUSIC Model Results; Baseline Scenario, West Beach Total discharging into Patawalonga Creek

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	348	369	248
Total Suspended Solids (kg/yr)	56,600	60,300	43,500
Total Phosphorous (kg/yr)	124	136	93.2
Total Nitrogen (kg/yr)	951	1,010	688
Gross Pollutants (kg/yr)	8,440	9,760	7,770

Table 5.5 – MUSIC Model Results; Baseline Scenario, Lockleys, Cowandilla Mile End Catchment Total discharging into Patawalonga Creek

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	1,580	1,700	1,270
Total Suspended Solids (kg/yr)	298,000	324,000	247,000
Total Phosphorous (kg/yr)	621	673	512
Total Nitrogen (kg/yr)	4,470	4,810	3,600
Gross Pollutants (kg/yr)	63,700	69,700	56,500

Table 5.6 – MUSIC Model Results; Baseline Scenario, River Torrens Pumping Station Total discharging into the River Torrens

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	517	568	420
Total Suspended Solids (kg/yr)	95,400	107,000	81,200
Total Phosphorous (kg/yr)	200	224	167
Total Nitrogen (kg/yr)	1,460	1,610	1,190
Gross Pollutants (kg/yr)	20,500	23,400	18,900

Table 5.7 – MUSIC Model Results; Baseline Scenario, River Torrens Total discharging into the River Torrens

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	907	965	737
Total Suspended Solids (kg/yr)	177,000	191,000	147,000
Total Phosphorous (kg/yr)	364	392	301
Total Nitrogen (kg/yr)	2,590	2,760	2,110
Gross Pollutants (kg/yr)	38,400	41,100	33,600

Table 5.8 – MUSIC Model Results; Baseline Scenario, Brown Hill Creek Lateral Drains Total discharging into Brown Hill Creek

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	1,230	1,340	1,010
Total Suspended Solids (kg/yr)	233,000	260,000	199,000
Total Phosphorous (kg/yr)	483	537	411
Total Nitrogen (kg/yr)	3,470	3,820	2,880
Gross Pollutants (kg/yr)	49,200	55,100	44,700

Table 5.9 – MUSIC Model Results; Baseline Scenario, Keswick Creek Lateral Drains Total discharging into Keswick Creek

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	1,040	1,110	849
Total Suspended Solids (kg/yr)	203,000	220,000	169,000
Total Phosphorous (kg/yr)	417	452	346
Total Nitrogen (kg/yr)	2,960	3,170	2,450
Gross Pollutants (kg/yr)	43,900	47,200	38,500

Table 5.10 – MUSIC Model Results; Baseline Scenario, Keswick – Western Adelaide Total discharging into Keswick Creek

Parameter	Source Load		
	Scenario 1	Scenario 2	Scenario 3 & 4
Flow (ML/yr)	755	784	595
Total Suspended Solids (kg/yr)	146,000	152,000	118,000
Total Phosphorous (kg/yr)	303	316	241
Total Nitrogen (kg/yr)	2,150	2,230	1,690
Gross Pollutants (kg/yr)	30,900	32,200	26,200

5.5 Existing Water Sensitive Urban Design

An existing scenario MUSIC model of the West Torrens study area was created which included WSUD measures already existing within the catchment. The creation of this model was necessary to understand the impact the existing treatment measures have on water quality and to what extent they reach the required water quality improvement targets outlined in Section 5.6. Three separate existing WSUD models were produced for each scenario (existing development (Scenario 1), future development (Scenario 2), and future development with reduced annual rainfall due to climate change (Scenario 3 & 4)). Each existing model was compared to its respective baseline scenario model.

The existing WSUD MUSIC model will ultimately be used to create the future MUSIC model which will include proposed WSUD measures.

Existing WSUD measures present in the study area were identified through the following sources:

- Council supplied data and reports
- WSUD Interactive Map – watersensitivesa.com.au
- Site inspections
- GIS measurements

In some cases, MUSIC subcatchments were spilt up when an existing WSUD measure only treats a portion of the subcatchment area. See an example of this in Figure 5.3 below.



Figure 5.3 – Example of MUSIC subcatchment being separated by 'area being treated by raingardens' and 'area with no treatment'

As previously mentioned, WSUD measures within the River Torrens, Brown Hill Creek and Keswick Creek have not been modelled as the contributing catchments that are treated by these measures extend far upstream of the West Torrens SMP Study Area.

The following sections describe the identified WSUD measures that were included in the existing MUSIC models. An overview of all the existing WSUD measures modelled within the Study Area is provided in Figure 5.4.

Note that measures such as existing privately owned rainwater tanks have not been included in this assessment. Rainwater tanks will be included as a part of the future upgrade scenario based on the predicted amount of new development.



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Data Sources:
City of West Torrens [Existing Stormwater Network, Existing WSUD]
WSSA [Existing WSUD]
NearMap [Aerial Photograph]

southfront

West Torrens
Stormwater Management Plan

Existing Water Sensitive Urban Design - Location Plan
Figure 5.4

5.5.1 Constructed Wetlands

Constructed wetlands are artificial versions of a natural wetland system that use vegetation, enhanced sedimentation, fine filtration, and biological pollutant uptake processes to improve water quality.

Wetlands function to improve water quality by:

- Removing sediments and suspended solids, together with their attached pollutants
- Removing a range of dissolved nutrients and contaminants.

Wetlands also reduce peak flows from frequent rainfall events and thus reduce downstream erosion potential and can facilitate stormwater harvesting.

A total of six constructed wetlands are located in the West Torrens Study Area and are listed below:

- Apex Park Wetland
- Sir Donald Bradman Drive Wetland
- Glenelg Golf Course Wetland – not modelled as described below.
- Kings Reserve Wetland
- Western Parklands ephemeral wetland
- Breakout Creek Wetland – not modelled as described below.

The Glenelg Golf Course Wetland treats water pumped from Brown Hill Creek along with water that falls directly on the Golf Course. The water pumped from Brown Hill Creek has is not included in this assessment as the Brown Hill Creek Catchment extended far beyond the West Torrens area.

The Breakout Creek wetland which is a part of the River Torrens has not been modelled for the same reason as above; the River Torrens Catchment extends beyond the scope of the SMP. It is noted Breakout Creek Wetland Stage 3, located west of Tapleys Hill Road, is currently being designed to have local drainage outlet wetlands. These will treat water quality of the majority of the River Torrens Pumping Stations Catchment but have not yet been constructed and are not included in the SMP modelling, as agreed upon with the CWT.

The Apex Park Wetland (Figure 5.5) treats runoff from the majority of the River Torrens Pumping Stations Catchment. The wetland has been assumed to treat up to a 1 EY flow as the wetlands is situated at the low point of the catchment.

The Sir Donald Bradman Drive Wetland (Figure 5.6) is situated at the north-west corner of the Airport and has been assumed to treat up to a 3-month flow of the upstream contributing catchment area.

For the existing MUSIC model, all constructed wetlands were assumed to be working optimally.

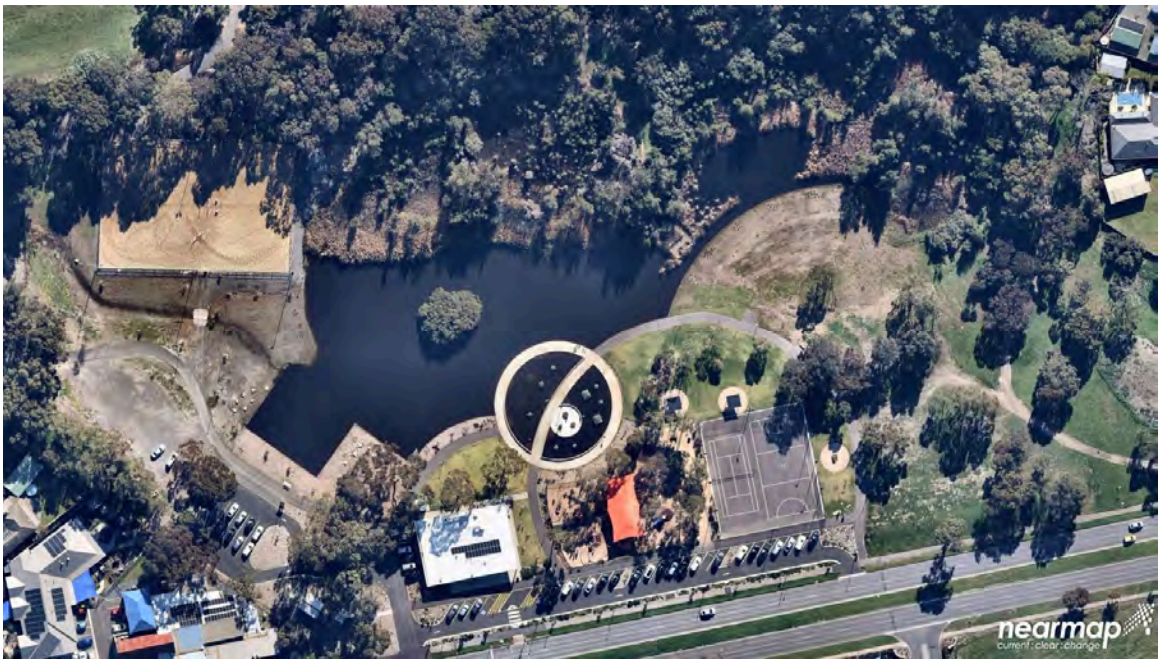


Figure 5.5 – Apex Park Wetland



Figure 5.6 – Sir Donald Bradman Drive Wetland

5.5.2 Detention Basins

Detention Basins are a common stormwater management technique to mitigate stormwater flows to a level that ensures that the performance of the downstream drainage systems and associated flood risk are not adversely affected.

There are several online detention basins throughout the West Torrens Study Area which provide some water quality improvement for base flows.

Modelling parameters for the various online detention basins and infiltration systems were determined by site inspections and GIS measurements.

5.5.3 Bioretention Systems (Raingardens)

Bioretention systems, also known as raingardens, are landscaped basins that facilitate treatment of stormwater by vegetation prior to the filtration of runoff through soil media. Percolated runoff is typically collected at the base of the filter media using perforated underdrains for subsequent harvesting and reuse or discharge to receiving waterways.

The system can be lined to prevent infiltration to the surrounding soil profile, and a submerged zone is often incorporated beneath the underdrain to improve the potential for denitrification and provide a moisture storage to support the vegetation during prolonged periods without rainfall.

Maintenance of bioretention systems is primarily about promoting healthy vegetation, removing excess collected sediments, ensuring the surface remains free draining and removing any material that blocks hydraulic structures. A simple schematic showing how stormwater is passed through a bioretention system is shown Figure 5.7.

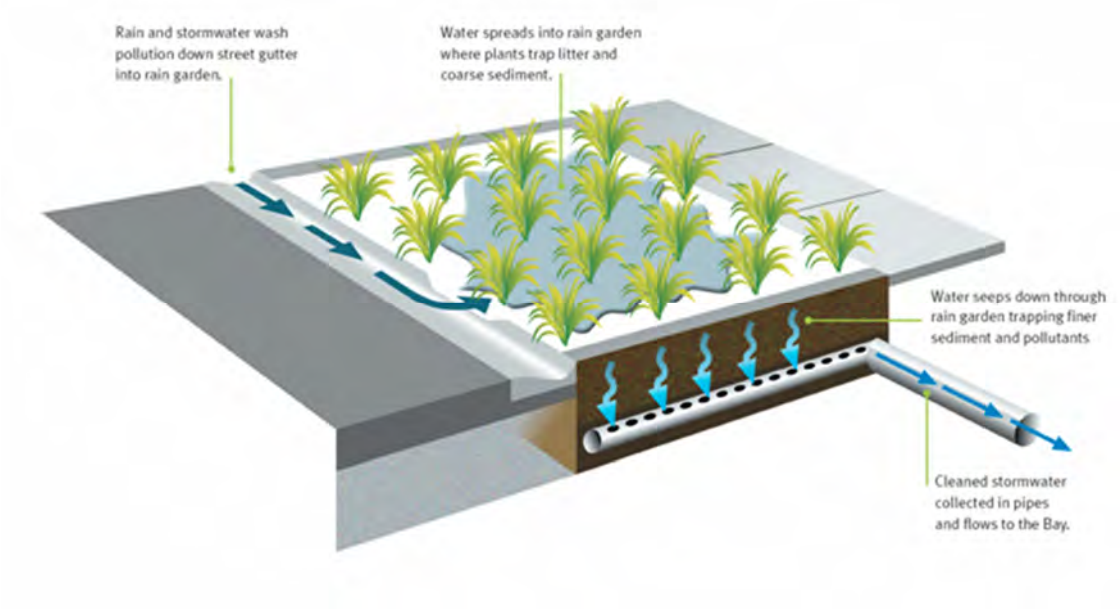


Figure 5.7—Bioretention System Schematic (City of Kingston)

There are numerous existing streetscape raingarden systems present throughout the catchment. Suburbs such as Mile End have the majority of their catchment area being treated by streetscape raingardens. An example of a streetscape bioretention system, in its establishment phase, is shown in Figure 5.8.



Figure 5.8—Bioretention System (Raingarden), Tarragon Street, Mile End

West Torrens rain gardens have been categorised into four groups. Raingardens were compiled for each subcatchment as one treatment node based on the number and types of each raingarden treating that subcatchment. Modelling assumptions for each raingarden type are provided in Table 5.11.

Table 5.11 – Existing Raingarden Parameters

MUSIC Model parameter	Raingarden Tree Pit	Small Raingarden	Medium Raingarden	Large Raingarden
Surface Area (m^2)	7	20	35	75
Filter area (m^2)	6	18	32	68
Filter depth (m)	0.5	0.5	0.5	0.5
Base Lined?	Yes	Yes	Yes	Yes

5.5.4 Tree Infiltration Wells

There are numerous tree infiltration wells throughout the West Torrens Study Area. An example of one is provided in Figure 5.9 below. The City of West Torrens has been an active adopter of tree infiltration wells and permeable pavements with new tree plantings. These provide incremented improvements to water quality and volume reduction of runoff flows through passive reuse. These were modelled in MUSIC as small infiltration systems treating low flows.



Figure 5.9 – Example Tree Infiltration Well

5.5.5 Gross Pollutant Traps

Gross Pollutant Traps (GPTs) are primary treatment devices that are designed to remove anthropogenic waste, organic matter and coarse sediment from stormwater flows. There are many different proprietary makes and models of GPT, ranging from below ground 'wet sump' devices to above ground trash racks and capture nets on pipe outlets.

GPTs were assumed to treat up to a 3 month flow. Assumed pollutant removal efficiencies for the two types of GPTs modelled are shown in Table 5.12.

Table 5.12 – Assumed Gross Pollutant Trap Annual Pollutant Removal Efficiency

Pollutant	Trash Rack	HumeGard® GPT (various sizes) [1]
Total Suspended Solids	0%	41%
Total Phosphorous	0%	44%
Total Nitrogen	0%	24%
Gross Pollutants	50%	85%

[1] Values taken from MUSIC node for HumeGard® provided on Humes website.

5.5.6 Other existing measures not modelled

Not all existing water quality improvement measures in the Study Area were modelled. Privately Owned Rainwater Tanks contribute to stormwater flow reduction, but these were not modelled

as the number of tanks is unknown. For the future upgrade modelling an assumption is made for the number and size of rainwater tanks included as a part of new developments.

Some commercial and industrial developments have onsite WSUD measures in place to ensure their stormwater runoff being discharged into Councils systems is being treated. The extent of private development treatment measures is unknown. Not including these measures in the modelling is a conservative approach and water quality improvements could be greater than indicated.

5.5.7 Assessed Performance

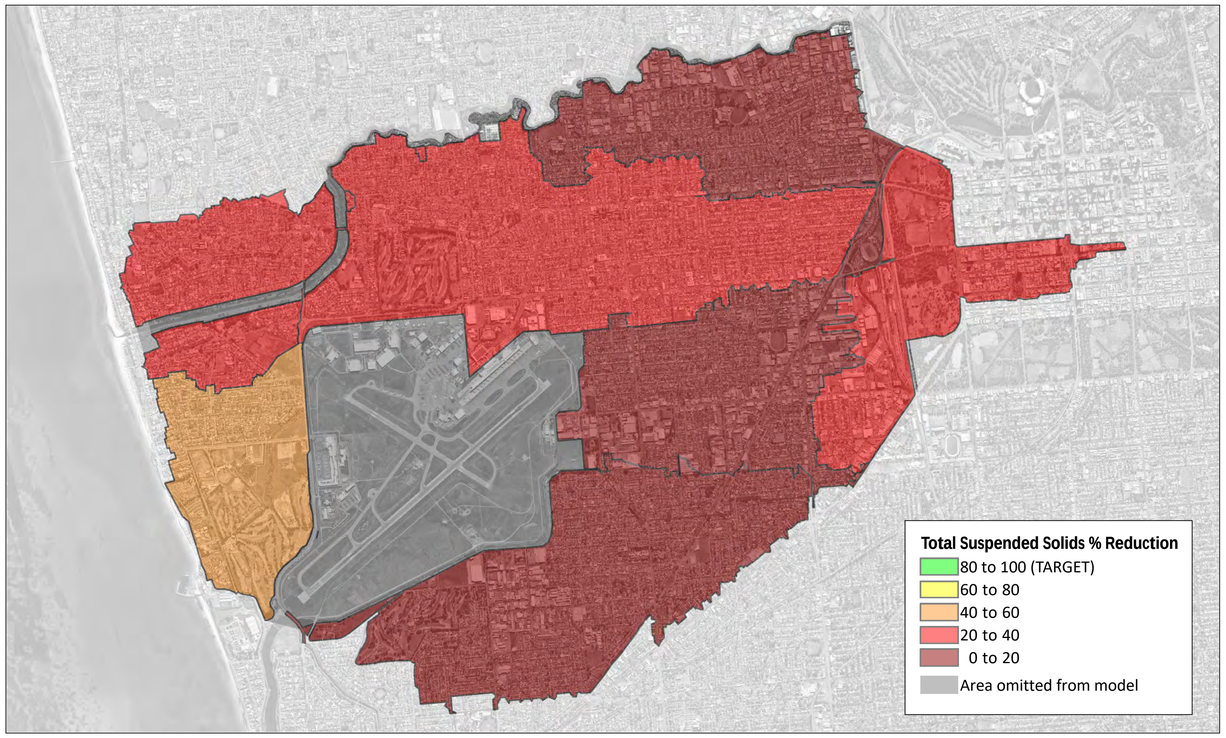
The MUSIC model was executed to assess the overall performance of the existing WSUD scenario under existing climate conditions and existing development as summarised in Table 5.13. Table 5.14 to Table 5.20 provide the performance for each separate catchment discharging into their respective receiving water body under existing climate conditions and existing development (Scenario 1).

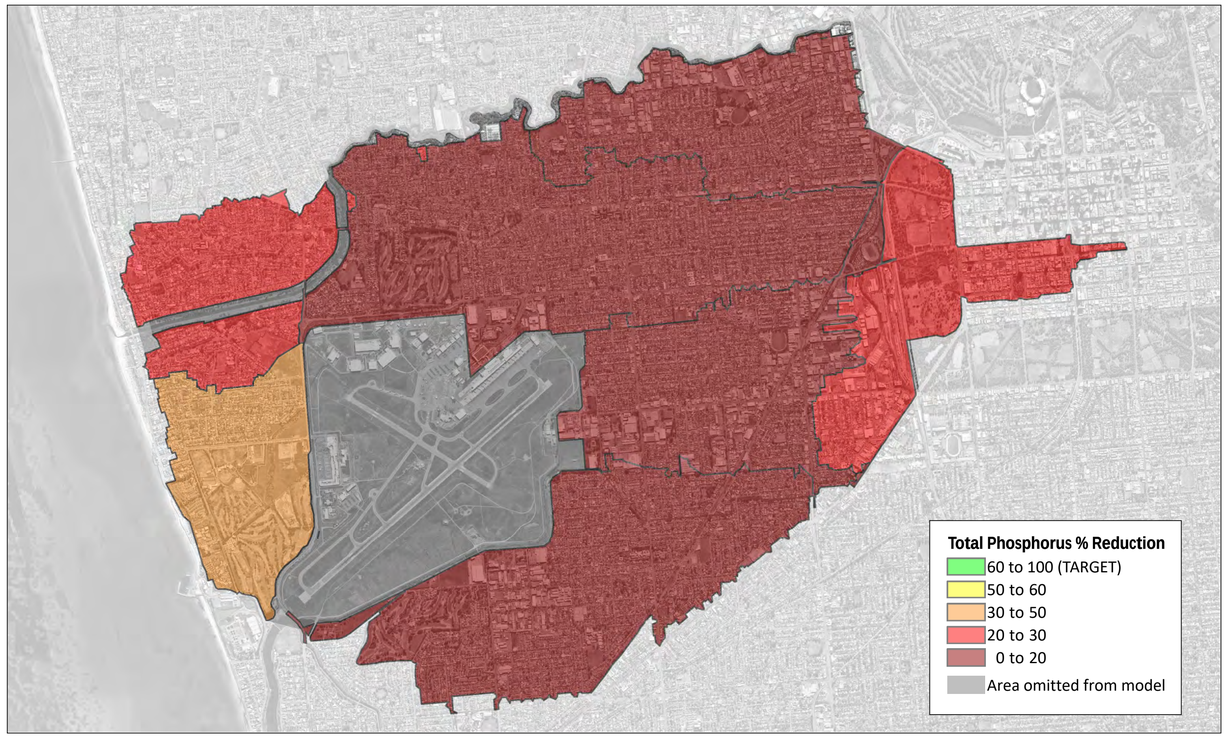
Table 5.13 – Existing Scenario 1, Total West Torrens Catchment Area discharging into Gulf St Vincent

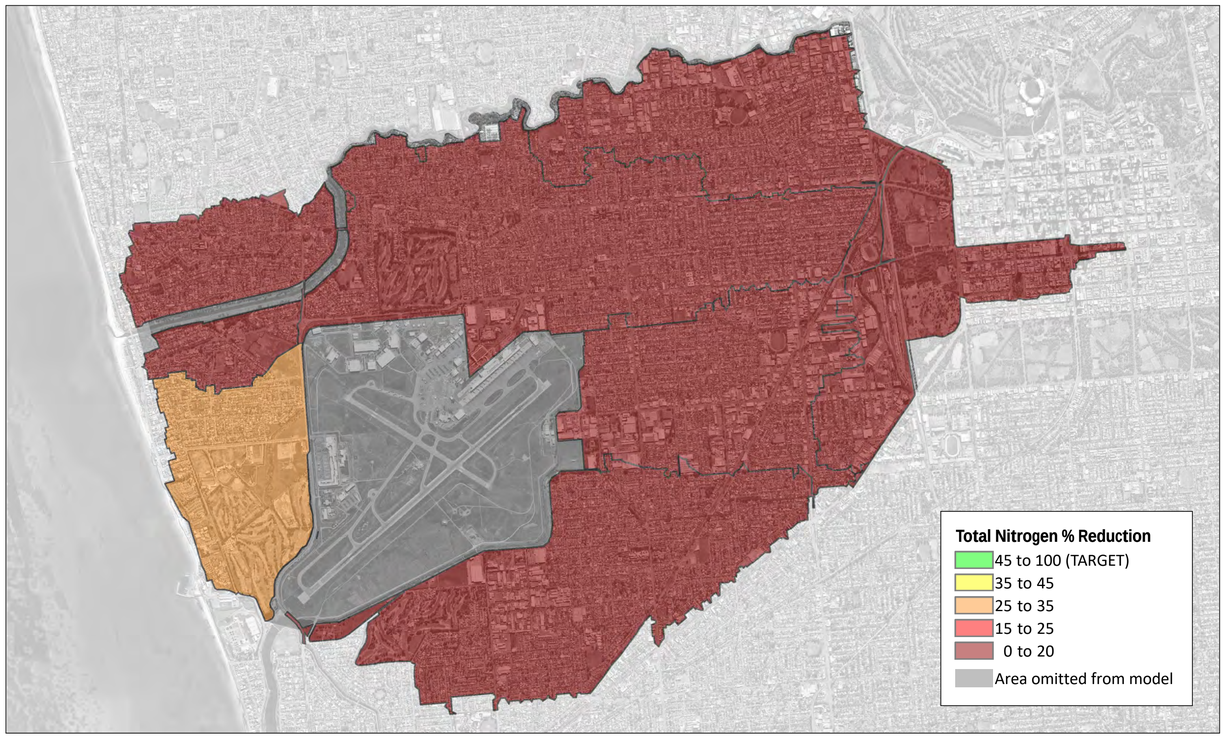
Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	6,380	6,280	2%	-
Total Suspended Solids (kg/yr)	1,210,000	980,000	19%	80%
Total Phosphorous (kg/yr)	2,510	2,160	14%	60%
Total Nitrogen (kg/yr)	18,000	16,200	10%	45%
Gross Pollutants (kg/yr)	255,000	155,000	39%	90%

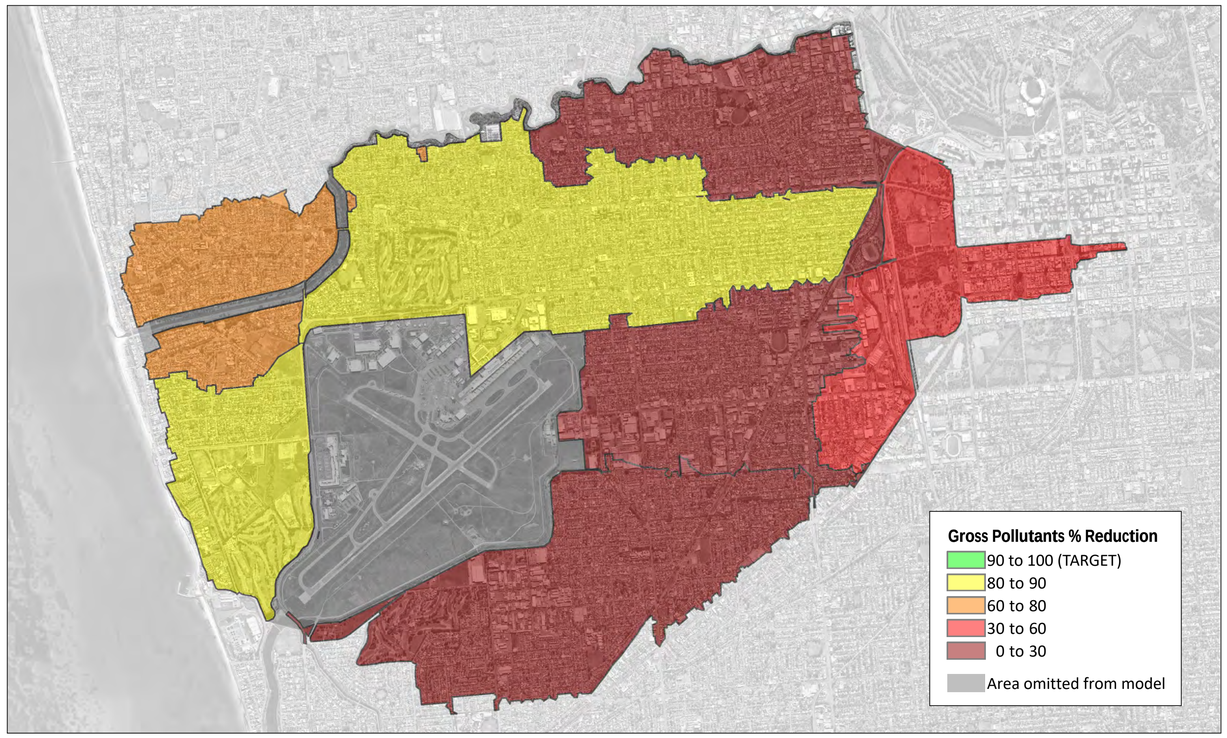
[1] From Baseline Scenario model.

As can be seen the existing WSUD measures provide some pollutant reduction but are significantly less than the required targets for the whole Study Area. Figure 5.10 provides the water quality heat map which indicates the pollutant reduction for each catchment for Scenario 1. For water quality heat maps under Scenario 2 and Scenario 3 & 4, please refer to Appendix H.









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Data Sources:
Southfront [Water Quality Heat Mapping]
NearMap [Aerial Photograph]

West Torrens
Stormwater Management Plan

Existing Development, Existing Infrastructure (Scenario 1) Water Quality Heat Map
Figure 5.10

Table 5.14 – Existing Scenario 1, West Beach Total discharging into the Patawalonga Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	348	342	2%	-
Total Suspended Solids (kg/yr)	56,600	25,400	55%	80%
Total Phosphorous (kg/yr)	124	76	39%	60%
Total Nitrogen (kg/yr)	951	704	26%	45%
Gross Pollutants (kg/yr)	8,440	1,010	88%	90%

[1] From Baseline Scenario model.

Table 5.15 – Existing Scenario 1, Lockleys, Cowandilla Mile End Catchment Total discharging into the Patawalonga Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,580	1,560	1%	-
Total Suspended Solids (kg/yr)	298,000	233,000	22%	80%
Total Phosphorous (kg/yr)	621	519	16%	60%
Total Nitrogen (kg/yr)	4,470	3,850	14%	45%
Gross Pollutants (kg/yr)	63,700	11,200	82%	90%

[1] From Baseline Scenario model.

Table 5.16 – Existing Scenario 1, River Torrens Pumping Station Total discharging into the River Torrens

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	517	494	4%	-
Total Suspended Solids (kg/yr)	95,400	67,500	29%	80%
Total Phosphorous (kg/yr)	200	151	25%	60%
Total Nitrogen (kg/yr)	1,460	1,200	18%	45%
Gross Pollutants (kg/yr)	20,500	7,360	64%	90%

[1] From Baseline Scenario model.

Table 5.17 – Existing Scenario 1, River Torrens Total discharging into the River Torrens

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	907	889	2%	-
Total Suspended Solids (kg/yr)	177,000	170,000	4%	80%
Total Phosphorous (kg/yr)	364	353	3%	60%
Total Nitrogen (kg/yr)	2,590	2,500	3%	45%

Parameter	Sources[1]	Residual	Reduction	Objective
Gross Pollutants (kg/yr)	38,400	36,000	6%	90%

[1] From Baseline Scenario model.

Table 5.18 – Existing Scenario 1, Brown Hill Creek Lateral Drains Total discharging into Brown Hill Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,230	1,220	1%	-
Total Suspended Solids (kg/yr)	233,000	195,000	16%	80%
Total Phosphorous (kg/yr)	483	432	11%	60%
Total Nitrogen (kg/yr)	3,470	3,270	6%	45%
Gross Pollutants (kg/yr)	49,200	39,600	20%	90%

[1] From Baseline Scenario model.

Table 5.19 – Existing Scenario 1, Keswick Creek Lateral Drains Total discharging into Keswick Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,040	1,030	1%	-
Total Suspended Solids (kg/yr)	203,000	187,000	8%	80%
Total Phosphorous (kg/yr)	417	396	5%	60%
Total Nitrogen (kg/yr)	2,960	2,850	4%	45%
Gross Pollutants (kg/yr)	43,900	40,200	8%	90%

[1] From Baseline Scenario model.

Table 5.20 – Existing Scenario 1, Keswick – Western Adelaide Total discharging into Keswick Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	755	744	1%	-
Total Suspended Solids (kg/yr)	146,000	102,000	30%	80%
Total Phosphorous (kg/yr)	303	230	24%	60%
Total Nitrogen (kg/yr)	2,150	1,790	17%	45%
Gross Pollutants (kg/yr)	30,900	20,000	35%	90%

[1] From Baseline Scenario model.

The West Beach Catchment provides the greatest water quality improvement due to recently constructed large GPTs located upstream of the West Beach basin. The Lockleys, Cowandilla Mile End performs relatively well compared to the other catchments due to downstream

measures such as the Sir Donald Bradman Drive Wetland and extensive streetscape raingardens in suburbs such as Mile End.

The River Torrens Pumping Station Catchment also performs relatively well compared to the other catchments. Here the Apex Park Wetland is providing the majority of the water quality improvements.

The catchment discharging directly into the River Torrens, Brown Hill Creek and Keswick Creek do not have significant reductions in pollutant loads. These catchments are formed by a number of smaller systems and such are not able to be treated by a single downstream WSUD measure. Note that WSUD measures such a trash racks within the River Torrens and Brown Hill Creek have not been modelled.

Table 5.21 and Table 5.22 show the total West Torrens Catchment Area pollutant reductions due to the existing WSUD for Scenario 2 and Scenario 3 & 4. Table 5.23 compares the total pollutant reductions of the different scenarios. As shown, the change in development and climate does not significantly impact the amount of pollutant reduction occurring due to the existing WSUD infrastructure.

Table 5.21 – Existing Scenario 2, Total West Torrens Catchment Area discharging into Gulf St Vincent

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	6,840	6,730	2%	-
Total Suspended Solids (kg/yr)	1,310,000	1,070,000	18%	80%
Total Phosphorous (kg/yr)	2,730	2,340	14%	60%
Total Nitrogen (kg/yr)	19,400	17,400	10%	45%
Gross Pollutants (kg/yr)	279,000	170,000	39%	90%

[1] From Baseline Scenario model.

Table 5.22 – Existing Scenario 3 & 4, Total West Torrens Catchment Area discharging into Gulf St Vincent

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	5,120	5,030	2%	-
Total Suspended Solids (kg/yr)	1,000,000	822,000	18%	80%
Total Phosphorous (kg/yr)	2,070	1,780	14%	60%
Total Nitrogen (kg/yr)	14,600	13,100	10%	45%
Gross Pollutants (kg/yr)	226,000	138,000	39%	90%

[1] From Baseline Scenario model.

Table 5.23 – Pollutant Reduction Comparison, Total West Torrens Catchment Area discharging into Gulf St Vincent

Parameter	Scenario 1	Scenario 2	Scenario 3 & 4	Objective
Flow (ML/yr)	2%	2%	2%	-
Total Suspended Solids (kg/yr)	19%	18%	18%	80%
Total Phosphorous (kg/yr)	14%	14%	14%	60%
Total Nitrogen (kg/yr)	10%	10%	10%	45%
Gross Pollutants (kg/yr)	39%	39%	39%	90%

[1] From Baseline Scenario model.

5.6 WSUD Strategy

A Water Sensitive Urban Design (WSUD) strategy has been developed for the West Torrens Study Area in order to reduce the volume and improve the quality of stormwater discharges to the receiving waters. In accordance with the objectives outlined in Section 3, the implementation of the WSUD strategy shall target a reduction in average annual loads of:

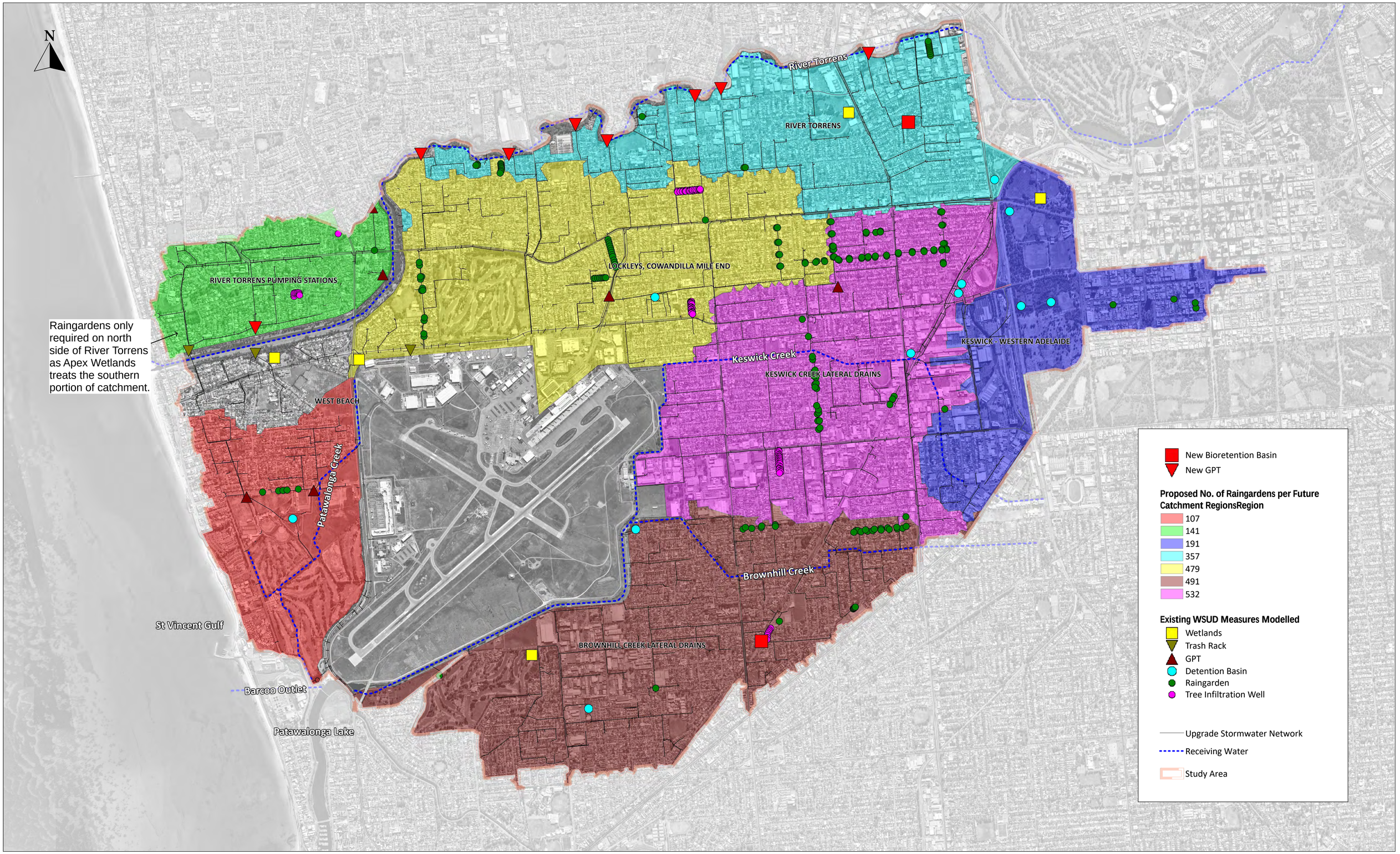
- Total Suspended Solids (TSS) by 80 per cent;
- Total Phosphorus (TP) by 60 per cent;
- Total Nitrogen (TN) by 45 per cent; and
- Gross Pollutants (GP) by 90 per cent.

This shall be demonstrated based on modelling procedures which compare the performance of the proposed WSUD strategy for the catchment with an equivalent, untreated catchment. Therefore, a WSUD strategy MUSIC model has been compiled, building upon the existing WSUD model, to enable comparison to the baseline scenario MUSIC model. This has also enabled preliminary sizing of WSUD elements and budget cost estimation.

The range of WSUD measures that are proposed to be implemented across the West Torrens area include streetscape raingardens, reserve scale bioretention systems and gross pollutant traps.

The WSUD strategy has also identified allotment-level opportunities for beneficial reuse of stormwater, which will reduce the overall volume of stormwater that is discharged to receiving waters. This includes the provision of rainwater tanks for new developments.

An overview of all WSUD upgrades is shown in Figure 5.11, and each of the proposed works packages have been assigned a Project ID which corresponds to action summary tables.



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Data Sources:
City of West Torrens [Existing Stormwater Network, Existing WSUD]
Southfront [Proposed WSUD]
NearMap [Aerial Photograph]

West Torrens
Stormwater Management Plan

Proposed Water Sensitive Urban Design - Overview Plan
Figure 5.11

5.6.1 Future Baseline Model

As the proposed flood mitigation upgrades result in a number of flow diversions, the sizes of each of the major catchments changes, whilst the total Study Area Catchment area remains the same. For example, the large trunk drain upgrade in Cowandilla and Mile End takes flows from the large portion of that catchment to Keswick creek rather than to the Airport channel and the Patawalonga Creek. The Baseline MUSIC model was updated to reflect these new catchments and flow diversions, thus allowing for a fair comparison with the proposed WSUD upgrade MUSIC model. Table 5.24 below provides the total West Torrens Catchment results for the Existing Baseline and Future Baseline models. As can be seen they are essentially equal.

Table 5.24—Baseline Model Result Comparison, Total West Torrens Catchment Area discharging into Gulf St Vincent

Parameter	Existing Baseline	Future Baseline
Flow (ML/yr)	6,840	6,840
Total Suspended Solids (kg/yr)	1,310,000	1,320,000
Total Phosphorous (kg/yr)	2,730	2,730
Total Nitrogen (kg/yr)	19,400	19,400
Gross Pollutants (kg/yr)	279,000	277,000

The Future development Scenario with no climate change was adopted for the future Baseline and Upgrade WSUD MUSIC models. As previously stated, the reduction to annual average rainfall due to climate change does not play a significant role in the water quality results.

5.6.2 Q1 – Streetscape Raingardens

The primary water quality improvement strategy for the West Torrens Catchment is the use of streetscape raingardens. It is proposed to construct lined bioretention systems throughout the Study Area, primarily within residential and commercial regions.

The locations of proposed streetscape bioretention systems include road reserves that may become the sites of stormwater drainage upgrades, and that have sufficient width to accommodate bioretention systems without adversely impacting on other streetscape features such as parking provisions. In these cases, bioretention systems are proposed to be used in lieu of traditional side entry pits, to treat the flows from small contributing catchments. In addition to bioretention systems being constructed where new stormwater works have been proposed, it is recommended that bioretention systems be retrofitted to existing stormwater systems in order to maximise the water quality improvement performance of this Plan.

30m² bioretention systems were assumed for MUSIC modelling. MUSIC modelling parameters for the proposed streetscape bioretention systems are included in Table 5.25.

Table 5.25 – Streetscape Bioretention System Properties

Parameter	Streetscape Bioretention System
Surface Area (m²)	30
Filter Area (m²)	27

Parameter	Streetscape Bioretention System
Extended Detention Depth (m)	0.2
High Flow Bypass (L/s)	250
Filter Depth (m)	0.5

The number of raingardens required in each major catchment area was determined by ensuring each of the subcatchments being treated by raingardens reached the desired water quality targets. That is, the numbers of 30m^2 raingardens were increased until the water quality targets were reached for that particular subcatchment.

Streetscape bioretention systems are suitable for widespread implementation across the Study Area and would ideally be delivered in conjunction with the road reconstruction and open space upgrade programs of the Councils.

The estimated cost of constructing each bioretention system is $36,000. The estimated annual maintenance cost for each raingarden is $700. Table 5.26 provides a breakdown of the number of new raingardens required and the estimated costs involved.

Table 5.26 – Streetscape Bioretention System per Catchment

Catchment	No. of Raingardens	Capital Cost	Annual Cost
West Beach	107	$3,853,000	$75,000
Lockleys, Cowandilla Mile End	424	$15,266,000	$297,000
North-east Adelaide Airport	55	$1,980,000	$39,000
River Torrens Pumping Stations	141*	$5,077,000	$99,000
River Torrens	357	$12,854,000	$250,000
Brown Hill Creek Lateral Drains	491	$17,678,000	$344,000
Keswick Creek Lateral Drains	532	$19,155,000	$372,000
Keswick - Western Adelaide	191	$6,877,000	$134,000
TOTAL	**2,298**	$82,739,000	$1,609,000

*Only on north side of River Torrens as Apex Wetlands treats the southern portion of catchment.

It is noted that this number of raingardens has a significant cost involved. Increasing the implementation of other strategies and non-structural measures could potentially reduce the number of raingardens required. Larger scale WSUD such as wetlands would also reduce the number of raingardens required. There have been previous concept designs of constructed

wetlands in the Adelaide Shores golf reserves, however there is no current desire to proceed with these.

Breakout Creek Wetland Stage 3, located west of Tapleys Hill Road, is currently being designed to have local drainage outlet wetlands. These will treat water quality of the majority of the River Torrens Pumping Stations Catchment and contribute to reducing the number of raingardens required in the Catchment.

5.6.3 Q2 – Reserve / Basin Bioretention Systems

Bioretention systems are proposed to be integrated with flood mitigation basins outlined in the Section 4.8. These bioretention systems are to be fully lined and include a submerged zone that will provide moisture storage to support the vegetation during prolonged periods without rainfall. These bioretention systems will provide an opportunity for high quality landscaping and integration with the surrounding reserves. The size of the filter area was determined using the MUSIC model and ensuring that water leaving a bioretention node meets the required water quality improvement targets. A brief description of each is provided below.

McArthur Avenue Reserve Bioretention Basin (flood mitigation strategy D30)
A new detention basin is proposed to be constructed at McArthur Avenue linear reserve as a part of the flood mitigation strategy. This basin in proposed to be online and so a bioretention element has been included. The bioretention system is to have a combined filter area of 200 m^2 and be elevated above the floor of the detention basin such that the maximum depth of submergence is 0.3 metres. The construction costs for the bioretention system have been considered in the flood mitigation strategy cost estimates.

Dove Street Reserve Bioretention Basin (flood mitigation strategy D14)
A new detention basin is proposed to be constructed at Dove Street reserve as a part of the flood mitigation strategy. This basin in proposed to be online and so a bioretention element has been included. The bioretention system is to have a combined filter area of 1,000 m^2 and be elevated above the floor of the detention basin such that the maximum depth of submergence is 0.3 metres. The construction costs for the bioretention system have been considered in the flood mitigation strategy cost estimates.

Deacon Avenue Reserve Bioretention Basin (flood mitigation strategy D20, potential)
A new detention basin/underground tank system is proposed to be constructed at the linear reserve adjacent to Moss Avenue. If an above ground basin is feasible then a bioretention element should be considered. Note that this was not modelled as a WSUD element for the SMP.

James Congdon Drive / South Road Bioretention Basin (flood mitigation strategy D19, potential)
A new detention basin/underground tank system is proposed to be constructed at the patch of bare land at the James Congdon Drive / South Road intersection. If an above ground basin is feasible then a bioretention element should be considered. Note that this was not modelled as a WSUD element for the SMP.

Note that there is further potential for basin bioretention systems to be included with flood mitigation strategies such as D1 (Halsey Pump Station and Drainage) and D2 (Burnley Street Pump Station and Drainage). As previously mentioned in Section 4.8.2, detention basins could be considered for William Atkin Reserve (Lexington Road, Henley Beach South) and Coast

Watchers Park along Coral Sea Avenue, Fulham. Options such as this would be assessed during further design development.

5.6.4 Q3 – Rainwater Tanks

The installation of rainwater tanks into new residential development was mandated by the State Government a number of years ago. Prior to 2021, this stipulation required that new development provide a minimum 1 kL tank to receive site-generated stormwater runoff, with the tank plumbed into any combination of toilet, laundry, or hot water system demand nodes.

The new South Australian Planning and Design Code (released in March 2021) currently requires rainwater tanks for new dwellings (residential development comprising detached, semi-detached or row dwellings, or less than 5 group dwellings or dwellings within a residential flat building) based on allotment size, as outlined in the table below.

Table 5.27 – Rainwater Tank Requirement by allotment size (Planning and Design Code - 19 March - Version 2021.2)

Allotment Size (m^2)	Minimum Rainwater Tank Volume (L)
<200	1000
200 – 400	2000
>401 – 500	4000

The cadastre blocks identified as likely to be developed given the adopted increase of 5,800 dwellings (Section 2.4.3) were used to determine the locations and numbers of new rainwater tanks. Each new dwelling was assumed to have an allotment size of 300m^2, and a 2kL rainwater tank as required by the new planning and design code (see table above). 200m^2 of roof area was assumed to be connected to each rainwater tank.

This policy is considered to be appropriate given that:

- Capture of stormwater would reduce the pollutant load discharged to receiving waters;
- Capture of stormwater would reduce the volume of runoff directed into the Council stormwater system;
- Greater storage capacities would achieve a greater reduction in residential mains water usage; and
- Rainwater tank prices have become more competitive in recent years, and therefore the payback period of providing a greater storage capacity has been reduced.

The MUSIC modelling has assumed that the rainwater tanks for new dwellings shall supply a daily demand of 200 L/day. This allowance includes watering gardens, flushing of toilets, and washing machines, for example. The cost of rainwater tanks shall be borne by the homeowner.

It is noted that the assumed rainwater tank installation compliance in the modelling may not occur in practice. Hence, it is extremely important that Council undertake compliance checks of rainwater tanks associated with new development. An annual cost of $50,000 has been assumed to account for compliance checks.

5.6.5 Q4 – Gross Pollutant Traps

Burnley Street pump Station

The proposed Burnley Street Pump Station system in Fulham is to have a GPT constructed upstream of the pump station. This has been based on similar HumeGard® underground models used for the existing Riverway and Chippendale Pump Station systems, however, scaled up. The cost of the proposed pump station GPT has been included in the flood mitigation cost estimates.

New Drainage Systems Discharging into the River Torrens

Each of the proposed drainage upgrades that discharge into the River Torrens are to have a GPT installed. Again, these have been based on similar HumeGard® underground models used for the existing Riverway and Chippendale Pump Station systems, however, scaled up/down. The cost of the proposed GPTs has been included in the flood mitigation cost estimates. There are a total of 8 GPTs proposed (includes Burnley Street Pump Station GPT).

5.6.6 Assessed Performance

The existing MUSIC model with future development was modified to incorporate the various WSUD features described above. The MUSIC model was run to assess the overall performance of the proposed WSUD strategy, as summarised in Table 5.28.

Table 5.28 – Upgrade Scenario, Total West Torrens Catchment Area discharging into Gulf St Vincent

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	6,840	6,430	6%	-
Total Suspended Solids (kg/yr)	1,320,000	257,000	81%	80%
Total Phosphorous (kg/yr)	2,730	9386	66%	60%
Total Nitrogen (kg/yr)	19,400	10,100	48%	45%
Gross Pollutants (kg/yr)	277,000	2,150	99%	90%

[1] From Baseline Scenario model.

As can be seen the proposed WSUD strategy meets each of the pollutant reduction targets.

It should be noted that the benefits of WSUD are not limited to water treatment. Table 5.29 below summarises the potential benefits of WSUD in a general sense, as described in *Water Sensitive Urban Design* (Department of Environment, Water and Natural Resources, 2013).

Table 5.29 – Potential Benefits of WSUD

Economic	Environmental	Social
Capital cost savings – Reduced sizing of off-site pipe work, drains and stormwater infrastructure	*Hydrological balance* – maintains the hydrological balance by using natural processes of storage, infiltration and evaporation.	*Amenable urban and residential landscapes.*
Construction cost savings – grading and tree clearing.	*Sensitive area protection* – can contribute to protecting environmentally sensitive areas from urban development.	*High visual amenity.*

Water quality cost savings – reducing the costs of water quality improvement by maintaining existing waterways.	*Waterways restoration* – supports restorations and enhancement of urban waterways.	*Linking* – opportunities to link community nodes through open space.
Developer cost savings – reduced developer contributions to downstream drainage capacities and open space requirements.	*Impact reduction* – minimises the impact of urban development on the environment.	*Ameliorating urban heat island effects.*
Improved market value – making such developments more desirable and marketable.	*Natural habitats enhancement* – can enhance the diversity of natural habitats/landscapes.	
Improved resource utilisation – offers cost benefits where areas are unsuitable for residential development, but are suitable for passive recreation and contribute to required public space allocation.	*Groundwater recharge.*	

Table 5.30 to Table 5.36 below provide the model results for each of the major catchments. Figure 5.12 provides the water quality heat map which indicates the pollutant reduction for each catchment for the upgrade scenario.

Table 5.30 – Upgrade Scenario, West Beach Total discharging into the Patawalonga Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	366	350	4%	-
Total Suspended Solids (kg/yr)	59,800	11,800	80%	80%
Total Phosphorous (kg/yr)	133	49	63%	60%
Total Nitrogen (kg/yr)	1,010	513	49%	45%
Gross Pollutants (kg/yr)	9,450	8	100%	90%

[1] From Baseline Scenario model.

Table 5.31 – Upgrade Scenario, Lockleys, Cowandilla Mile End Catchment Total discharging into the Patawalonga Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,310	1,230	6%	-
Total Suspended Solids (kg/yr)	249,000	49,100	80%	80%
Total Phosphorous (kg/yr)	518	172	67%	60%
Total Nitrogen (kg/yr)	3,700	1,860	50%	45%
Gross Pollutants (kg/yr)	52,800	1	100%	90%

[1] From Baseline Scenario model.

Table 5.32 – Upgrade Scenario, River Torrens Pumping Station Total discharging into the River Torrens

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	559	522	7%	-
Total Suspended Solids (kg/yr)	106,000	19,600	82%	80%
Total Phosphorous (kg/yr)	219	67	69%	60%
Total Nitrogen (kg/yr)	1,580	794	50%	45%
Gross Pollutants (kg/yr)	22,900	112	100%	90%

[1] From Baseline Scenario model.

Table 5.33 – Upgrade Scenario, River Torrens Total discharging into the River Torrens

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,010	959	5%	-
Total Suspended Solids (kg/yr)	199,000	39,800	80%	80%
Total Phosphorous (kg/yr)	410	138	66%	60%
Total Nitrogen (kg/yr)	2,890	1,510	48%	45%
Gross Pollutants (kg/yr)	42,700	9	100%	90%

[1] From Baseline Scenario model.

Table 5.34 – Upgrade Scenario, Brown Hill Creek Lateral Drains Total discharging into Brown Hill Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,350	1,240	8%	-
Total Suspended Solids (kg/yr)	259,000	48,600	81%	80%
Total Phosphorous (kg/yr)	538	186	65%	60%
Total Nitrogen (kg/yr)	3,830	1,970	49%	45%
Gross Pollutants (kg/yr)	54,800	7	100%	90%

[1] From Baseline Scenario model.

Table 5.35 – Upgrade Scenario, Keswick Creek Lateral Drains Total discharging into Keswick Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	1,460	1,380	5%	-

Parameter	Sources[1]	Residual	Reduction	Objective
Total Suspended Solids (kg/yr)	289,000	57,800	80%	80%
Total Phosphorous (kg/yr)	592	211	64%	60%
Total Nitrogen (kg/yr)	4,170	2,220	47%	45%
Gross Pollutants (kg/yr)	62,100	868	99%	90%

[1] From Baseline Scenario model.

Table 5.36 – Upgrade Scenario, Keswick – Western Adelaide Total discharging into Keswick Creek

Parameter	Sources[1]	Residual	Reduction	Objective
Flow (ML/yr)	788	744	6%	-
Total Suspended Solids (kg/yr)	154,000	29,500	81%	80%
Total Phosphorous (kg/yr)	319	113	65%	60%
Total Nitrogen (kg/yr)	2,240	1,230	45%	45%
Gross Pollutants (kg/yr)	32,400	1,140	96%	90%

[1] From Baseline Scenario model.

The opportunity for further measures primarily exists at the private property level, including stormwater harvesting and using site runoff for passive irrigation. Implementation of these measures may be influenced by compliance checks to ensure water quality infrastructure is installed and functioning as intended using the building approvals process. Additionally, stricter site-based water quality requirements that exceed the current stormwater runoff water quality requirements for certain types of development (i.e., large commercial and industrial sites) may be appropriate.

Non-structural measures are described in Section 5.7.6 can further assist in reaching the pollutant reduction targets.

5.6.7 Non-structural Measures

Q5 – Maintaining Existing Wetlands
It is recommended that the existing wetlands in the West Torrens Catchment have regular maintenance, monitoring and management plans in place to ensure they are performing as intended.

The MUSIC eWater formula used for calculating life cycle costs has been utilised for estimating the typical annual maintenance (TAM) cost for the existing constructed wetlands. The cost is a function of the wetland area. Approximately 50 ha of Council wetlands has been assumed (Apex Park Wetland, Sir Donald Bradman Drive Linear Wetland and Kings Reserve Wetland).

Q6 – Integration with Council Business Plans
A goal identified from this Stormwater Management Plan is for the Councils to ensure that there is ongoing integration between the proposed stormwater upgrade works and other capital programs (roads, open space) in the annual Business Plan. It is recommended that the Councils

actively identify viable WSUD projects suitable for integration with other capital works as set out in the Business Plan.

It is also recommended Council investigate the overlap between suggested WSUD locations and heat mapping data to encourage working on both problems simultaneously. This would improve support for the business case for the use of raingardens or alternative WSUD measures.

Q7 – Community Education and WSUD Promotion
It is recommended that the Councils seek to maximise the uptake of WSUD measures on private property through community education and the promotion of WSUD demonstration sites.

Council staff and volunteers should seek to educate community groups, local residents, businesses and schools about what they can do to manage the stormwater runoff generated by their property in an environmentally responsible manner, including the use of rainwater tanks, passive irrigation systems and raingardens.

Council should also engage community in the restoration and maintenance of the local environment to ensure the community are more aware of their local watercourses and riparian ecosystems.

Initiatives may include articles in Council newsletters, street corner meetings, community group meetings, website updated, brochures and school education. An example already is place is the City of West Torrens' rebate scheme for rainwater tanks available for residents.

It is recommended to utilise and share the Water Sensitive SA website with the community. WSSA have a page on their website, 'Smart water solutions for your home & backyard', which provides information and instructions on how to integrate WSUD into a homeowner's property. Information is provided on rainwater tanks, permeable paving and reducing hard surfaces outside the house, raingardens for the backyard and general ideas for a new home. This website has many other resources that can be utilised for community education on WSUD and related issues.

Q8 – Investigating how Receiving Watercourses can be Better Utilised
Investigate if specific receiving watercourses (River Torrens, Patawalonga Creek, Brown Hill Creek and Keswick Creek) can be improved for other Council uses such as stormwater detention, stormwater treatment, greening, cooling and to improve their use for recreation and amenity.

An existing example is the River Torrens Breakout Creek Wetlands Project being delivered by Green Adelaide. The River Torrens outlet channel (a receiving watercourse for the WT northern catchments) has been steadily transformed from an artificial channel into a more natural flowing and healthy creek. The project provides several benefits for the environment and community including:

- Creating wetlands to capture and clean stormwater and manage high flows
- Removing weeds
- Planting native vegetation to slow and treat water coming down the river
- Providing open space for people to enjoy with trails, picnic areas, signage, and art
- Involves the traditional owners of the land, the Kaurna people, to acknowledge the significance of the area

- Creates healthy habitat for fish and bird species and improve the water quality of the Torrens.

Stages 1 and 2 of this project are complete with Stage 3 to begin shortly.

Council should investigate whether similar projects would be beneficial in other receiving watercourses in the West Torrens Study Area such as:

- Brown Hill Creek, along the southern edge of the airport
- Keswick Creek, along the eastern edge of the airport
- The open channel along the northern edge of the airport
- Artificial open channel of the Patawalonga Creek system alongside Military Road, West Beach.

Organisations such as SA Water and the Adelaide Airport would require involvement in these investigations as Council does not own the land of these watercourses in most cases, however, stands to benefit from as these watercourses directly impact Council's local environment and community.

Q9 – Supporting Community Groups Contributing to the Achievement of the SMP Objectives
Council should foster appreciation of the local environment and engage the community in its restoration and maintenance. Existing community groups such as Friends of Patawalonga Creek participate in looking after the Patawalonga Creek Conservation Reserve at Adelaide Airport. They conduct a Clean Up Australia Day event and general monthly activities including hand weeding, rubbish collection and site maintenance. Although this is Airport land, Council is encouraged to support existing groups like Friends of the Patawalonga Creek and any existing/future groups that may be involved with the Brown Hill and Keswick Creeks and River Torrens.

Support for local community groups may involve:

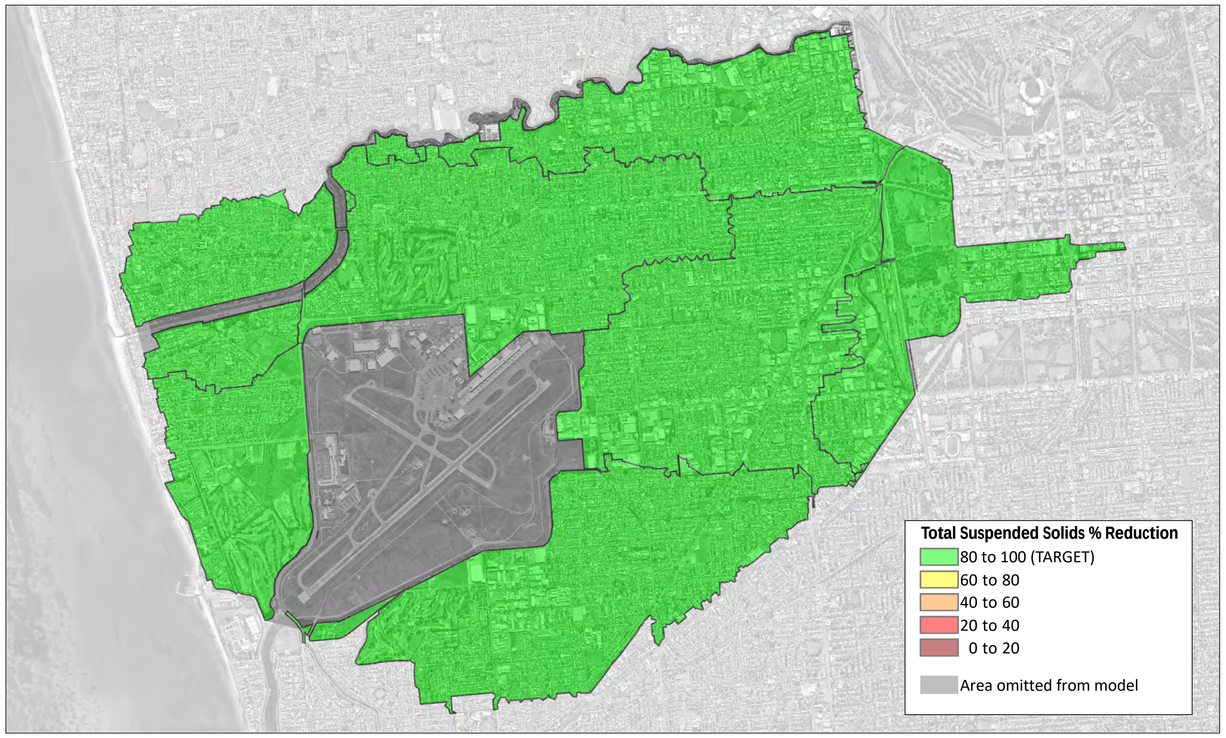
- Grant programs
- Assisting with communication with the wider community
- Providing facilities for community group events

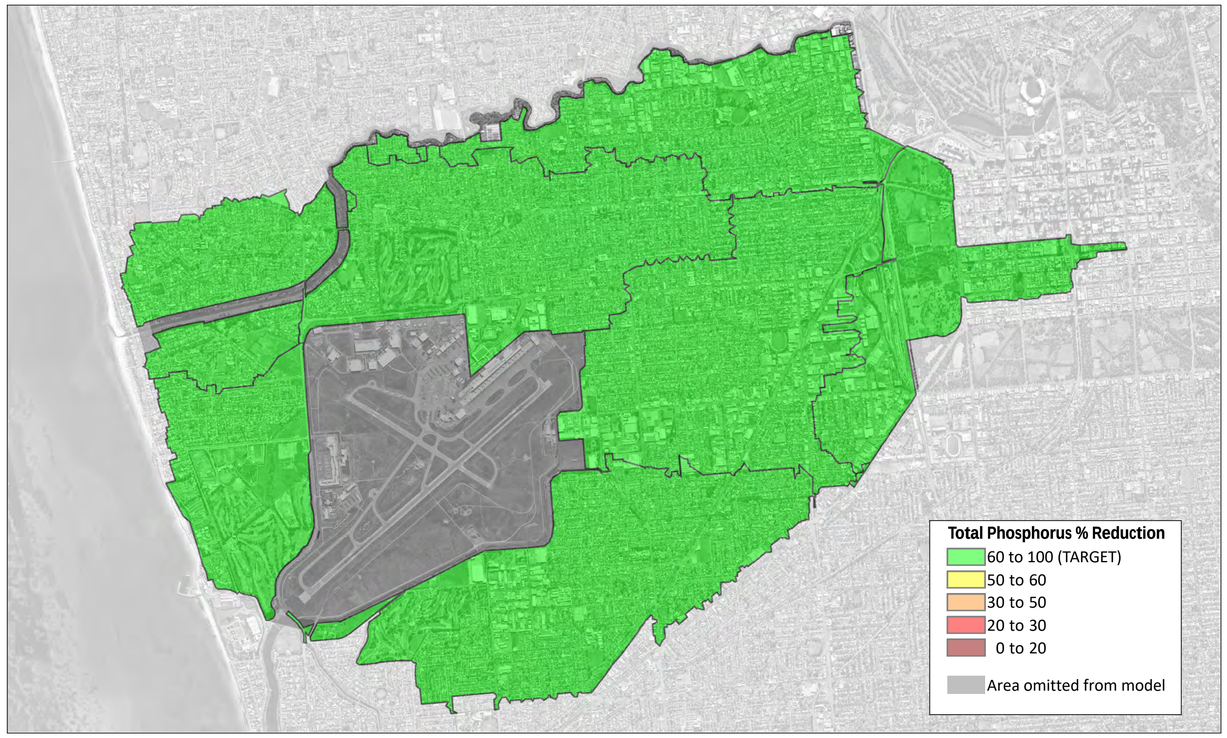
5.7 WSUD Strategy Action Summary

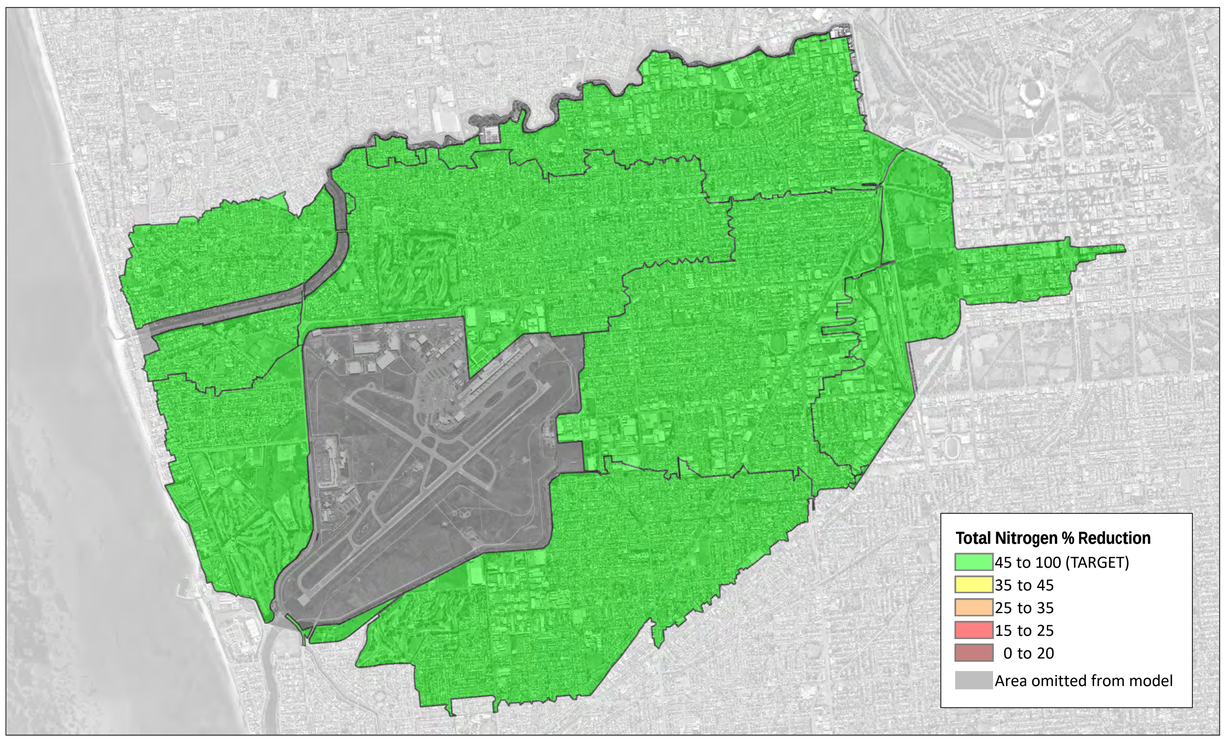
A consolidated summary of the WSUD strategies across the study area is presented in Table 5.37. The costs of establishing the proposed detention basins were included as part of the flood mitigation strategy cost estimates in Section 4.8. In other cases where WSUD elements are to be integrated with flood mitigation works at a single project site, the costs below are representative of the WSUD elements only.

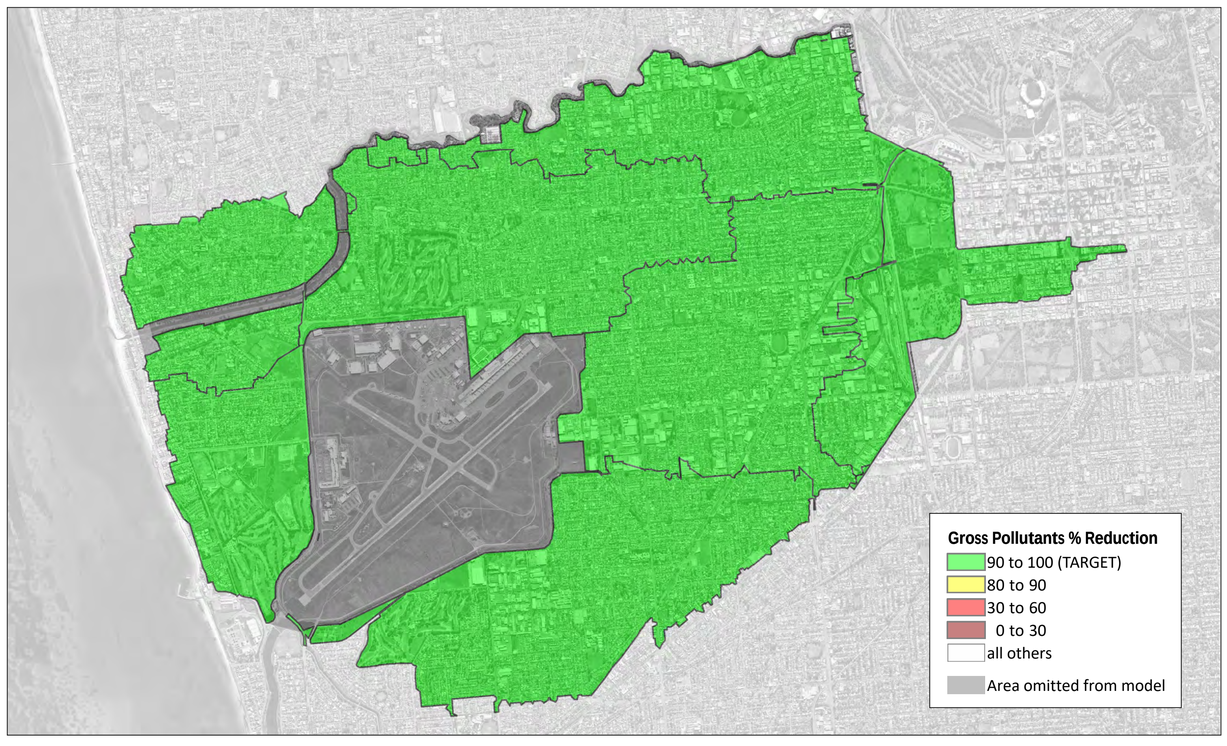
SMP objectives that have been addressed by a particular WSUD strategy action are shown in Table 5.37 using the objective reference IDs from Table 3.3.

A number of the WSUD strategies proposed incur ongoing maintenance costs which have been included in Table 5.37. These estimates are based on historical knowledge and industry sources.









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Data Sources:
Southfront [Water Quality Heat Mapping]
NearMap [Aerial Photograph]

southfront

West Torrens
Stormwater Management Plan

Future Development, Upgrade Infrastructure Water Quality Heat Map
Figure 5.12

Table 5.37 – WSUD Strategy Action Summary

Project ID	Project Location / Type of Works	LGA & Catchment	Precursor Project	Budget Estimate	Annual Maintenance / Program Cost	Priority	Description	Objectives Addressed
Q1	Streetscape raingardens / bioretention	Various	Various	$82,740,000	$700 per raingarden	30 - 40 years	2,298 streetscape raingardens, each with a footprint of 30 m²	O3, O4, O5
Q2	Reserve / Detention Basin Bioretention Systems	WT	Various	Cost included in corresponding flood mitigation strategy	$1,000 per biofiltration system	Included in corresponding flood mitigation strategy	Bioretention systems are proposed to be integrated with proposed flood mitigation basins.	O3, O5, O9
Q3	Rainwater Tanks	Various	N/A	N/A	$50,000	0-10 years	A requirement for installing rainwater tanks for new dwellings and compliance checks.	O4, O7
Q4	Gross Pollutant Traps	WT	Various	Cost included in corresponding flood mitigation strategy	$2,000 per GPT	Included in corresponding flood mitigation strategy	8 GPTs to be installed for new systems discharging into the River Torrens. Each GPT requires regular maintenance.	O3, O5
Q5	Maintenance of existing wetlands	WT	N/A	N/A	$110,000 (based on approx. 50 ha of Council maintained wetlands)	0-10 years	Ensure existing wetlands are maintained as development occurs within the catchment to continue achieving water quality benefits to the lower catchment	O3, O5, O6

Project ID	Project Location / Type of Works	LGA & Catchment	Precursor Project	Budget Estimate	Annual Maintenance / Program Cost	Priority	Description	Objectives Addressed
Q6	Integration with Council Business Plans	Various	N/A	N/A	N/A	0-10 years	Councils to ensure that there is ongoing integration between proposed stormwater upgrade works and other capital programs in the annual Business Plan	O9
Q7	Community Education and WSUD Promotion	Various	N/A	N/A	$10,000	0-10 years	Council staff and volunteers should seek to educate community groups, local residents, businesses and schools about how to manage stormwater runoff generated by their property in an environmentally responsible manner, including the use of rainwater tanks, passive irrigation systems and raingardens	O4, O7, O8
Q8	Investigating how Receiving Watercourses can be Better Utilised	Various	N/A	N/A	N/A	0-10 years	Investigate if specific receiving watercourses (River Torrens, Patawalonga Creek, Brown Hill Keswick Creek) can be improved for other Council uses	O5, O8, O9

Project ID	Project Location / Type of Works	LGA & Catchment	Precursor Project	Budget Estimate	Annual Maintenance / Program Cost	Priority	Description	Objectives Addressed
Q9	Supporting Community Groups Contributing to the Achievement of the SMP Objectives	Various	N/A	N/A	$10,000	0-10 years	Council is encouraged to support existing groups like Friends of the Patawalonga Creek and any existing/future groups that may be involved with the Brown Hill and Keswick Creeks and River Torrens.	O5, O8, O9
			TOTAL	$82,740,000				

6 Harvesting and Reuse Opportunities

6.1 Existing Regional Schemes

There are two existing Managed Aquifer Recharge (MAR) schemes within the study area located at the Adelaide Airport and Glenelg Golf Club. An overview of these schemes is presented in Section 2.6.4.

Other smaller scale existing storage and re-use schemes in within the study area include:

- Holland Street Plaza raingarden harvest and storage system
- Streeters Road / Gardner Street bioretention storage tank
- Thebarton oval storage and re-use system

6.2 Previously Identified Regional Scheme Opportunities

Past studies that have investigated the potential for reuse and harvesting within the study area include:

- *Adelaide Shores Stormwater Harvesting Feasibility Study* (Wallbridge & Gilbert, 2010)

This report investigates and develops concept plans and cost estimates for a stormwater harvesting scheme in the north-eastern area of the Adelaide Shores site. The investigation recommend that it is possible to construct a scheme within the golf course site without having a significant impact on the existing course and achieve a yield of 460 ML per year using a biofilter system.

- *Recycled Water Extension to CWT Reserves Concept Investigation* (Tonkin, 2018)

This report investigates the existing irrigation of City of West Torren's reserves by the Glenelg to Adelaide Parklands (GAP) and Glenelg to Adelaide Airport Class A Recycled Water Schemes. These recycled water scheme use water from the Glenelg Wastewater Treatment Plant for irrigation purposes. The report provides a number of options to expand the two systems to irrigate more Council reserves and assess the construction and life cycle costs involved.

- *West Torrens Catchment SMP - Hydrogeological Assessment* (Wallbridge and Gilbert, 2020)

This report was prepared for the purposes of this Stormwater Management Plan, with a summary of the assessed potential for additional MAR activity in the catchment presented in Section 2.7.4. This report highlights the potential limitations associated with further MAR activity in the area.

6.3 Local Availability and Demand for Harvested Stormwater / Recycled Water

As determined through MUSIC modelling of the catchment described in Section 5, the existing West Torrens Urban Catchment is estimated to generate an average stormwater flow volume of 6.38 GL/yr (5.12 GL/yr for climate change scenario).

Adopting stormwater/recycled reuse allows local government to reduce their own mains water usage and allows irrigation without the restrictions that may be imposed on mains water use on occasion, and to create cooler spaces through regular irrigation.

A desktop assessment of spaces within the catchment that could require irrigation have been identified and their potential demands mapped (see Figure 6.1). These spaces include a mixture of:

- Major community assets, have a high presentation factor and a visual objective or green appearance all year;
- Developed irrigated reserves, have a medium to high presentation factor and a visual objective of green in winter and spring and light green in summer;
- Developed reserves are non-irrigated, have a medium presentation factor and a visual objective of green in winter, light green in spring and green/brown in summer;
- Undeveloped reserves have a low presentation factor and a visual objective of green in winter, light green in spring and brown in summer.

These spaces result in a total area of 426 hectares. These mapped spaces have been used to approximate a demand based off an irrigation requirement of 4.7 ML/ha/yr, estimated assuming a Turf Quality Visual Standard Classification No.3 – Local Sports Turf (SA Water, 2007). Assuming this irrigated standard for all reserves, a total estimated demand across the entire catchment is equal to 2,002 ML/yr.

Providing irrigation to areas currently not irrigated and providing more reliable irrigation in summer to those areas that are irrigated will increase the recreational experience of the community, in addition to the direct stormwater management benefits.

6.4 Harvesting and Reuse Strategy

6.4.1 R1 – Small Scale Stormwater Re-use

The most compelling area for a large stormwater harvest and re-use scheme in the West Torrens Study area is within the Adelaide Shores site. No further action has been taken to progress the concept plans recommended in the WGA, 2010 Feasibility Study.

Through discussions with the SMP steering committee, no other sites within the Study Area have been identified to be suitable for large scale stormwater harvesting and re-use.

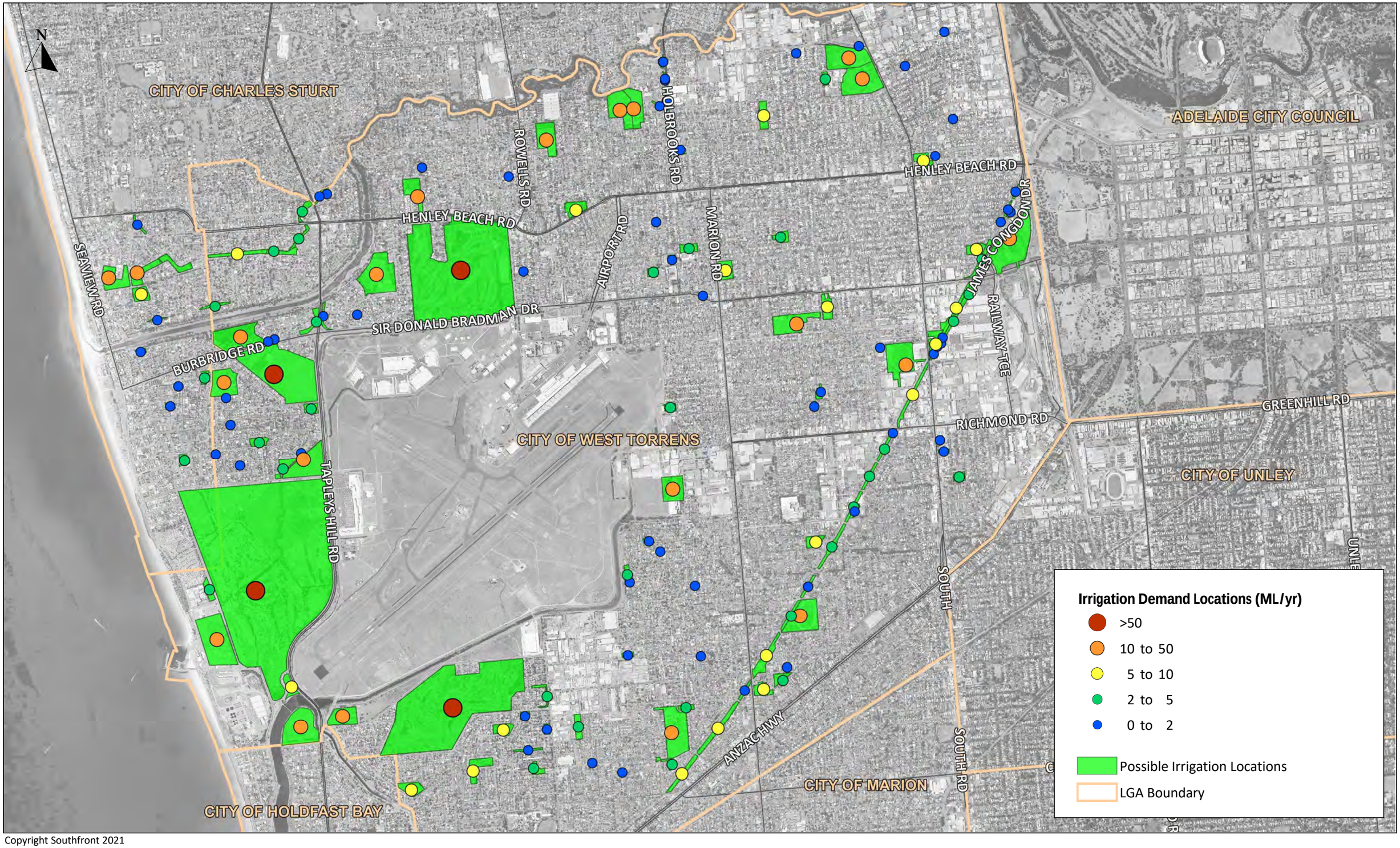
It is recommended that smaller scale storage and reuse schemes be implemented where possible, similar to the Holland Street Plaza raingarden harvest and storage system and Streeters Road / Gardner Street bioretention storage tank. Smaller systems like this should be considered when designing and constructing the numerous raingardens proposed in Section 5.

It is also recommended that street-scale soakage and infiltration technologies are implemented across the SMP catchment where possible. Soakage pits, infiltration trenches and tree pits and nets, are forms of street-scale reuse. These technologies provide passive irrigation to street side vegetation, reducing stormwater flows in minor events and reducing the need for formal irrigation.

6.4.2 R2 – Expanding Glenelg to Adelaide Parklands (GAP) Recycled Water Scheme and Glenelg to Adelaide Airport Class A Recycled Water Scheme

Many West Torrens parks and reserves are currently irrigated by the GAP and Class A recycled water schemes. Figure 6.2 provides a map of the existing irrigated areas.

As stated in the Tonkin Recycled Water Extension to CWT Reserves Concept Investigation report, there is scope to extend the recycled water schemes to irrigate more green spaces within West Torrens. Figure 6.3 provides some proposed areas to be irrigated by extending these schemes. These locations are based on the Tonkin Report and demand locations identified in Section 6.3. Note these are only suggestions – the Tonkin Study should be referred to for more accurate demands, yields and costs involved with expanding these schemes.



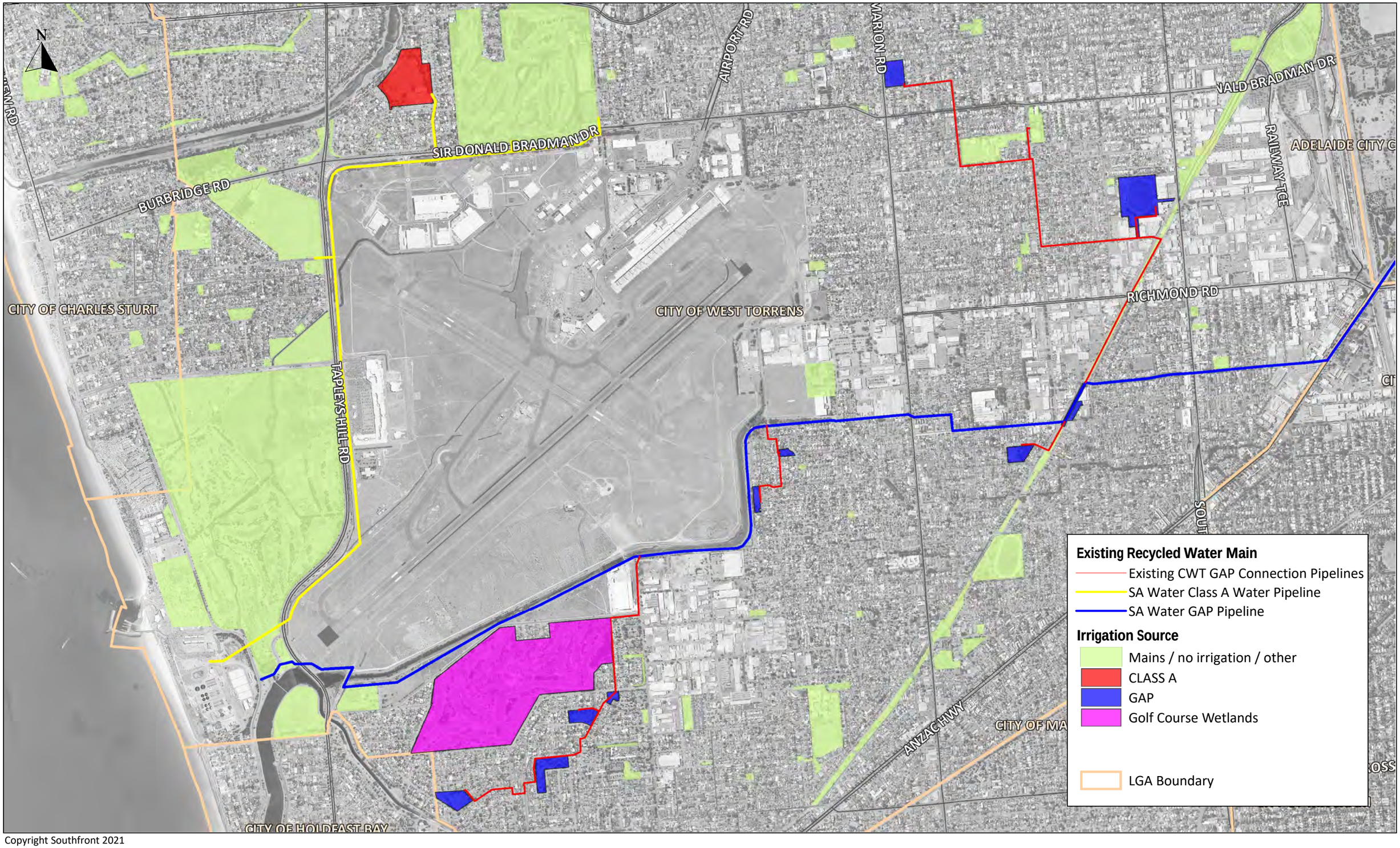
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Data Sources:
Southfront [Irrigation Demand]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

Irrigation Demand Locations
Figure 6.1



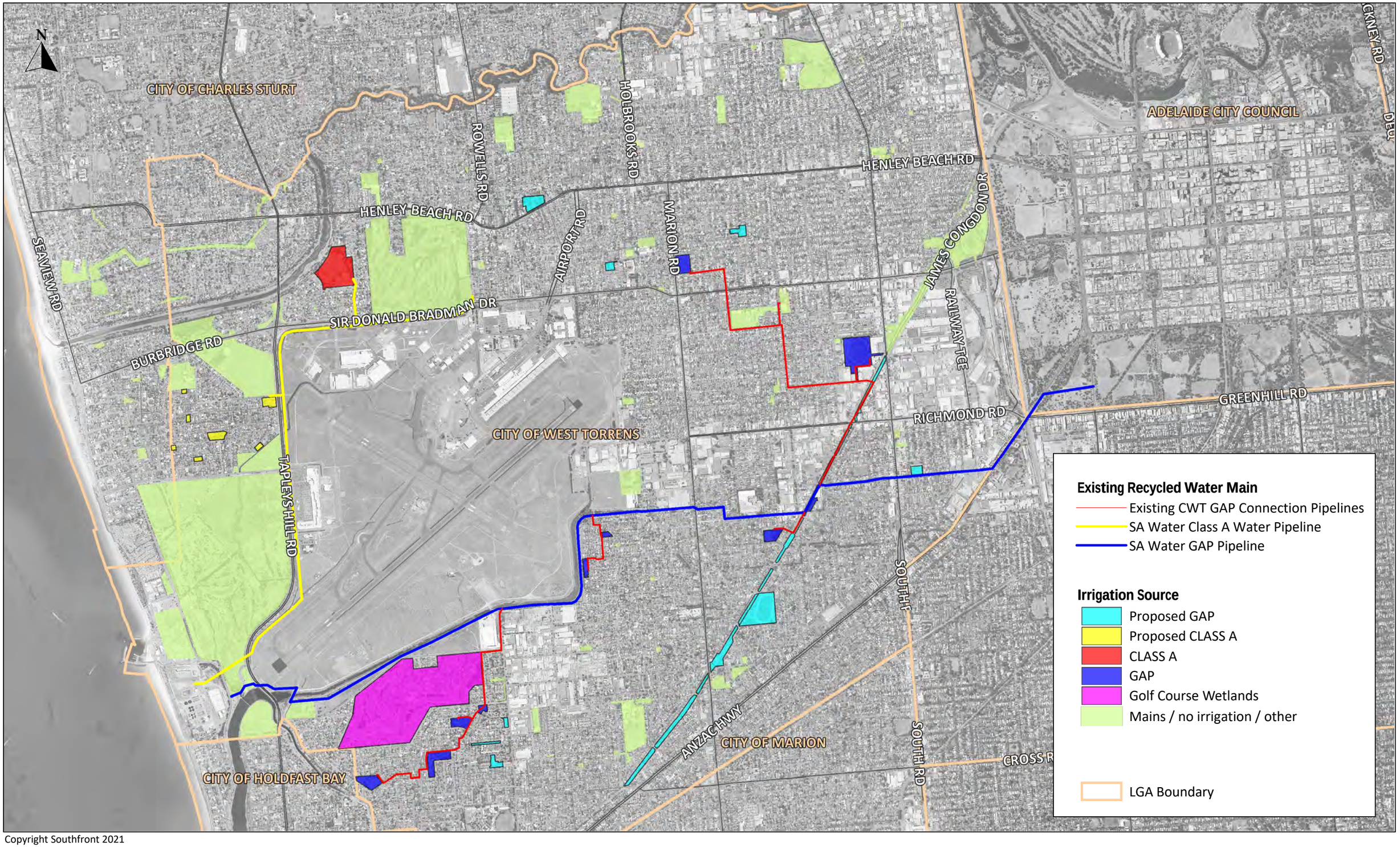
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Data Sources:
City of West Torrens [Recycled Water Main and Irrigation Data]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

CWT Reserves Irrigated by Existing Recycled Water
Figure 6.2



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Data Sources:
City of West Torrens [Recycled Water Main and Irrigation Data]
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West Torrens
Stormwater Management Plan

Potential Expansion of Recycled Water Network for Irrigation
Figure 6.3

7 Stormwater Management Plan

7.1 Prioritisation and Timeframes

The actions outlined in this Stormwater Management Plan will require implementation to be scheduled across many decades, in order to be accommodated sustainably within the budgets of the catchment Councils and other potential funding partners such as the Stormwater Management Authority.

Each of the actions within the Plan has been assigned one of five priority levels, which has an associated anticipated timeframe for the strategy action to be completed as follows:

- Short Term (0 - 10 years)
- Short to Mid Term (10 - 20 years)
- Medium Term (20 - 30 years)
- Medium to Long Term (30 - 40 years)
- Long Term (40+ years)

The priority rating of actions is flexible and subject to change over time, and it is expected that some actions will be 'brought forward', particularly when opportunities for external grant funding arise, or to meet 'once in a lifetime' opportunities to install infrastructure during other major capital works, such as an arterial road project. A number of flood mitigation projects have been identified that may be eligible for Stormwater Management Authority funding support. It is recommended that the catchment Councils liaise with the Stormwater Management Authority to identify a timeframe for the delivery of these projects that meets the forward budget limitations of all parties.

Projects not identified as eligible for Stormwater Management Authority funding support may still be eligible for other external funding opportunities.

7.2 Strategy Action Costs, Benefits, Objectives and Priority Summary

A consolidated list of prioritised actions is presented in Table 7.3, together with a brief description of the benefits realised and objectives addressed through implementation of each action. Actions that are potentially eligible for Stormwater Management Authority funding support (typically co-funding on a 50/50 basis with Local Government for projects with a contributing catchment area greater than 40 hectares) have been highlighted. It should be noted that meeting the eligibility for SMA funding does not guarantee the awarding of funding from the SMA. Note that the Authority has the discretion to contribute more or less than 50% of the cost of certain works and may elect to contribute to the cost of works in a catchment of less than 40 hectares, provided that those works form part of an approved Stormwater Management Plan.

Table 7.1 below summarises how this SMP addresses each of the Objectives outlined in Section 3.5.

Table 7.1 – West Torrens SMP Objectives Addressed

ID	Goal	Objective	Relevant Strategies/Actions	Objective Achieved?
O1	Provide an acceptable level of flood protection to the community and both private and public assets from flooding	Aspire to achieve no above floor inundation of properties for all events up to and including the 1% AEP (100 year ARI) storm. Where this is not practically achievable, a 5% AEP (20 year ARI) standard shall be sought. New developments to achieve a minimum 300mm freeboard to the 1% AEP flood level.	- New stormwater infrastructure recommended – flood mitigation strategies D1 through to D36. - Non-structural flood mitigation strategies D39 and D40 relating to new development controls.	The flood mitigation strategies recommended provide a 5% AEP flood protection to the existing flooding hotspots. Through consultation with Council, a 5% AEP flood standard was agreed upon due to practical/financial constraints with achieving a 1% AEP standard.
O2	Provide an acceptable level of performance in the minor (underground) drainage system and pits	Aspire to achieve minimum service standards for new or upgraded drainage systems as follows: Hydraulic grade line (HGL) for 0.2 EY storms to be minimum 150 mm below gutter level	- Flood mitigation strategies D1 through to D36.	The flood mitigation strategies recommended have been designed to provide a 0.2 EY underground standard (>150mm freeboard to gutter level).
O3	Improve the quality of runoff and reduce the impact of stormwater on receiving waters	Aspire to reduce pollutant loads discharged from the catchment by the following averages: ➤ Suspended solids 80% ➤ Phosphorous 60% ➤ Nitrogen 45% ➤ Gross Pollutants 90% Integrate water quality improvement goals into Council development requirements.	- Flood mitigation strategies D14 and D30 which include detention basins with biofiltration (also labelled Q2) - Streetscape raingardens (Q1) - Gross pollutant traps recommended for all new outlets into the River Torrens (Q4, D1, D2, D4, D5, D8, D9, D11, D12, D14) - Maintenance of existing wetlands (Q5)	The proposed solutions demonstrate (through MUSIC modelling) that the pollutant loads discharged from the catchment do reach the reduction targets.

ID	Goal	Objective	Relevant Strategies/Actions	Objective Achieved?
O4	Make beneficial use of stormwater runoff	Identify precinct-level opportunities for beneficial reuse of stormwater where economically viable. Expand on street-scale civic reuse activities. Encourage landowners to implement allotment-level opportunities for the retention and reuse of stormwater.	- Streetscape raingardens (Q1) - Rainwater tanks (Q3) - Community Education and WSUD promotion (Q7) - Small scale stormwater harvest and reuse (R1) - Expanding reserves irrigated by GAP and Class A recycled water (R2)	No viable large scale precinct level opportunities were identified in the West Torrens Catchment. The Adelaide Shores area (not owned by Council) is the best candidate. Expanding the large GAP and Class A recycled water systems is recommended. Streetscape raingardens are recommended to be used for storage and reuse where viable. Rainwater tanks are promoted as an important addition to new developments to achieve allotment-level opportunities for the retention and reuse of stormwater.

ID	Goal	Objective	Relevant Strategies/Actions	Objective Achieved?
O5	Provide conditions which would allow desirable (improved) end-state values for receiving waterways to be achieved	Support ongoing strategies seeking to restore and sustain the ecological processes, environmental values and productive capacity of the River Torrens, Patawalonga Creek and Brown Hill Keswick Creek by minimising the urban runoff volume and nutrient loads discharged into these receiving watercourses.	- Flood mitigation strategies D14 and D30 which include detention basins with biofiltration (also labelled Q2) - Streetscape raingardens (Q1) - Gross pollutant traps recommended for all new outlets into the River Torrens (Q4) - Maintenance of existing wetlands (Q5) - Investigating how Receiving Watercourses can be Better Utilised (Q8) - Supporting Community Groups Contributing to the Achievement of the SMP Objectives (Q9)	Each of these strategies do seek to restore and sustain the ecological processes, environmental values and productive capacity of the River Torrens, Patawalonga Creek and Brown Hill Keswick Creek by either minimising the urban runoff volume and nutrient loads or recommending increased support for the community to be further invested in their local environments.
O6	Sustainable management of stormwater infrastructure, including maintenance	Stormwater infrastructure will be resilient in consideration of the likely impacts of climate change. Ensure appropriate monitoring and asset management plans are in place to maintain infrastructure and public safety.	- Ongoing Maintenance and Monitoring of Council Assets (D41) - Maintenance of existing wetlands (Q5)	Both these strategies provide recommendations for Council to ensure the sustainable management of stormwater infrastructure is achieved.

ID	Goal	Objective	Relevant Strategies/Actions	Objective Achieved?
O7	Desirable planning outcomes associated with new development and management of open space, recreation, and amenity	Ensure new development complies with stormwater management development requirements, designed to achieve outcomes that are complimentary to the SMP objectives and goals. Maximise the use of open space for stormwater/rainfall infiltration WSUD and/or stormwater reuse.	- Development Controls – Floor Levels (D39) - Development Controls – On-site Detention / Retention (D40 - Rainwater tanks (Q3) - Community Education and WSUD promotion (Q7)	These strategies have been recommended so Council can go towards achieving the SMP objectives through development controls and private landowner participation.
O8	Effective communication and consultation with catchment stakeholders, businesses, and community members	Effectively engage with the community on stormwater management issues and proposed strategies including WSUD and stormwater reuse opportunities where possible. Raise awareness to enable businesses and the community to respond efficiently to extreme weather and flood warnings. Identify opportunities for partnerships with the community and agencies in the development and implementation of strategies. Achieve increased alignment between the goals of the SMP and the activities of stakeholders and community volunteers.	- Community Flood Response and Preparedness (D37) - Community Flood Response and Preparedness – Council's Community Emergency Management Plan (D38) - Community Education and WSUD promotion (Q7) - Investigating how Receiving Watercourses can be Better Utilised (Q8) - Supporting Community Groups Contributing to the Achievement of the SMP Objectives (Q9)	Together, these proposed strategies recommend increasing communication, education, and support for the community to ultimately achieve the goals of the SMP.

ID	Goal	Objective	Relevant Strategies/Actions	Objective Achieved?
O9	Multi-objective outcomes for stormwater management projects involving open space	Maintain the existing use of open space and provide new opportunities for public access and recreation where it is safe and practical to do so. Provide opportunities for sustainable landscaping, increased biodiversity, stormwater treatment and passive reuse. Maximise linkages with pedestrian and cycle networks. Develop flood mitigation solutions that minimise the frequency of inundation of active recreation areas and permit more frequent inundation of passive recreation areas.	- Flood mitigation strategies D14, D19, D20, D24, and D30 which all include detention basins to be integrated with in public open spaces. - Integration with Council Business Plans (Q6) - Investigating how Receiving Watercourses can be Better Utilised (Q8) - Supporting Community Groups Contributing to the Achievement of the SMP Objectives (Q9)	These recommended strategies all contribute to multi-objective outcomes for stormwater management projects involving open space. Landscaped detention basins in public reserves can provide amenity and an interactive space for the community. Investigating how watercourses can be better utilised includes reviewing opportunities for: - public access and recreation, - sustainable landscaping, - increased biodiversity, - stormwater treatment and passive reuse Community groups focussed on stormwater issues provide many perspectives and ideas to achieving multi-objective outcomes for stormwater management. Supporting these groups is beneficial to Council and the achieving the SMP objectives.

7.3 Responsibilities for Implementation and Funding Opportunities

The City of West Torrens and City of Charles Sturt are responsible for implementation of all activities identified within this Plan within their respective Council boundary. It is expected that the two Councils will continue to liaise with one another (where necessary), relevant State and Federal Government departments and agencies to satisfy a variety of regulatory requirements.

Council may be able to secure funding from the Green Adelaide particularly in relation to water quality improvement works outlined in Section 5. The South Australia Environmental Protection Authority (EPA) also occasionally provide grants for WSUD projects, such as the Rain Garden 500 programme which was held in 2017.

Potential contribution from the Stormwater Management Authority has been highlighted for a number of projects in Table 7-5. It should be noted that funding is at the discretion of the SMA that may contribute more or less than 50%. Also note that meeting the eligibility for SMA funding does not guarantee the awarding of funding from the SMA. The Commonwealth government also occasionally offers grants for the purpose of flood disaster planning and relief.

7.3.1 Inter-Council Cost Split

The majority of proposed stormwater works within this Plan are contained within the City of West Torrens council boundary for the benefit of the City of West Torrens. The two flood mitigation strategies that impact on both the City of West Torrens and City of Charles Sturt are the Halsey Pump Station and Drainage Scheme (D1) and the Burnley Street Pump Station and Drainage (D2). Whilst these two proposed upgrades remain in separate council areas, they both benefit each Council and so a cost split of the initial construction costs is recommended.

The solution set highlighted in this report is one option. More detailed investigation and design development would need to be undertaken as a joint project between the City of West Torrens and City of Charles Sturt. This would lead to further refinement of cost sharing and Council's Commitment to cost sharing. At this point in time, the City of Charles Sturt has not committed to undertaking any joint works.

This document recommends adoption of a model that distributes costs on two guiding principles:

- The extent to which each Council area causes the cost/damage (the 'cost cause')
- The extent to which each Council area avoids future flooding costs on completion of the mitigation works (the 'future costs avoided')

The 'cost cause' component is suggested to primarily take into account the contributing catchment area.

The 'future costs avoided' component can be determined by considering the number of properties removed from the flood plain (simple approach), or evaluation of reduction in flood damages (which considers varying damage value rates arising from different types of land use).

The relative weightings of these two components are not prescribed, however in two recent urban examples (Brown Hill - Keswick Creeks, Holdfast – Marion Coastal Catchments), a 50/50 split was assigned to these components.

This is recommended for the Halsey Road Pump Station and Burnley Street Pump Station Schemes, whereby:

- The 'cost cause' component attributable to each Council is based on its area within the subcatchment served by the drainage works.
- The 'future costs avoided' component attributable to each Council is based on the reduction in 1% AEP flood damages within its area.

For the purpose of determining the cost sharing between the two Councils, the proposed upgrades have been combined. The total combined catchment for the Halsey Road Upgrade Scheme and Burnley Street Upgrade Scheme (D2) is 155 hectares. The total combined capital cost of the two schemes is $20.47 million ($4.3m for D1 and $16.1m for D2). An estimate of the cost-sharing is provided in Table 7.2.

Table 7.2 – Cost Sharing Summary for Halsey Pump Station and Drainage and Burnley Street Pump Station and Drainage Schemes

LGA	Contributing Area		1% AEP Damages Reduction		Cost Share	
	(ha)	(%)	($m)	(%)	(%)	($m)
West Torrens	78	49%	$1.45m	48%	48.5%	$9.93m
Charles Sturt	80	51%	$1.54m	52%	51.5%	$10.54m
Total	155	100%	$2.99m	100%	100%	$20.47

It is noted that all proposed water quality works for the whole SMP Study Area are contained within each respective Council area and hence no cost-sharing relationship is proposed to apply to these works.

7.4 Implication for Adjoining Catchments

There are no significant implications for adjoining catchments to the West Torrens SMP Catchment. Flooding from local stormwater systems within the West Torrens Catchment is predominantly contained within the catchment area.

There is one exception worth noting at the southern end of Marion Road around Lydia Street and Osmond Terrace as shown in Figure 7.1. There is significant ponding in the local low trapped area on Marion Road just north of Lydia Street. Flooding in the larger storm events reaches the model boundary at Lydia Street. If the model were to be extended, the model would likely show road ponding and potential minor property inundation occurring at properties along Lydia Street. Flood mitigation strategies go towards alleviating the road ponding in Marion Road and ultimately reducing the flood risk along Lydia Street.

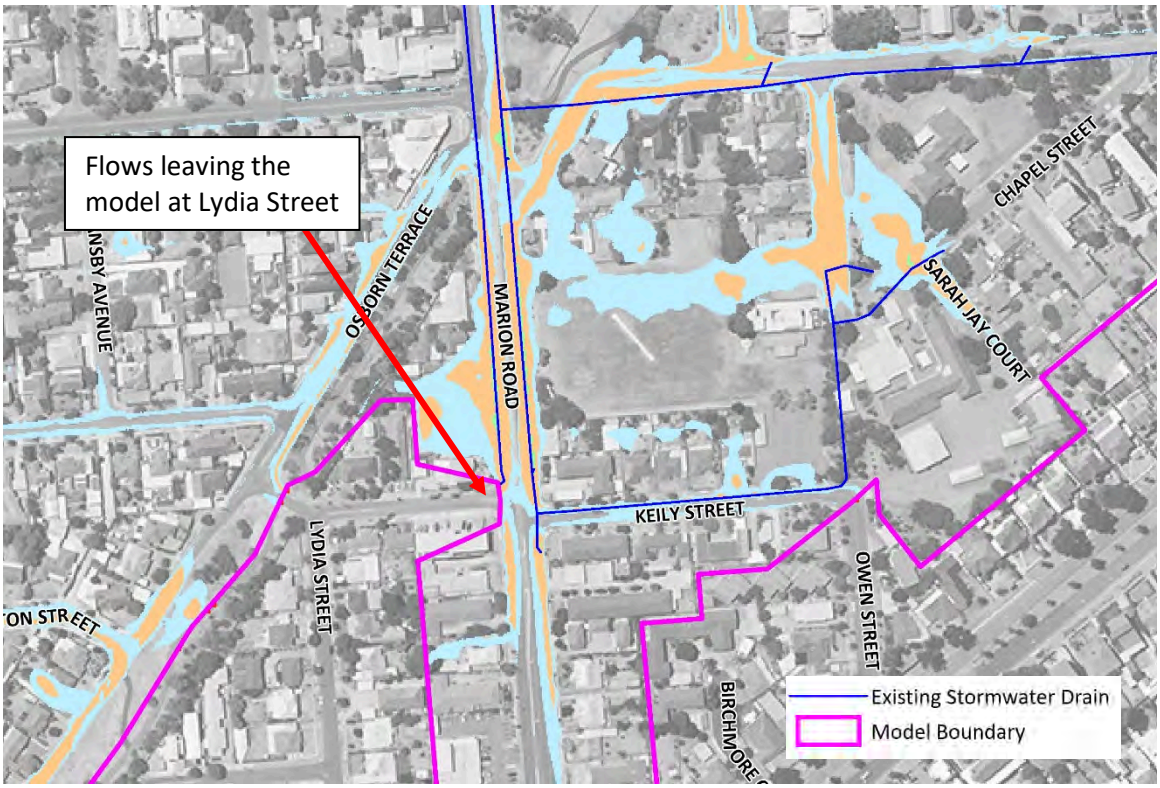


Figure 7.1 – Flows Reaching the Model Boundary

Table 7.3—SMP Strategy Actions

Priority	Project Location / Description	Catchment	LGA	Project ID	Flood Mitigation Benefit	Water Quality Benefit	Capital Cost	Annual Costs	SMA Eligible	Objectives Addressed
0 - 10 years	Lasscock Ave Drainage	River Torrens	WT	D9	✓	✓	$1,130,000	-		O1, O2, O3
0 - 10 years	Ashwin Parade Drainage	River Torrens	WT	D12	✓	✓	$2,010,000	-		O1, O2, O3
0 - 10 years	Ann Nelson Dr to Light Terrace Drainage and Detention Basin with Biofilter	River Torrens	WT	D14	✓	✓	$3,140,000	-	✓	O1, O2, O3, O5, O9
0 - 10 years	Allen Ave, Lysle St Road Bunds	Cowandilla Mile End	WT	D17	✓		$32,000	-		O1, O2
0 - 10 years	Milner Rd Drainage and Detention Storage	Keswick Creek Lateral Drains	WT	D20	✓		$2,060,000	-		O1, O2, O9
0 - 10 years	Arthur St Drainage	Keswick Creek Lateral Drains	WT	D21	✓		$1,410,000	-		O1, O2
0 - 10 years	Chambers Ave Drainage	Keswick Creek Lateral Drains	WT	D22	✓		$930,000	-		O1, O2
0 - 10 years	Knight St Drainage	Keswick Creek Lateral Drains	WT	D23	✓		$1,350,000	-		O1, O2
0 - 10 years	Warwick Ave Drainage	Brown Hill Creek Lateral Drains	WT	D25	✓		$1,590,000	-		O1, O2
0 - 10 years	Gray St Drainage	Brown Hill Creek Lateral Drains	WT	D26	✓		$1,770,000	-		O1, O2
0 - 10 years	Harvey Ave Drainage	Brown Hill Creek Lateral Drains	WT	D27	✓		$1,790,000	-		O1, O2
0 - 10 years	Edward Davies St Drainage	Brown Hill Creek Lateral Drains	WT	D29	✓		$800,000	-		O1, O2
0 - 10 years	North Plympton Trunk Drain + Laterals	Brown Hill Creek Lateral Drains	WT	D32	✓		$14,970,000	-	✓	O1, O2
0 - 10 years	Emma Pl Surcharge Basin Re-shape	Brown Hill Creek Lateral Drains	WT	D33	✓		$100,000	-		O1, O2
0 - 10 years	Hoylake St / Albert Ave Drainage	Brown Hill Creek Lateral Drains	WT	D35	✓		$1,720,000	-		O1, O2

Priority	Project Location / Description	Catchment	LGA	Project ID	Flood Mitigation Benefit	Water Quality Benefit	Capital Cost	Annual Costs	SMA Eligible	Objectives Addressed
0-10 years	Keswick Creek Channel Investigation and Prelim Design	Various	Various	D36			$200,000			O1
0-10 years	Community Flood Response and Preparedness	N/A	N/A	D37			N/A	$10,000		O8
0-10 years	Community Flood Response and Preparedness – Council's Community Emergency Management Plan	N/A	All	D38			N/A	N/A		O8
0-10 years	Development Controls – Floor Levels	N/A	All	D39			N/A	N/A		O7
0-10 years	Development Controls – On-site Detention / Retention	N/A	All	D40			N/A	N/A		O7
0-10 years	Ongoing Maintenance and Monitoring of Council Assets	All	All	D41			N/A	N/A		O6
0-10 years	Rainwater Tanks	Various	WT, CCS	Q3		✓	N/A	N/A		O4, O7
0-10 years	Maintenance of existing wetlands	Various	WT	Q5		✓	N/A	$110,000 (based on approx. 50 ha of Council maintained wetlands)		O3, O5, O6
0-10 years	Integration with Council Business Plans	N/A	All	Q6			N/A	N/A		O9
0-10 years	Community Education and WSUD Promotion	N/A	All	Q7			N/A	$10,000		O4, O7, O8
0-10 years	Investigating how Receiving Watercourses can be Better Utilised	Various	All	Q8			N/A	N/A		O5, O8, O9
0-10 years	Supporting Community Groups Contributing to the Achievement of the SMP Objectives	Various	All	Q9			N/A	$10,000		O5, O8, O9
0-10 years	Small scale stormwater harvest and reuse	Various	All	R1		✓	Unknown	Unknown		O4

Priority	Project Location / Description	Catchment	LGA	Project ID	Flood Mitigation Benefit	Water Quality Benefit	Capital Cost	Annual Costs	SMA Eligible	Objectives Addressed
0-10 years	Expanding reserves irrigated by GAP and Class A recycled water	Various	All	R2			Unknown	Unknown		O4
10 - 20 years	Matt St Drainage	Lockleys	WT	D5	✓	✓	$1,070,000	-		O1, O2, O3
10 - 20 years	Stephens Ave Drainage	River Torrens	WT	D13	✓		$630,000	-		O1, O2
10 - 20 years	Davenport Terrace Drainage	Keswick Creek Lateral Drains	WT	D18	✓		$3,040,000	-		O1, O2
10 - 20 years	South Rd Mile End Drainage and Detention Storage	Keswick Creek Lateral Drains	WT	D19	✓		$1,560,000	-		O1, O2, O9
10 - 20 years	Marleston to West Richmond Drainage and Detention Storage	Keswick Creek Lateral Drains	WT	D24	✓		$18,370,000	-	✓	O1, O2, O9
10 - 20 years	Glenburnie Tce Drain and Detention Basin with Biofilter	Brown Hill Creek Lateral Drains	WT	D30	✓	✓	$2,160,000	-		O1, O2, O3, O5, O9
10 - 20 years	Spring St Drainage	Brown Hill Creek Lateral Drains	WT	D31	✓		$670,000	-		O1, O2
10 - 20 years	Penong Ave Drainage	Brown Hill Creek Lateral Drains	WT	D34	✓		$1,150,000	-		O1, O2
20 - 30 years	Burnley Pump Station + Drainage	River Torrens Pumping Station	WT, CCS	D2	✓	✓	$16,140,000	$8,000	✓	O1, O2, O3
20 - 30 years	Frontage Rd Drainage	Lockleys	WT	D4	✓	✓	$950,000	-		O1, O2, O3
20 - 30 years	Douglas St Drainage	Lockleys	WT	D6	✓		$730,000	-		O1, O2
20 - 30 years	Malurus Ave Drainage	Lockleys	WT	D7	✓		$460,000	-		O1, O2
20 - 30 years	Grant Ave Drainage	Lockleys	WT	D8	✓	✓	$900,000	-		O1, O2, O3
20 - 30 years	Sherriff North Drainage	River Torrens	WT	D11	✓	✓	$910,000	-		O1, O2, O3
20 - 30 years	Cowandilla, Mile End to Keswick Creek Drainage	Cowandilla Mile End	WT	D15	✓		$23,040,000	-	✓	O1, O2
20 - 30 years	Airport Rd, Mellor Ave Drainage	Cowandilla Mile End	WT	D16	✓		$3,150,000	-		O1, O2
30 - 40 years	Riverway Drainage Upgrade	River Torrens Pumping Station	WT	D3	✓		$2,750,000	-		O1, O2

Priority	Project Location / Description	Catchment	LGA	Project ID	Flood Mitigation Benefit	Water Quality Benefit	Capital Cost	Annual Costs	SMA Eligible	Objectives Addressed
30 - 40 years	Streetscape raingardens / bioretention	Various	All	Q1		✓	$82,740,000	$700 per raingarden		O3, O4, O5
40+ years	Henley Beach Sth Pump Station Upgrade + Drainage	River Torrens Pumping Station	WT, CCS	D1	✓	✓	$4,330,000	$2,000	✓	O1, O2, O3
Included in corresponding flood mitigation strategy	Reserve / Detention Basin Bioretention Systems	Various	WT	Q2		✓	Cost included in corresponding flood mitigation strategy	$1000 per biofiltration system		O3, O5, O9
Included in corresponding flood mitigation strategy	Gross Pollutant Traps	Various	WT	Q4		✓	Cost included in corresponding flood mitigation strategy	$2,000 per GPT		O3, O5
Complete	Sheriff South Drainage + Raingardens	River Torrens	WT	D10	✓	✓	$280,000	-		O1, O2
Complete	Packard St Drainage	Brown Hill Creek Lateral Drains	WT	D28	✓		$1,090,000	-		O1, O2
TOTAL							**$201,120,000**			

8 Stakeholder and Community Consultation

8.1 Local, State Government Stakeholders

A draft report was circulated to representatives of the Cities of Adelaide and Charles Sturt, Green Adelaide and the Stormwater Management Authority. Following the collation of feedback from this process, a final draft report was prepared and distributed for community consultation.

8.2 Consultation on the Draft Stormwater Management Plan

8.2.1 Approach to Consultation on the Draft Plan

The draft Plan was placed on the City of West Torrens 'Your Say' website for consultation from 21 November 2022 to 19 December 2022, in accordance with Council's Consultation Policy. The availability of the draft Plan for review and comment was publicised via:

- Information screens at the City of West Torrens Civic Centre;
- City of West Torrens website; and
- Social Media.

The 'Your Say | West Torrens' website provided residents the opportunity to read the draft plan and provide feedback via online form. The website provided a number of tools for the visitor to browse the location and extent of proposed works, and a slider tool to view the changes to the 5% and 1% AEP flood plain extents associated with the proposed works.

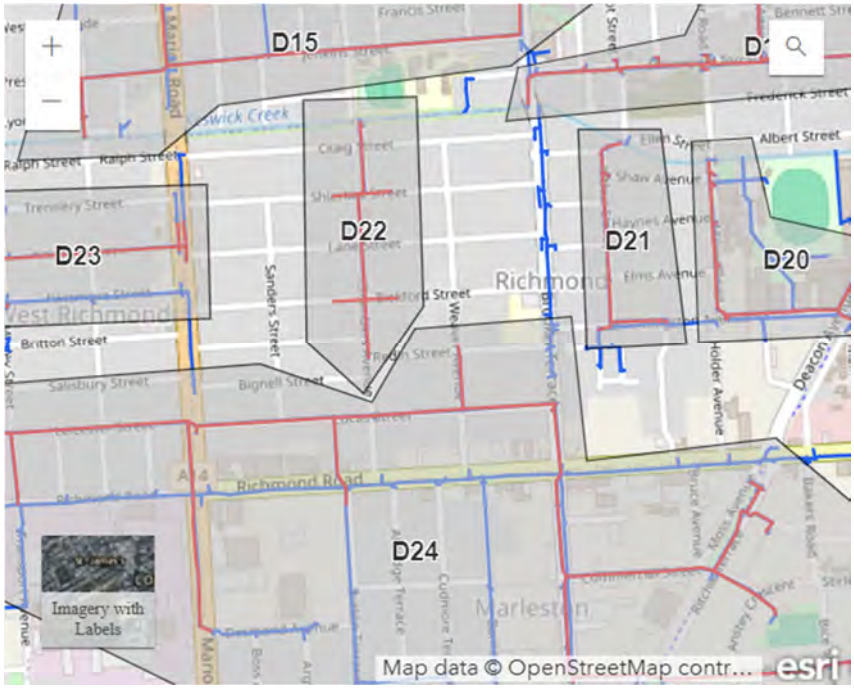


Figure 8.1 — Proposed Flood Works Browser

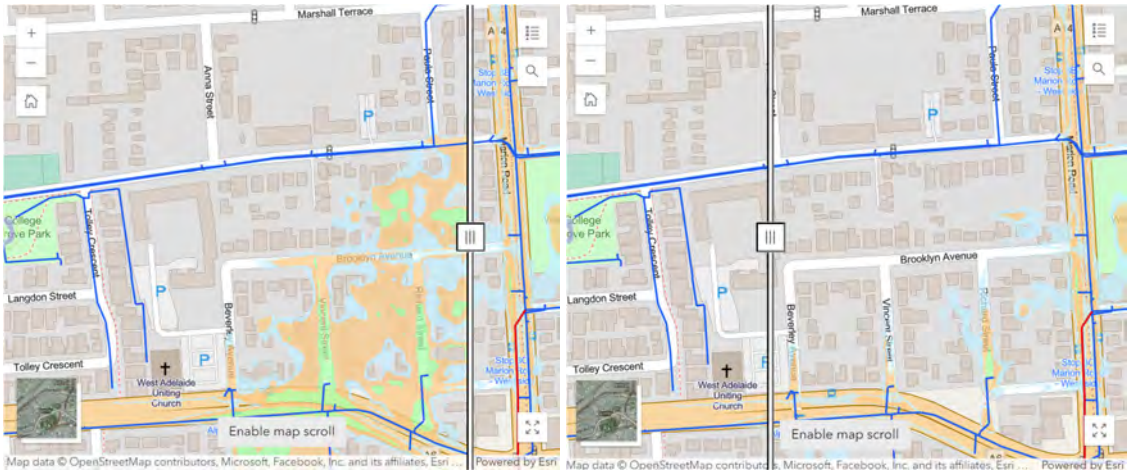


Figure 8.2 — Flood Improvements Slider Tool

8.2.2 Participation in the Consultation Process

The following participation in the consultation on the draft Plan was recorded from the Your Say Wes Torrens website:

- Total Page Views: 66
- Document downloads: 32
- Feedback form submissions (i.e. number of written responses/feedback to the plan): 1

Two phone calls were also received by Council staff during the consultation period. Both of the phone calls and the single feedback form submission highlighted localised drainage grievances, for which Council staff were able to successfully reference Stormwater Management Plan recommendations that would alleviate these issues.

8.2.3 Elected Members

The City of West Torrens elected members were briefed on the development of the Stormwater Management Plan at a workshop held on 4 February 2020.

8.3 Summary

The draft Stormwater Management Plan document was issues for consultation in accordance with Council's Consultation Policy. While community participation in the consultation process was relatively low, no issues were raised requiring amendment to the Plan.

9 References

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Appendix A

Pump Station Desktop Study Report (Southfront 2020)



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26 November 2020

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Dear Nicky

Desktop Study of Riverway and Chippendale Pump Stations

Council has engaged Southfront to conduct a desktop study of the Chippendale Pump Station and Riverway Pump Station design reports in order to determine any significant differences in modelling techniques and assumptions used in the West Torrens Stormwater Management Plan (SMP).

The two pump stations have undergone recent upgrades within the last decade. Hence, a detailed investigation of the design reports has been conducted to ensure these pump stations are being accurately depicted in the SMP TUFLOW model for future model runs.

The following three design reports have been provided by Council:

- Chippendale Stormwater Pump Station Upgrade, Concept Design Report, 21 December 2010
- Riverway Place stormwater pump station upgrade, Catchment hydrologic model and concept flood event protection 2009
- Riverway Place Stormwater Pump Station Upgrade, Detailed Design Summary Report, 25 September 2009

Scope

The scope of the investigation is as follows:

- Review provided reports and drawings (Riverway and Chippendale concept design reports)
- Compare hydrology and hydraulic model assumptions in pump reports with SMP assumptions. Key comparisons:
    - Catchment areas
    - Rainfall data
    - Runoff coefficients
    - Stormwater network pipe sizes
    - Hydrologic and hydraulic models used
    - Incoming flows for different AEP events
    - Pump rates
    - Pump sump/basin storage sizes

- Report findings and any significant differences
- Provide recommendations moving forward with the SMP

Model Comparisons

Table 1 and **Table 2** below summarise the key techniques and assumptions used in the design reports and SMP for the Chippendale and Riverway pump stations respectively.

Table 1 – Chippendale Pump Station, Modelling Techniques and Assumptions Comparison

Modelling Component	Design Report	West Torrens SMP	Comments and Recommendations
1. Catchment areas	A total area of 12.4 ha was modelled according to the Design Report. This includes the overflows from several commercial properties that are within the Riverway Catchment.	The subcatchments contributing to the system in the SMP have a total area of 8.67 ha. The TUFLOW model takes into account overflows from adjacent catchments.	The catchment size discrepancy is not seen as a significant difference as the TUFLOW model takes into account overflows from adjacent catchments which would result in similar overall catchment sizes.
2. Hydrologic model	ILSAX hydrologic model used. Depression Storages: - Paved = 1 mm - Supp = 1 mm - Grassed = 5 mm Soil Type: 2 (moderate infiltration rates and moderately well-drained – 13 to 200 mm/h)	ILSAX hydrologic model used. Depression Storages: - Paved = 1 mm - Supp = 1 mm - Grassed = 45 mm Soil Type: Manually specified – set to achieve a continuing loss of 3 mm/h	The SMP has assumed a larger initial grassed storage. This assumption is consistent with other urban models. The grassed initial storage is only relevant for major storms (>5% AEP / 20 year ARI) when the storage is exceeded. The Design Report states an assumption of moderately well drained soils. This results in a continuing loss rate that is quite larger than the SMP assumption of 3 mm/h. The SMP uses a smaller continuing loss, however, a greater initial loss compared to the design report. These are seen, to a certain degree, to offset each other and not result in dramatically different losses. It is not recommended that the continuing loss value is changed as this is a standard assumption widely used for urban area stormwater modelling.
3. Rainfall data	1987 ARR rainfall data was used. No increase in rainfall intensity due to climate change was assessed.	2016 ARR rainfall data was used. These generally result in a slight increase in rainfall intensity for the larger storm events. Climate change rainfall intensity increases were assumed for two of the existing infrastructure scenarios. (an 8.5% and 18.1% rainfall intensity increase)	The difference in rainfall intensity between the 1987 and 2016 ARR rainfall would result in a minor though likely insignificant difference in stormwater flows. The intensity increases due to climate change are much larger and these scenarios are expected to have lower performance standards compared to the Design Report where climate change was not considered. It is recommended to use the 2016 ARR rainfall for the SMP.
4. Runoff coefficients	Existing development runoff coefficients: Residential area: Directly connected = 30% - 40%, Supplementary = 10% - 20%, Grassed = 50% Commercial area: Directly connected = 80%, Supplementary = 10%, Grassed = 10% No future dxevelopment scenario considered.	Existing development runoff coefficients: Residential: Directly connected = 42%, Supplementary = 28%, Grassed = 30% Commercial: Directly connected = 85%, Supplementary = 5%, Grassed = 10% Future development runoff coefficients: Residential: Directly connected = 46%, Supplementary = 24%, Grassed = 30% Commercial: Directly connected = 90%, Supplementary = 5%, Grassed = 5%	Both the existing development and future development scenarios from the SMP have assumed higher directly connected impervious percentages compared to the Design Report. The SMP assumption for the indirectly connected impervious (supplementary) area for the residential land use type is also larger than what was assumed in the Design Report. The larger impervious fractions used in the SMP would result in larger stormwater flows and so is likely a contributing factor to the lower performance standard seen in the SMP flood maps. These impervious fractions have been measured and calculated as described in Section 4.2 of the SMP Report. These values are more conservative and the future runoff coefficients provide a more appropriate estimate of the long-term development scenario. Future development was not considered in the Chippendale Pump Station Design Report. It is not

Modelling Component	Design Report	West Torrens SMP	Comments and Recommendations
			recommended that the SMP runoff coefficients are changed as these are based on a more accurate and detailed analysis.
5. Hydraulic model	DRAINS was used for the hydraulic modelling to determine the required storage and pump rates.	TUFLOW	With all the hydrological parameters being the same, DRAINS will produce slightly different results as TUFLOW, purely due to the difference in model structures and computations. The difference would not be considered significant. TUFLOW is superior at handling overland flows and flow mitigation due to surface storage.
6. Stormwater network pipe sizes	Existing drainage from the Design Report consists of two 600 mm systems connecting to one 825 mm pipe which then connects to the storage at the pump station.	The same pipe sizes as the Concept Design Report were used	There is no difference in the pipe sizes used.
7. Pump sump/basin storage sizes	Five 2700 mm diameter pipes, each 20 m long were proposed (approx. 570 m^3 total storage).	No separate storage was modelled at the pump station in the SMP TUFLOW model.	It is recommended that the storage is modelled in future runs of the SMP. While the storage is not overly large, it will provide some further flood mitigation.
8. Maximum pump flow rates	A maximum pump rate of 350 L/s (recommended Option 2 form report) was nominated for the upgraded Chippendale Pump Station.	The Chippendale pump performance curves were provided by Council during the SMP model setup. As shown in the figure below, a maximum pump rate of 400 L/s is achieved across 3 pumps when the storage tank is full (sourced from the Chippendale Stormwater Pump Station Upgrade Civil Works Specification, 2011). 	The maximum pump rate of 400 L/s will continue to be used for future SMP model runs as it is based on provided pump curves.
9. Incoming flows to storage for different AEP events	20 year ARI – 0.9 m^3/s to storage 50 year ARI – 1.03 m^3/s to storage 100 year ARI – 1.34 m^3/s to storage	The peak incoming flow rate is capped by the maximum pump rate of 400 L/s as no storage has been modelled in the SMP.	Peak incoming flow rates will increase once a storage node has been added in the SMP model, which will improve the system performance to a certain degree.
10. Flood protection performance standard	The recommended 'Option 2' from the Design Report provided a 50 year ARI flood protection.	Flood modelling shows a 5% AEP (20 year ARI) standard in the existing development scenario. Property flooding occurs in the 2% AEP (50 year ARI) event.	As stated in Comments Row 3 and 4, the rainfall data and assumed runoff coefficients from the SMP would produce larger stormwater flows and a lower performance standard

Modelling Component	Design Report	West Torrens SMP	Comments and Recommendations
			than those of the Design Report. This is seen in the SMP flood results, particularly for the climate change scenario. Additionally, no storage tank was modelled at the pump station in the SMP further contributing to the lower performance standard seen in the SMP. It is proposed that the storage tank is modelled in future SMP model runs. This will potentially improve the flood standard and better align with the desired standard from the Design Report of 50 year flood protection for at least the existing development scenario in the SMP.

Table 2 – Riverway Pump Station, Modelling Techniques and Assumptions Comparison

Modelling Component	Design Report	SMP Assumption	Comments and Recommendations
1. Catchment areas	A total area of 18.3 ha was assumed to contribute to the Riverway stormwater system.	Subcatchments contributing to the Riverway system in the SMP have a total area of 19.66 ha.	The larger catchment area assumed in the SMP would produce a slightly larger runoff flow provided all other parameters are equal. This difference in catchment area is not seen as significant and no change is recommended.
2. Hydrologic model	ILSAX hydrologic model used. Depression Storages: - Paved = not specified - Supp = not specified - Grassed = 30 mm Continuing loss of 3 mm/h	ILSAX hydrologic model used. Depression Storages: - Paved = 1 mm - Supp = 1 mm - Grassed = 45 mm Soil Type: Manually specified – set to achieve a continuing loss of 3 mm/h	No significant difference between SMP and Design Report. SMP values to remain, as stated in Table 1 (row 2).
3. Rainfall data	1987 ARR rainfall data was used. Climate change impacts were not considered.	2016 ARR rainfall data was used. These generally result in a slight increase in rainfall intensity for the larger storm events. Climate change rainfall intensity increases were assumed for two of the existing infrastructure scenarios. (an 8.5% and 18.1% rainfall intensity increase)	The difference in rainfall intensity between the 1987 and 2016 ARR rainfall would result in a minor though likely insignificant difference in stormwater flows. The intensity increases due to climate change are much larger and these scenarios are expected to have lower performance standards compared to the Design Report where climate change was not considered. It is recommended to use the 2016 ARR rainfall for the SMP.
4. Runoff coefficients	Existing development runoff coefficients: Directly connected = 30% No other information provided. No future	Existing development runoff coefficients: Residential: Directly connected = 42%, Supplementary = 28%, Grassed = 30% Commercial: Directly connected = 85%, Supplementary = 5%, Grassed = 10% Future development runoff coefficients: Residential: Directly connected = 46%, Supplementary = 24%, Grassed = 30% Commercial: Directly connected = 90%, Supplementary = 5%, Grassed = 5%	The SMP impervious fractions have been measured and calculated as described in Section 4.2 of the SMP Report. These values are more conservative than the design report and the future runoff coefficients provide a more appropriate estimate of the long-term development scenario. Future development was not considered in the Riverway Pump Station Design Report. It is not recommended that the SMP runoff coefficients are changed as these are based on a more accurate and detailed analysis.
5. Hydraulic model	DRAINS was used for the hydraulic modelling to determine the required storage and pump rates.	As per Table 1 (row 5)	As per comment in Table 1 (row 5)
6. Stormwater network pipe sizes	The existing stormwater trunk drain ranged from 450 mm diameter to 600 mm, 675 mm and finally 900 mm just upstream of the pump station storage.	The existing stormwater drainage used in the SMP matches the Design Report drainage except for the 900mm drain at the downstream end of the system. The provided Council drainage data does not show this drain but rather a 675mm drain.	The SMP does not currently include the 900 mm drain at the downstream end of the system as stated in the design report. It is recommended that the drain size is updated for future SMP model runs.

Modelling Component	Design Report	SMP Assumption	Comments and Recommendations
7. Pump sump/basin storage sizes	Three 2600 mm diameter, 18 m long pipes were proposed, resulting in a total volume of 310 m^3. The additional volumes of the pump chamber and connecting pipes equalled 35 m^3. Total storage volume of 345 m^3	No separate storage was modelled at the pump station in the SMP TUFLOW model.	It is recommended that the storage is modelled in future runs of the SMP. While the storage is not overly large, it will provide some flood mitigation.
8. Maximum pump flow rates	The Design Report proposed three pumps with separate rising mains. Each pump has a maximum pump rate of 300 L/s, resulting in a total maximum flow of 900 L/s for the pump station.	The maximum flow rate used for the Riverway Pump Station in the SMP was 300 L/s.	There is a significant difference in maximum pump rates between the SMP and Design Report. It is recommended that the pump rate will be updated to have a maximum rate of 900 L/s and will be used for all future SMP model runs.
9. Incoming flows for different AEP events	A peak flow rate of 560 L/s is reported for the existing gravity drainage.	The peak incoming flow rate is capped by the maximum pump rate of 300 L/s as no storage has been modelled in the SMP.	Peak incoming flow rates will increase once the pump rate, incoming pipe size and storage has been updated in the SMP model.
10. Flood protection performance standard	The Riverway Design Report does not include any upgrade to the existing stormwater drains. It states that no further flood protection is provided other than that presently provided (approx. 5 year ARI). The report states that the pump station will have the capacity to provide between a 10 and 20 year ARI flood protection standard in the event that upstream drainage is upgraded at a later date.	The initial SMP flood modelling shows that the Riverway system has a 0.5 EY (2 year ARI) flood standard in the existing development scenario. Though, as identified above, the initial model has not included a storage and large enough pump rate.	The smaller pump rate, no modelled storage and smaller incoming pipe size in the SMP all contribute to the low performance standard. It is recommended that these are all updated as per the Design Report for future SMP model runs. Note that the SMP considers future development and climate change which have not been specifically considered in the Design Report (hydrology component was not provided). Once the above updates are made the flood standard stated in the Design Report may not be reached for the future development and climate change scenarios if these were not considered in the hydrology component of the Report.

Recommendations Summary

A summary of the recommended updates to the SMP modelling for both the Chippendale and Riverway Pump Stations is provided below. The recommendations should be implemented in future SMP model runs. It is also recommended that the existing scenario models are updated and re-run.

Chippendale recommendations:

- No change to catchment areas, hydrologic model parameters, runoff coefficients or rainfall data
- No change to maximum pump rate (400 L/s)
- Include a storage node at the pump station in the TUFLOW model with a volume of 570 m^3

Riverway recommendations:

- No change to catchment areas, hydrologic model parameters, runoff coefficients or rainfall data
- Increase maximum pump rate to 900 L/s
- Include a storage node at the pump station with a volume of 345 m^3.
- Increase the size of the incoming stormwater drain from 675 mm to 900 mm.

Please do not hesitate to call us on 8172 1088 if you require any further information regarding the above.

Yours sincerely



Drew Jacobi BEng (Hons) FIEAust CPEng NER
Principal Engineer

Appendix B

Development Potential: Residential and Infrastructure Assessment Report (Infraplan, 2017)



infraPlan






policy – strategy – planning – infrastructure – transport – environment

Development Potential: Residential and Infrastructure Assessment for West Torrens Catchment Stormwater Management

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1. Introduction

This report outlines the investigations undertaken by InfraPlan specific to the urban planning and development potential requirements for the Stormwater Management Plan (SMP). This report will assist in identifying potential increases to the impervious areas. InfraPlan has applied several assessment approaches to represent development potential, and the likely outcomes from development. The report also assesses the policies within the West Torrens Council Development Plan (with regard to current development requirements and those proposed in policies and development areas), and calculates the dwelling increase potential across the SMP catchment. Importantly, the InfraPlan approach also applies qualitative and quantitative approaches with regard to market influences on development: although planning policies are significant, the market and development responses can often be incongruent with policy expectations.

The following sections are contained within the report:

- Strategic and Policy overview: exploring the policies which have led to an infill development agenda;
- Development trends, Land Supply and Population Forecasts: exploring historic and future development and population trends;
- Development potential and yield scenarios: 4 development scenarios are explored, generating a range of potential scenarios for residential development across the SMP catchment.
- Transport and Infrastructure assessment: increasing the impervious land area

For the purposes of this report, InfraPlan has applied industry best practise assessment and calculations for development potential and urban infill, as well as its own assessment methods and investigations developed specifically for this report. Despite this, actual future populations/development potential and infill locations will likely vary from these projections, especially given the assessments have been applied over a 30-year timeframe. Therefore, it is recommended that the outputs of this report be reviewed on a semi-regular basis and be recalibrated using updated relevant data to ensure that the Development Potential Scenarios (Chapter 4) and Spatial Distribution of Dwellings (Chapter 3) remain relevant. This is especially important given the likely implications on infrastructure investment and resource suitability for the West Torrens stormwater catchment assets.

1.1 Study Area

The defined study area for the stormwater management plan (SMP) primarily covers the West Torrens Local Government Area (LGA) with a minor portion of Charles Sturt LGA to the North-West and Adelaide City LGA to the East (See Figure 1).

For the purposes of these investigations a dwelling database for the study area has been provided by the Department of Planning, Transport and Infrastructure. Given that the most outputs available are aggregated in to larger data sets this data has been integral in the outputs of these investigations (with some data being reported on an LGA-wide basis). The database is for residential dwellings and includes parcel identification, capital value/site value ratio, year built, land use code (used to determine dwelling type), parcel area (m^2). For data cleansing it was necessary to remove some of the line items from the data set, as car parks with a separate title were removed as was the duplicate for some parcels that may have more than one title.

From the provided data, the following share of dwellings across the catchment area has been determined:

Table 1: Number of dwellings across the study area

LGA Name	Number of residential dwellings within the Study Area	% share of dwellings within the Study Area	Area (ha) within the Study Area	% share of area within the Study Area	Number of Vacant (Urban) land parcels
West Torrens	18,412	86.88%	3,395	90.56%	358
Charles Sturt	1,515	7.15%	147	3.92%	11
Adelaide	1,265	5.97%	207	5.52%	39
Study Area Total	**21,192**	**100%**	**3,749**	**100%**	**408**

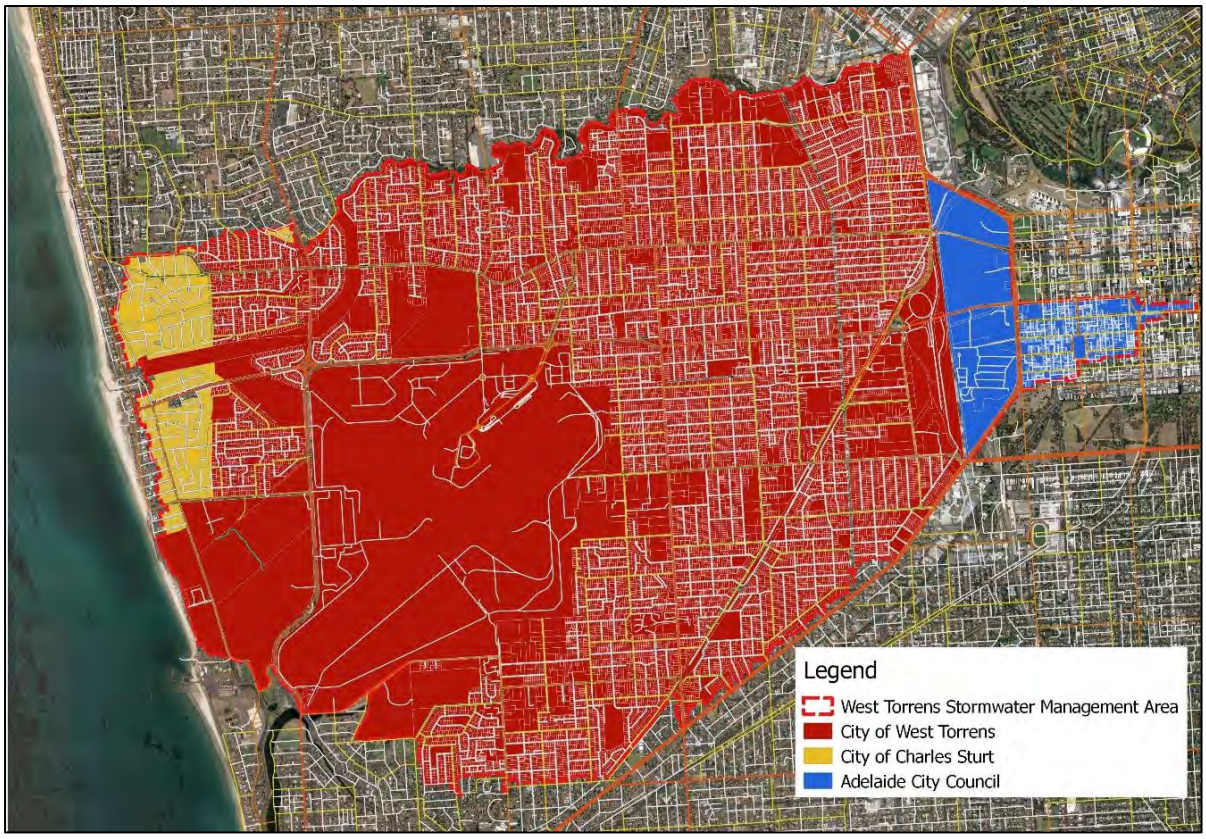


Figure 1: Stormwater Management Plan Area (Study Area)

1.2 Rationale for Investigations

The recent discussions, policy and legislation relating to urban renewal, infill development and increasing housing densities raises fundamental questions for planners, state and local government agencies and infrastructure providers. As a result of the infill growth conditions, there is a requirement to understand how infill dwelling development is likely to occur over the stormwater assessment study area, how this will increase impermeable areas, and ultimately how this will impact on stormwater infrastructure capacity.

The scenarios explored in this report are for the purpose of informing the development of a long-term stormwater management plan, and should be considered in the context that planning policies (and their related social, economic and environmental influences) do vary over time.

Adelaide is experiencing moderate densification across its metropolitan area. Growth in Adelaide's middle and inner suburbs (including the City) now accounts for over 70% of dwelling increases. This is a shift since the early 1990's from a position where population was actually falling in these locations.

Demolition, subdivision and redevelopment is increasing the housing stock within existing urban areas. Much of this development is categorised as '*minor infill*' as most projects result in the production of only one or two additional dwellings. This is in comparison to 'greenfield' development which predominantly occurs on the urban fringe.

While there are many factors which influence development patterns across metropolitan Adelaide, perhaps the most significant shift in recent years has been the introduction of policies to increase the infill demand. These policies are reflected in this report.

The State Government and many Local Governments have an 'urban renewal' agenda which is aligning with the market demand for inner and middle metropolitan living.

Emerging policies (broadly explored in this report) reflect the following:

- higher residential density targets, including regulations that allow denser development in appropriate locations, such as high frequency transit corridors and activity centres;
- affordable housing that is accessible to employment and transport opportunities;
- protection policies on the urban fringe, specifically in the Adelaide context the Environmental and Food Protection Areas which increase the role of infill development in housing future population;
- relaxing of constraints on dwelling sizes and types to facilitate greater housing diversity, and;
- policies that seek to regulate development within close proximity to Airports to enhance safety and amenity.

For the purposes of this report, the follow terms have been broadly defined:

- Infill development: can be defined in various ways including 'urban consolidation', 'urban renewal', 'redevelopment', 'medium density housing' or 'high rise development'. Infill tends to be defined as: 'the more intensive use of land for residential development in urban areas'.
- Minor infill: residential development within the inner and middle rings of Adelaide which result in nominal site dwelling yield increases, or 1:1 replacement of housing stock.
- Greenfields development: residential development that occurs on the urban fringes of metropolitan Adelaide resulting in significant site dwelling increases (more than 10 dwellings). Generally encompassing non-productive land, habitats and productive farmland.

2. Strategic and Policy Overview

The generalised land use illustrates that the SMP Study Area is predominantly residential. This is significant given the purpose of the study. Other notable land uses include industrial (primarily Adelaide Airport) and commercial uses along main road frontages, recreation and education land uses are disbursed throughout the catchment also. Figure 1 illustrates land uses across the SMP Study area.

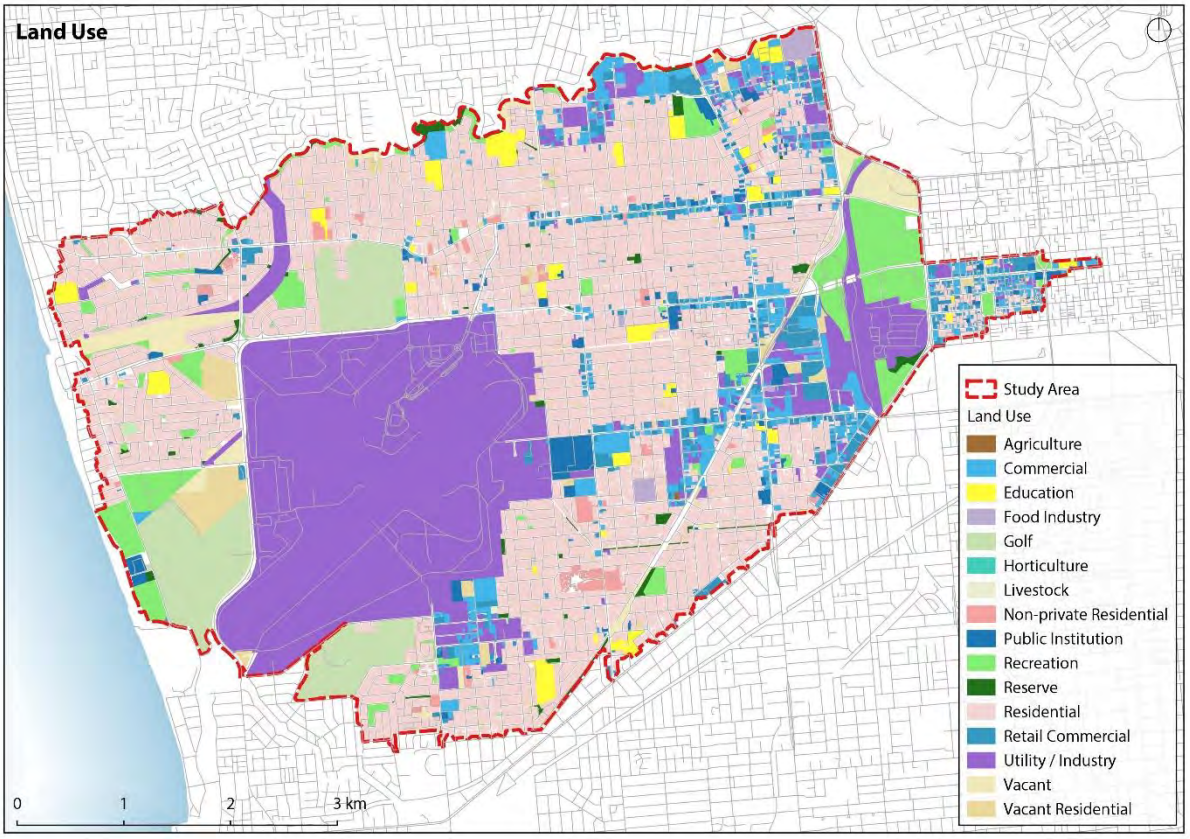


Figure 2: Land Uses (Generalised) within the SMP Catchment

2.1 Statewide Strategies, Policies and Targets

2.1.1 30-Year Plan for Greater Adelaide

The Draft 30-Year Plan for Greater Adelaide 2016 Update is focused on creating a new walkable urban form with a pronounced shift away from continued urban sprawl, to build a more liveable, competitive and sustainable region. The 6 refined targets within the update include:

1. 85% of all new housing in metropolitan Adelaide will be built in established urban areas by 2045;
2. 60% of all new housing in metropolitan Adelaide is built within close proximity to current and proposed fixed line (rail/tram/O-Bahn) and high frequency bus routes;
3. Increase the share of work trips made by active transport modes by residents of Inner, Middle and Outer Adelaide by 25% by 2045;
4. Increase the percentage of residents living in walkable neighbourhoods in Inner and Middle Adelaide by 25% by 2045;
5. Tree canopy cover is increased by 20% across metropolitan Adelaide by 2045; and
6. Increase housing choice by 25% to meet changing household needs in metropolitan Adelaide by 2045.

The emphasis on liveability, walkability and sustainability throughout the update has resulted in targets that strive to develop a more compact urban form through the renewal of existing neighbourhoods. Given targets 1, 2, 4 and 6 all directly relate to residential development within established areas, it can be considered that there is a strong infill agenda at the State level. This has resulted in various implications for local governments, particularly those within the inner and middle metropolitan regions as they are encouraged to adapt this agenda into their local planning frameworks.

2.1.2 Integrated Transport and Land Use Plan

The 2015 Integrated Transport and Land Use Plan for South Australia (ITLUP) sets out a number of actions that have potential to impact upon the SMP study area. This includes:

- Glenelg tram line – increase service frequencies and increase tram size and tram fleet;
- Partner with local councils to complete the Airport Bikeway, including crossings of arterial roads;
- West*LINK* - extend trams along Henley Beach Road, with an extension to Adelaide Airport
- Upgrade intersections along Sir Donald Bradman Drive to reduce congestion and improve reliability of travel times to the airport, and provide upgrades for taxi, commercial vehicle and bus access via Richmond Road.

These actions are likely to attract infill development as they have potential to enhance the liveability and desirability of the West Torrens Council area. Furthermore, the strategic emphasis on urban consolidation and increased housing densities around reliable and fixed line transit corridors (such as the existing Glenelg tramline and potential West*LINK* alignment through the council area), will make the study area important for meeting state-wide infill targets.

2.1.3 Environment and Food Protection Areas

While not incorporated with the City of West Torrens area*, *Environment and Food Protection Areas* have been implemented to protect sensitive land uses from urban development. These therefore further encourage the building of new homes in inner and middle ring areas, such as the West Torrens Stormwater Catchment study area. The boundary is likely to increase demand for infill development due to the reduced amount of land available for greenfield development.

*The Environment and Food Protection Area (EFPA) surrounds the built-up area of Adelaide from the north along the Gawler River, following the foothills southwards, along the western boundary of the McLaren Vale Preservation District and back towards the coast south of Sellicks Beach. The EFPA is defined as the existing rural lands that surround Greater Adelaide.



Figure 3: Environmental and Food Protection Areas with SMP Study Area Overlayed

2.1.4 Residential Development Code

A significant policy change in accelerating urban growth was introduction of the Residential Development Code in 2009. The Residential Development Code was introduced to make planning and building approvals for residential construction and renovation simpler, faster and cheaper. Under the code, you can apply in most cases for:

- Common residential works and structures such as sheds, carports, verandahs and rainwater tanks;
- Single-storey additions and alterations to existing homes; and
- New single-storey and two-storey detached and semi-detached homes.

The code does not apply to residential areas that are:

- Heritage locations, such as local heritage places, state heritage places, state heritage areas and historic conservation zones;
- The Hills Face Zone of the Adelaide Hills; and
- Flood-prone areas (unless the applicant can demonstrate that the development meets the flood protection standards of the relevant development plan).

Perhaps the most significant aspect of the Residential Development Code in the context of this report is that complying development with a total roofed area of 60% of the site is allowed: this represents an increase in the allowable impervious area on residential lots. The Residential Development Code also stipulates the minimum private open space requirements at the following rates:

Table 2: Residential Code Provisions

Allotment size	Minimum area of private open space	Minimum dimension
> 500m^2	80m^2	4m
300—500m^2	60m^2	4m
< 300m^2	24m^2	3m

These rates decrease the previous private open space requirements for most areas that are defined under the Code.

The Residential Development Code applies to much of the SMP study area. The extent of the Residential Code across the SMP Study are is depicted in Figure 4 below. While the Residential code is not expected to be incorporated into the new Planning System, its historical context is important for understanding the development trends which have been used in predicting the future development scenarios.

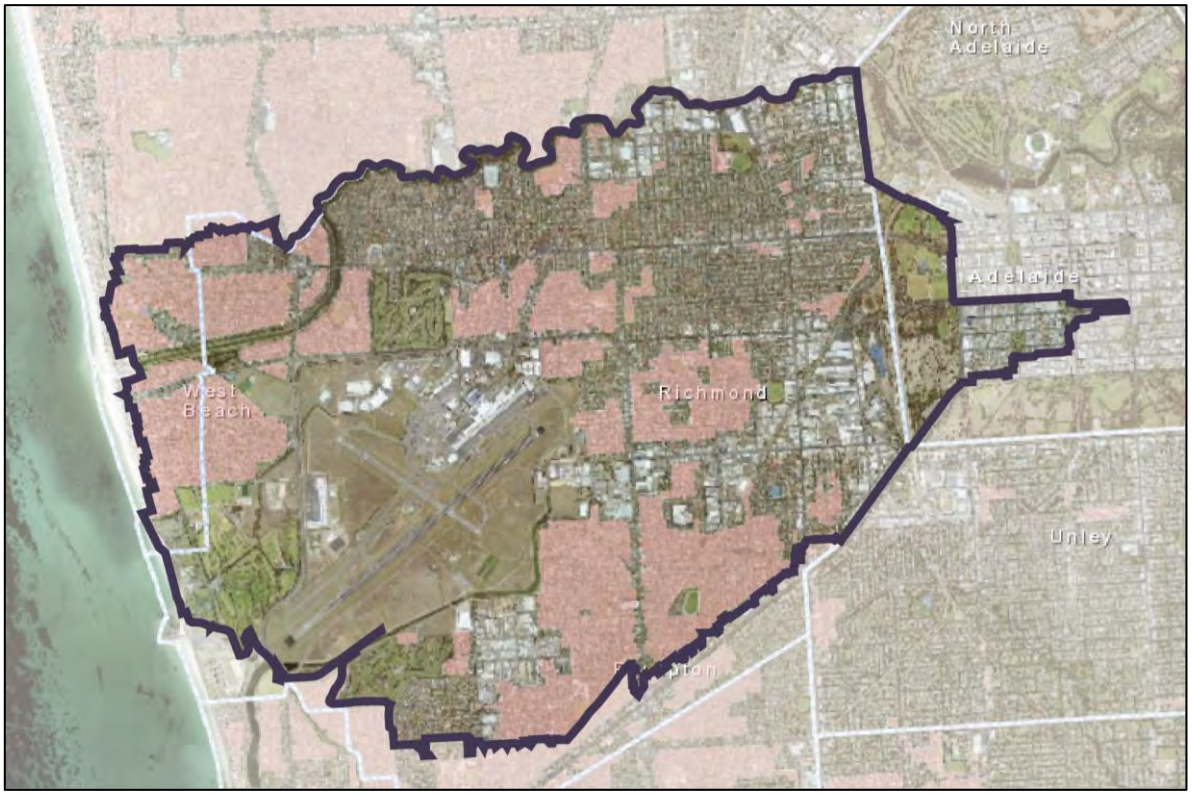


Figure 4: Residential Code Areas with SMP Study Area Overlayed

2.2 Development Plan Review

This section examines the current residential/infill and stormwater management policies within Councils' Development Plan. The West Torrens Council Development Plan (consolidated 5 May 2016) was consulted to inform this review.

It is important to note that *The Planning, Development and Infrastructure Act* was passed in 2016, and will result in reform of the planning system. While much of this new system is still under development, the policies, targets and guidelines released to date (such as in the 30 Year Plan Review) aim to facilitate infill growth where appropriate. Importantly the transition to this new planning system will implement the Planning and Design Codes which will effectively replace the existing Councils Development Plan. While the investigations in this report have (somewhat) relied upon the existing Development Plan zones, for the purpose of this report it has been assumed that much of the protection areas and areas which already encourage or allow for infill development will remain relatively consistent in the transition to the Planning and Design Codes.

2.2.1 Residential Development and Infill

As the West Torrens LGA stretches across inner and middle metropolitan Adelaide, Council has been subject to various policy amendments pertaining to housing densities and infill development. These DPA's seek to facilitate 30-Year Plan objectives by supporting the target of increasing urban infill to 85% of all new development across Greater Adelaide. This has resulted in the rezoning of areas along key transport corridors and suitable locations for land intensification.

High density residential development is now envisaged in newly implemented Urban Corridor Zones such as Anzac Highway, Port Road and Henley Beach Road where mixed use development between 2 and 8 storeys is envisaged. As a majority of land along these corridors is already built up, enabling redevelopment that incorporates residential uses has the potential to increase the amount of pervious land through the required landscaping of communal areas.

Policy Areas in residential zones have also been amended to support infill development through Councils' recent Housing Diversity DPA. This DPA intends to change the future form and character of parts of the City by creating policies that facilitate medium density infill development while also better protecting areas which have a desirable, established residential character. Land intensification within close proximity to activity centres has been endorsed through the DPA whereby the minimum site area and other requirements for residential development are reduced for land parcels within 400m of appropriate centre zones.

Within the current Residential Zone, two Medium Density Policy Areas (18 & 19), two Low Density Policy Areas (20 & 21), and a number of small Character and Conservation Policy Areas (22-33) have been established (See Figure 5 overfeaf). Medium Density Policy Areas within 400m of centre zones are considered prime locations for infill development. Low Density Policy Areas have larger site area requirements which generally favour detached dwellings and are more likely facilitate minor 1:1 infill development. Character and Conservation Policy Areas may also see 1:1 infill development, however this is less likely due to strict aesthetic guidelines. Council are currently considering the possibility of adjusting the design codes within these Character and Conservation Policy Areas to enable suitable infill that enhances the amenity of existing housing stock while also achieving increased density targets.

The key infill supportive zones and policy areas are detailed below:

Table 3: West Torrens Infill Supportive Zones and Policy Areas

Zone	Policy Area	Envisaged Development	% of Study Area
Urban Corridor	34 Boulevard	• Mixed use shop-top housing (non-residential development at the ground and first floor) • Minimum 100 dwellings per hectare • 3-8 storeys high	1.18%
	35 High Street	• Mixed use shop-top housing (non-residential development at the ground and first floor) • Minimum 70 dwellings per hectare • 3-6 storeys high	0.93%
	36 Transit Living	• Mixed use shop-top housing (non-residential development at the ground and first floor) • Minimum 45 dwellings per hectare • 2-4 storeys high	0.26%
	37 Business	• Mixed use shop-top housing (non-residential development at the ground and first floor) • No minimum dwellings per hectare • 3-6 storeys high	1.01%
			TOTAL URBAN CORRIDOR: 3.38%
Residential	18 Medium Density	• 150-250m^2 minimum site area o Reduced to 100-150m^2 for affordable housing • Max site coverage 70% • 1-4 storeys	3.00%
	19 Medium Density	• 270 m^2 minimum site area o Reduced to 150-250m^2 for affordable housing • Max site coverage 60% • 1-3 storeys	5.97%
			TOTAL MEDIUM DENSITY RESIDENTIAL: 8.97%

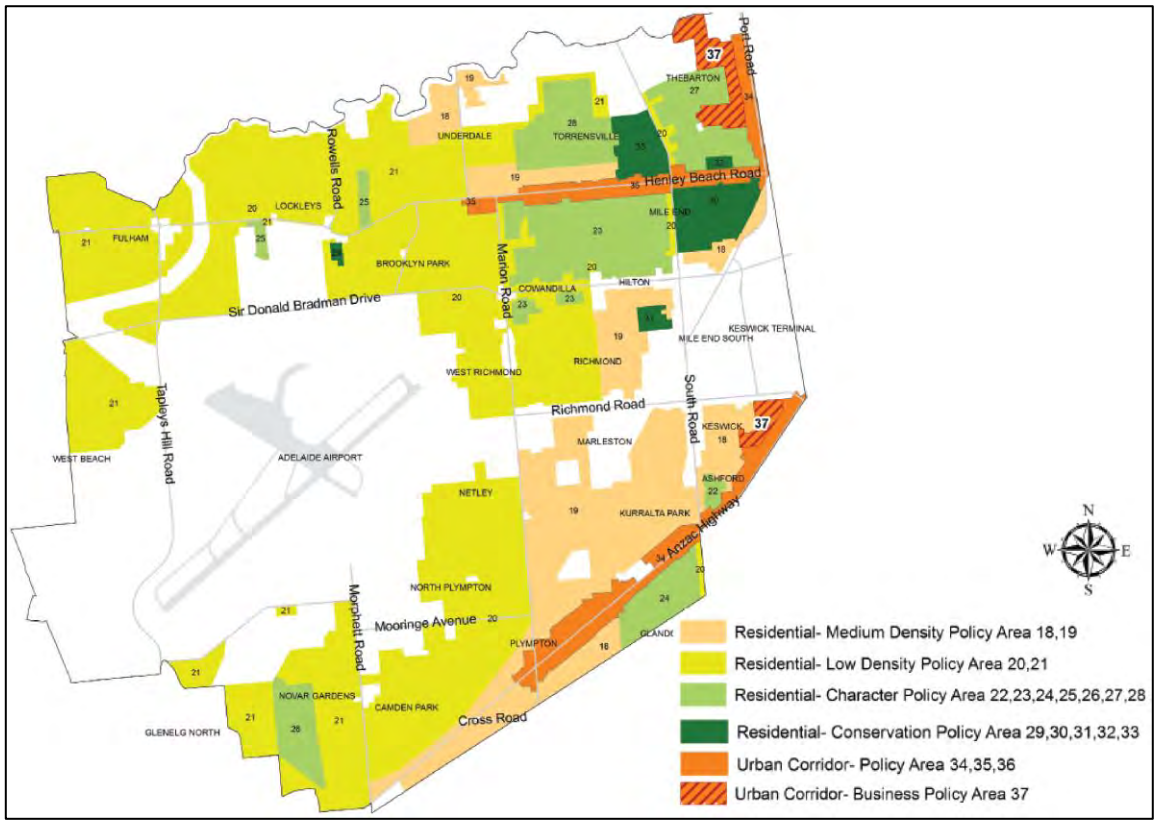


Figure 5: Housing Diversity DPA policy areas

In the context of this report, an aspect of Councils' development plan to note is the lack of site coverage provisions. Such provisions have only been implemented for Medium Density Policy Areas 18 and 19, leaving most residential policy areas without any regulation in this field. It can be assumed that the Residential Code provision of 60% site coverage applies to those areas covered by the code (see Figure 4).

2.2.2 Stormwater Management Policies

There are numerous provisions throughout the West Torrens Development Plan regarding stormwater management.

General provisions relating to stormwater management state that 'Development should not be undertaken in areas liable to inundation by … drainage or flood waters, unless it is developed with a public stormwater system capable of catering for a 1-in-100-year average return interval flood event' (General Section – Hazards (Flooding) PDC 5a).

In terms of land division 'Stormwater should be capable of being drained safely and efficiently from each proposed allotment and disposed of from the land in an environmentally sensitive manner' (General Section – Land Division PDC 1). Additionally, 'The arrangement of roads, allotments, reserves and open space should enable the provision of a stormwater management drainage system that: (a) contains and retains all watercourses, drainage lines and native vegetation (b) enhances amenity (c) integrates with the open space system and surrounding area' (General Section – Land Division PDC 11)

With respect to residential development, PDC 1(d) states:

> *'Residential allotments and sites should maximise solar orientation and have the area and dimensions to accommodate … water sensitive design systems that enable the storage, treatment and reuse of stormwater'*

Regarding private open space for residential development, PDC 22 states:

'Private open space at ground level should be designed to provide a consolidated area of deep soil (an area of natural ground which excludes areas where there is a structure underneath, pools and non-permeable paved areas) to: (a) assist with ease of drainage (b) allow for effective deep planting (c) reduce urban heat loading and improve micro-climatic conditions around sites and buildings.'

Furthermore, in terms of landscaping and parking 'Development should incorporate open space and landscaping and minimise hard paved surfaces in order to maximise stormwater reuse' (General Section – Landscaping, fences and walls PDC1j) and 'To assist with stormwater detention and reduce heat loads in summer, outdoor vehicle parking areas should include landscaping.' (General Section – Transportation and Access (Vehicle Parking) PDC 41)

While these provisions within the West Torrens Development Plan directly relate to stormwater management, few are quantified or measurable. Perhaps the most significant aspect of these provisions in the context of this report is that there are no specific regulations regarding the size of pervious and impervious areas for residential private open space.

2.3 Future Policy and DPA's

2.3.1 Inner and Middle Metropolitan Corridor Infill Development Plan Amendment

The State Government is planning for the future growth and revitalisation of strategic areas of metropolitan Adelaide. To achieve this, DPTI and several inner metro councils are investigating zoning changes to allow for a mix of new homes, offices and shops in key locations, such as along existing transport corridors within close proximity to the Adelaide CBD.

The re-zonings are being introduced through a DPA currently in development. It is understood the proposed changes will occur in part within the study area, having an overall impact on development potential. To date, zone changes at the following locations are under investigation:

- **Richmond Road** from Anzac Highway to Marion Road; and
- **Sir Donald Bradman Drive** from James Congdon Drive to Bagot Avenue.

Council should remain cognisant of changes to maximum site coverage and minimum private open space requirements proposed for these corridor zones and their impact on the area of impervious surfaces.

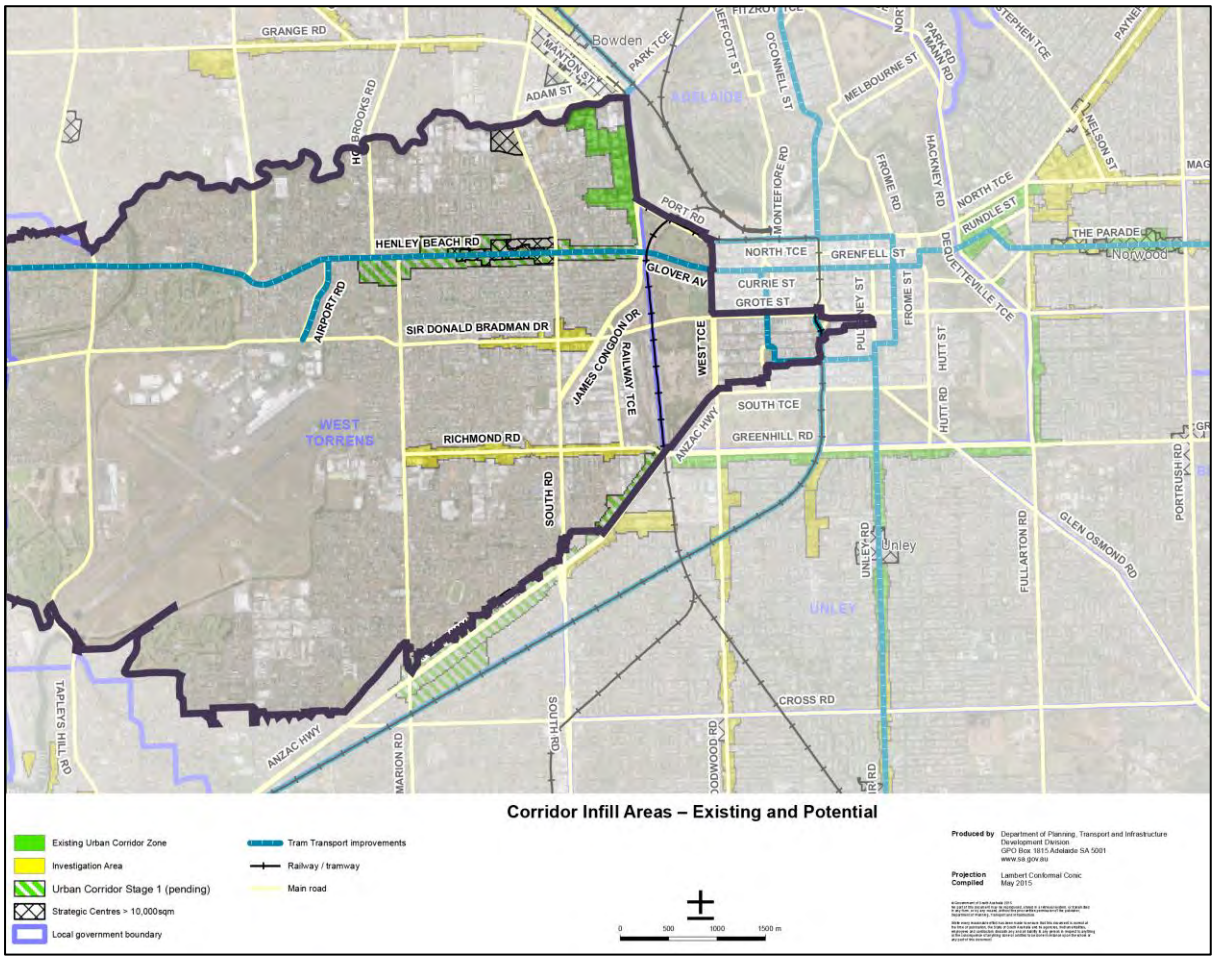


Figure 6: Inner Metro Growth Corridor Map

While these corridors are still undergoing investigation, there is possibility that this ministerial DPA will occur at a site-specific level rather than the corridors identified in Figure 6. This would apply to the Marleston TAFE site on Richmond Road and the CHG clinic on the corner of Railway Terrace and Henley Beach Road.

2.3.2 Airport Safety Zones

In Australia, there is no clearly-defined policy regarding public safety zones at airports. The National Airports Safeguarding Framework (NASF) Guidelines on public safety zones have long been considered but are still awaiting release. No South Australian requirements or guidelines have been published.

The NASF is a national land use planning framework which promotes a national approach to improving planning outcomes near airports and under flight paths, noting that the responsibility for land use planning primarily rests with State and Local Governments.

The NASF therefore that aims to:

- Improve community amenity by minimising aircraft noise for sensitive developments near airports; and
- Improve safety outcomes by ensuring aviation safety requirements are recognised in land use planning through guidelines being adopted by jurisdictions on various safety related issues.

One way this is achieved is by supplying Local Governments with data such as the Australian Noise Exposure Forecast (ANEF). The ANEF is updated every year based on factors such as aircraft size, models, flight paths and airport schedules. This data is mapped into contour lines based on the severity of noise exposure, which helps local authorities determine the type of development acceptable near airports. This is commonly reflected in development constraint overlay sections of Local Government Development Plans. Table 4 represents the acceptability of various land uses in ANEF Zones.

Table 4: Land use and building type acceptability in ANEF Zones

Land Use/ Building Type	ANEF Zone		
	Acceptable	Conditionally Acceptable	Unacceptable
Residential	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Hotel/hostel	Less than 25 ANEF	25 to 30 ANEF	Greater than 30 ANEF
Education	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Medical Facility	Less than 20 ANEF	20 to 25 ANEF	Greater than 25 ANEF
Public Building	Less than 20 ANEF	20 to 30 ANEF	Greater than 30 ANEF
Commercial	Less than 25 ANEF	25 to 35 ANEF	Greater than 35 ANEF
Light Industrial	Less than 30 ANEF	30 to 40 ANEF	Greater than 40 ANEF
Other Industrial	Acceptable in all ANEF zones		

While ANEF data is used to inform local land use and development policies, there is potential for the release of NASF Guidelines for public safety zones which will significantly impact on the development potential for land surrounding the Adelaide Airport. The approach to public safety zones is based on the calculation of individual risk, which is defined as the risk of death per year to an individual as a result of specific hazards. The individual is assumed to reside continuously at a particular location, 24 hours a day, 365 days a year. For this reason, residential development is considered the most sensitive use as the time of occupation is likely to be considerably more than non-residential development. This therefore increases the levels of risk to which individuals are exposed.

If implemented, these policy changes are likely to discourage residential infill development to minimise the number of individuals exposed to risk. However, recent initiatives from the State Government seek to modify the design code for buildings within future airport public safety zones in order to allow for greater housing densities while simultaneously reducing the impact of noise exposure and associated risks.

2.4 Heritage Items

There are some heritage items which would require planning consideration within the immediate locations and adjacent areas. Some of these key Heritage Items (lots) include:

- West Torrens Council Chambers (1935 Building only)
- Thebarton Theatre
- Former Thebarton Baptist Church & Hall
- 'The Oaks' and row of cottages
- 'Plympton House' and former Gardener's Cottage
- Temple Christian College (Former Thomas Hardy & Sons Wine Cellars, Tintara House)
- Lady Gowrie Child Centre

As well as these State heritage items, there are local heritage villas, dwellings, shops and churches throughout the study area. As illustrated in Figure 7 below, these are largely confined to the north-east of the Study Area.

However, within the context of development potential the density/number of these items are not significant enough to considerably impact on the residential development potential, especially in comparison to other areas such as within the City of Burnside and City of NPSP which have much higher concentrations of heritage items.

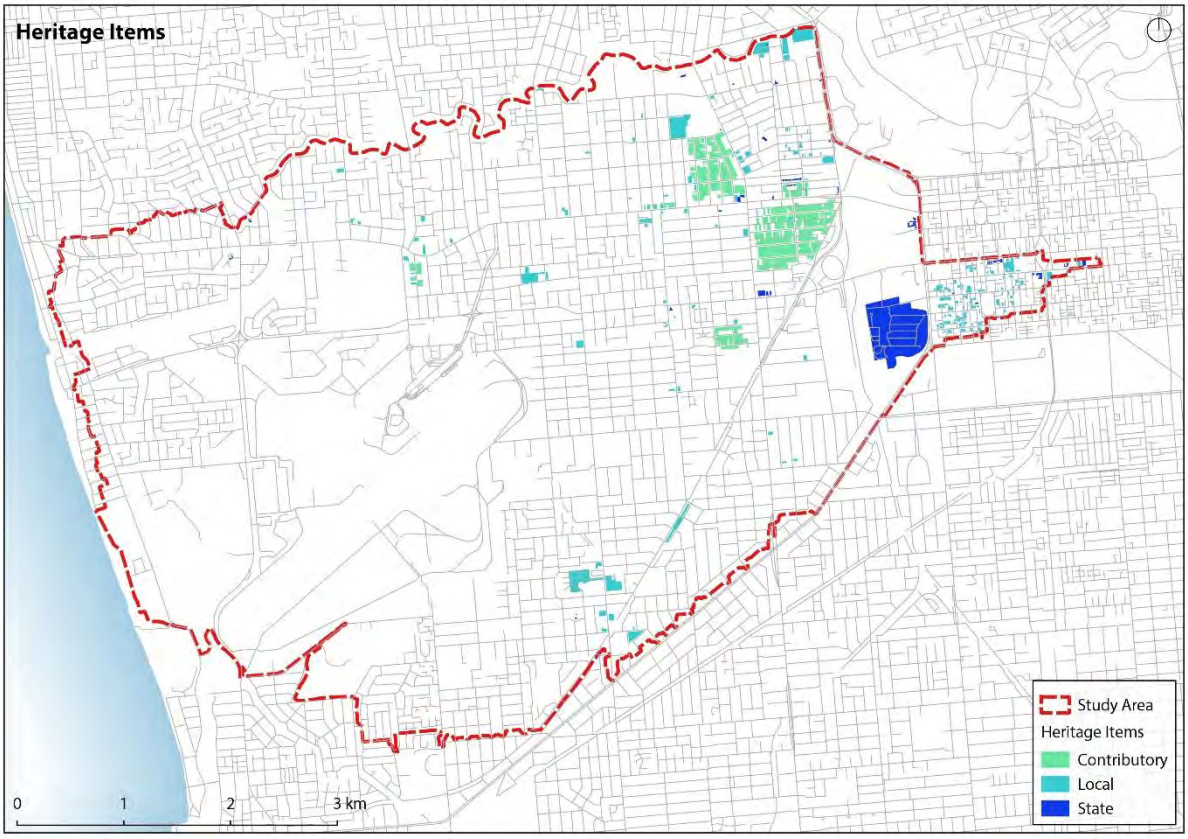


Figure 7: Heritage Items across the Study area

3. Development Trends, Land Supply and Population Forecasts

The following section of the report assesses the historical growth across the study area and reviews the Historical Development Trends within the study area, land supply of Greater Adelaide and population scenarios within the study area. Historical development trends provide an overview of the recent dwellings and insight into how the region has been developing in recent years. The data and assumptions from this assessment will provide an overview of the population/dwelling yield across the region, as well as a basis for forecasting development data in preceding sections of this report.

3.1 Historic Growth: Residential Properties (Year Built)

It is useful to review the historical development trends across the study area to provide an overview of how the study area has developed over time. Historical dwelling growth is demonstrated by reviewing the year that residential properties were built. Given the availability of data on the parcel level (as opposed to an LGA level) it is possible to provide detailed data for the defined stormwater study area.

The dwellings being built across the study area peaked in the post war eras, as reflected in the spikes in development between 1921 and 1930 and after 1941. Dwellings built between 1971 to 1990 shows limited development, with a spike in development from the year 2000 to 2010 (comparative to the development across all decades). These peaks and patterns are reflected in year built dwellings (Figure 8). Note that due to an absence of data, South Australian Housing Trust and other state-owned property is not included in this graph.

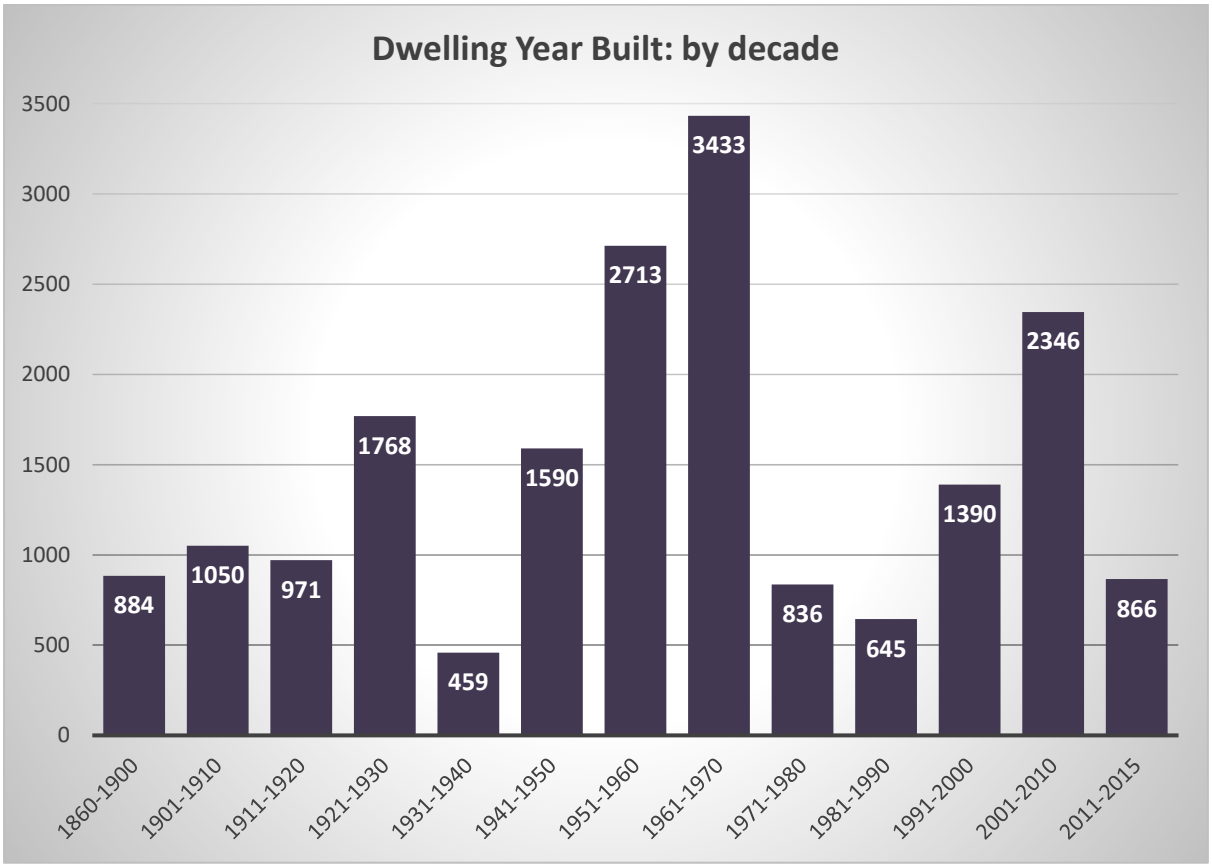


Figure 8: Dwellings by decade

The historical development pattern follows a similar trend to that of the rest of metropolitan Adelaide, with the areas closest to the city being developed first, and then moving away from the city (in a westerly direction) as time progressed. Dwelling development follows this pattern up until the 1980's at which point most of the residential areas had been developed (see Figure 9). From 1990, dwelling development starts to reflect the minor infill patterns which do not follow the patterns of east-to-west expansion of previous decades. With the exception of major infill sites (which show as clusters of development) dwellings across the study area appear not to follow any discernible spatial pattern. Given that the study area is historically established with most residential areas being developed prior to 1980 and is situated within the middle-ring, recent development can defined as minor infill. Much of this infill would be attributed as redevelopment (1:1 dwelling) and replacement of old housing stock.

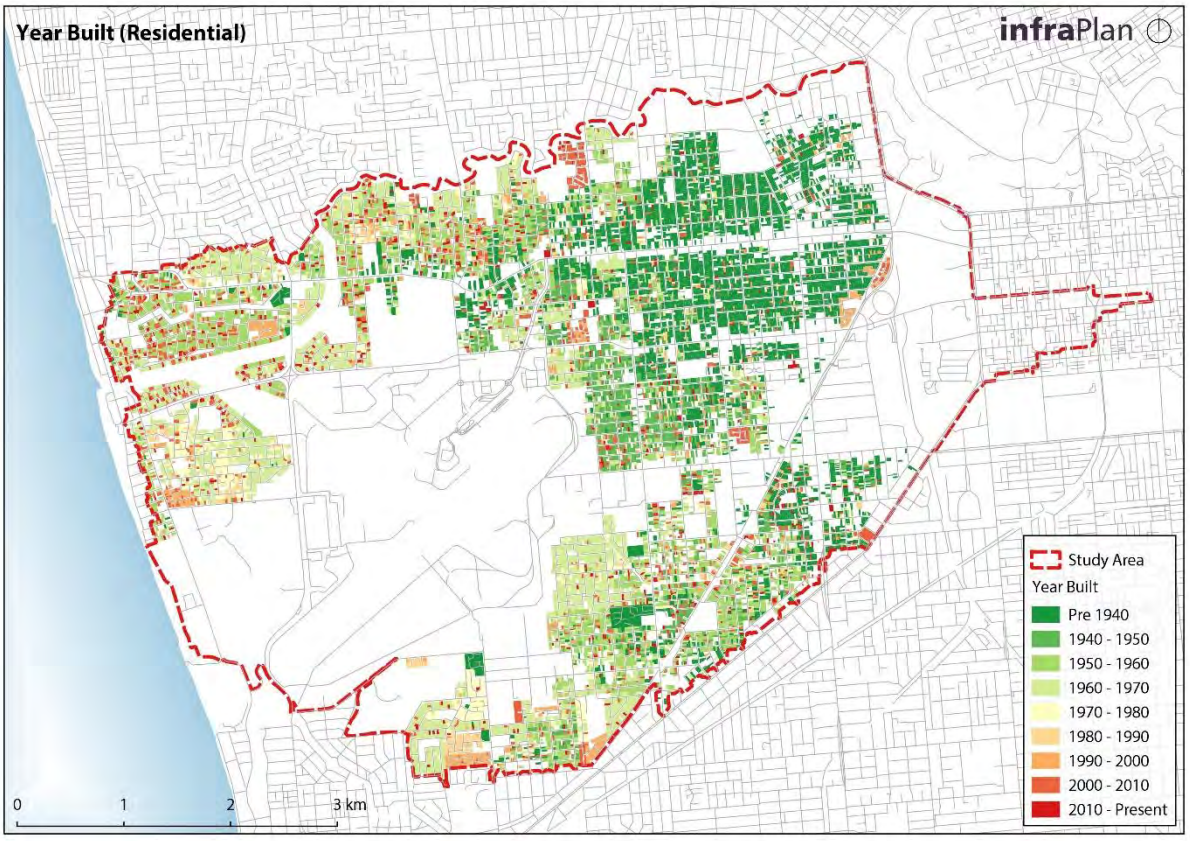


Figure 9: Settlement Pattern Dwellings Year Built, Stormwater Catchment Area (1836- 2015)

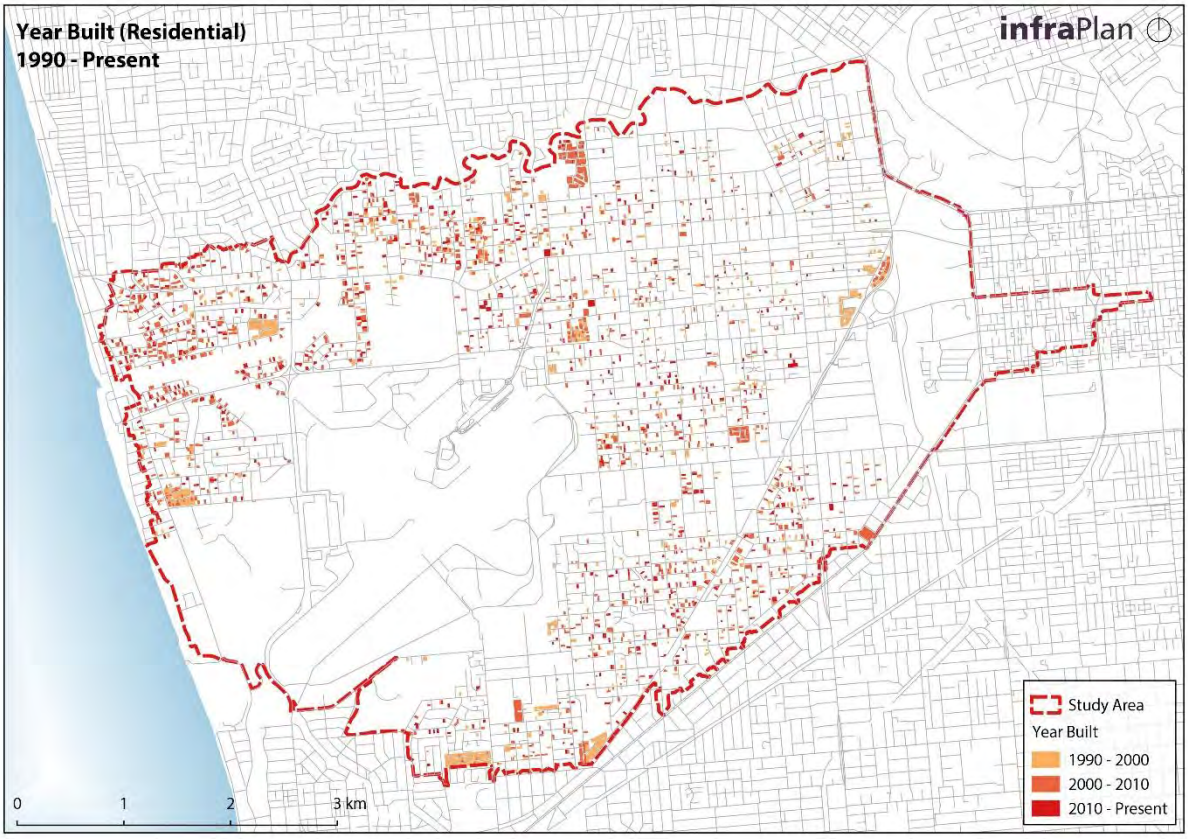


Figure 10: Settlement Pattern, Dwellings Year Built from 1980 - 2016

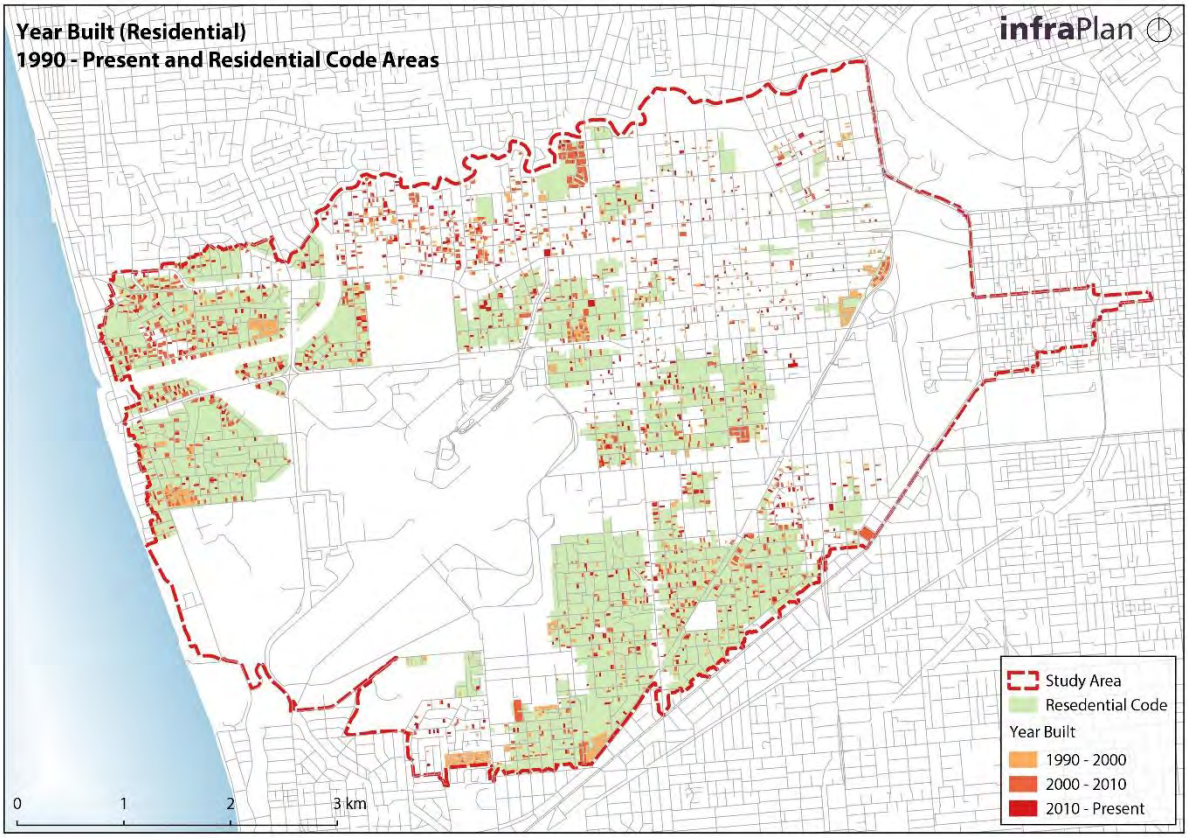


Figure 11: Development between 1990 and 2016 within the Residential Code Area

3.2 Land Supply, Land Development and Housing Monitoring

The State Government (through the Department of Planning, Transport and Infrastructure) monitors the land supply and land development of metropolitan Adelaide. One of the key objectives is to observe how the policies and targets of the *30 Year Plan for Greater Adelaide* are tracking. The Residential Land Development Activity reports (released quarterly) and The Residential Demolition and Resubdivision Report (2004-2010) provide the relevant context for this document

Reporting on development and housing is relevant as it helps infrastructure agencies ensure that infrastructure and urban development is effectively and efficiently coordinated, and provides a spatial guide to local government to help align regional implementation strategies.

It is important to note that data presented in this section is based on LGA, and not the study area

- Of the Charles Sturt LGA (5,214 ha) only 4.26% (222 ha) exists within the SMP Study area
- Of the Adelaide City LGA (1,557 ha) only 19.46% (303 ha) exists within the SMP Study area

3.2.1 Residential Land Development Activity

The State Government (Department of Planning, Transport and Infrastructure) releases a *Residential Land Development Activit*y report every 6 months, reporting on the different stages of land division across the State, specifically:

- proposed allotments in land divisions
- approved allotments in land divisions
- completed allotments in land divisions
- building approvals
- other summary information including; median lot size, share of infill versus greenfield development.

The data provided by the Department of Planning, Transport and Infrastructure (DPTI) for the West Torrens Stormwater Catchment Management Plan includes details of residential demolition and development activity across Adelaide. The data was extracted in March 2017 for the study area covering the local government councils of West Torrens, Charles Sturt and Adelaide City Council. The following tables were provided:

- completed allotments by LGA for the last 5 years, as shown in the Residential Development Activity Report, South Australia
- dwelling approvals by LGA for the last 5 years, as shown in the Residential Development Activity Report, South Australia
- Demolitions - net dwelling increase on residential demolition and resubdivision sites by LGA, 2008-2014.

Table 5: The number of additional allotments created from land division applications which have been deposited at the Land Titles Office, March 2011 – September 2013 (Data source: DPTI EDALA).

LGA Name	Mar-11	Jun-11	Sep-11	Dec-11	Mar-12	Jun-12	Sep-12	Dec-12	Mar-13	Jun-13	Sep-13
West Torrens	**34**	**39**	**53**	**43**	**38**	**22**	**27**	**33**	**25**	**49**	**52**
Charles Sturt	163	135	158	158	115	127	127	182	113	83	135
Adelaide City	64	4	6	13	36	24	157	16	108	17	5
Study Area (LGA) Totals	261	178	217	214	189	173	311	231	246	149	192

Table 6: The number of additional allotments created from land division applications which have been deposited at the Land Titles Office, December 2013 – June 2016 (Data source: DPTI EDALA).

LGA Name	Dec-13	Mar-14	Jun-14	Sep-14	Dec-14	Mar-15	Jun-15	Sep-15	Dec-15	Mar-16	Jun-16
West Torrens	**44**	**35**	**48**	**37**	**42**	**46**	**48**	**37**	**36**	**47**	**38**
Charles Sturt	146	105	165	172	127	131	172	179	173	128	254
Adelaide City	71	11	12	72	8	73	231	30	93	3	408
Study Area (LGA) Totals	261	151	225	281	177	250	451	246	302	178	700

Table 7: The number of new residential dwellings approved to be built March 2011 – September 2013 (Data source: ABS Building Approvals)

LGA Name	Mar-11	Jun-11	Sep-11	Dec-11	Mar-12	Jun-12	Sep-12	Dec-12	Mar-13	Jun-13	Sep-13
West Torrens	**93**	**48**	**98**	**55**	**50**	**39**	**63**	**70**	**51**	**41**	**64**
Charles Sturt	173	765	122	178	166	178	157	191	113	204	260
Adelaide City	0	199	13	12	8	8	3	77	12	166	53
Study Area (LGA) Totals	266	1012	233	245	224	225	223	338	176	411	377

Table 8: The number of new residential dwellings approved to be built December 2013 – June 2016 (Data source: ABS Building Approvals)

LGA Name	Dec-13	Mar-14	Jun-14	Sep-14	Dec-14	Mar-15	Jun-15	Sep-15	Dec-15	Mar-16	Jun-16
West Torrens	**77**	**71**	**96**	**40**	**119**	**55**	**81**	**74**	**61**	**75**	**141**
Charles Sturt	344	140	337	307	152	180	283	275	263	281	436
Adelaide City	52	183	131	283	596	430	3	60	335	58	79
Study Area (LGA) Totals	473	394	564	630	867	665	367	409	659	414	656

Although reviewing the rate at which gross allotments and dwellings are being created is important, more pertinent to this report is the net dwelling increases that have occurred. This is explored in the following sections.

3.2.2 Residential Demolition and Resubdivision report Adelaide Statistical Division

The Residential Demolition and Resubdivision Report provides a detailed historical assessment of residential development across metropolitan Adelaide between 2004 and 2010. Of specific interest is the total dwelling increase on all demolition and resubdivision sites by LGA, as well as the site replacement ratios for finished demolition site. This type of development can broadly be defined as 'infill' development and is pertinent to the inner and middle ring LGAs.

The report shows that from 2004 to 2010, an additional 11,521 dwellings were added to the metropolitan Adelaide housing stocks through demolition and resubdivision, with approximately 2,470 of these occurring within the LGA's of the Study Area (see Figure 12). The City of Charles Sturt accounted for a majority of these dwellings (approximately 70%), with the City of West Torrens and Adelaide City Council accounting for the remaining 28% and 2% respectively. However, it should be noted that much of the redevelopment within Charles Sturt occurred in the suburbs of Findon (141 dwellings) and Seaton (197) which both sit outside of the SMP Study Area.

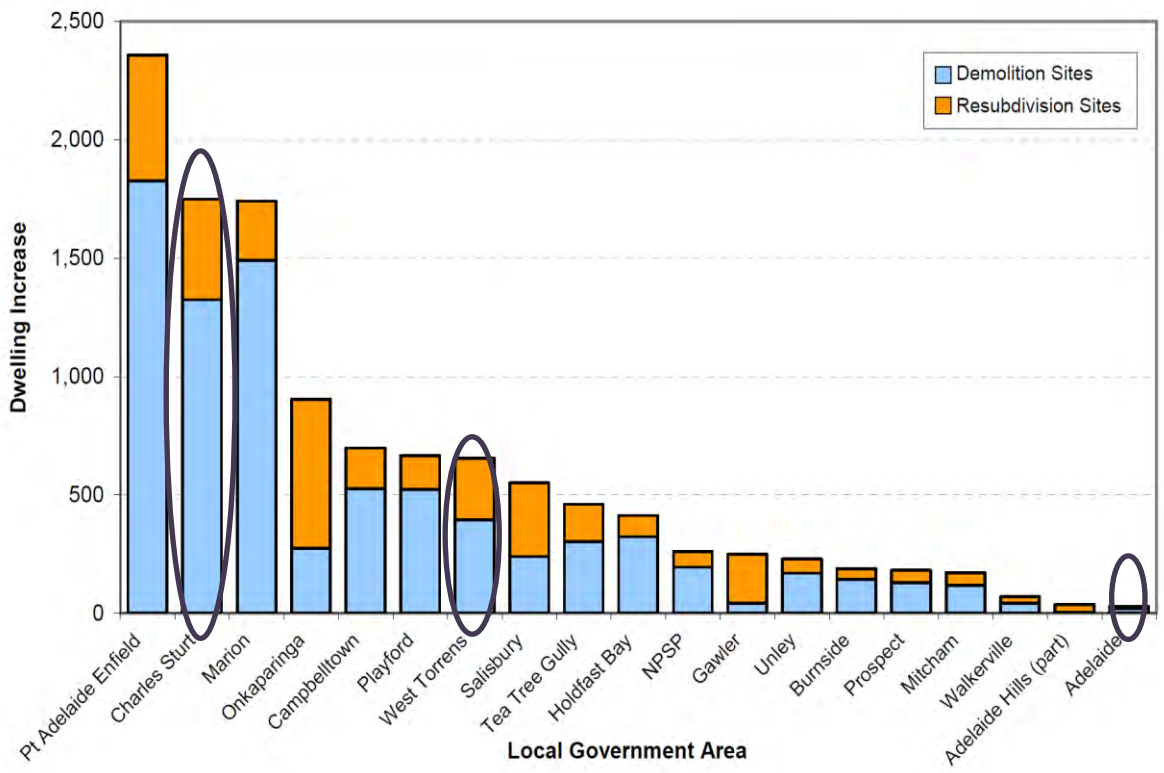


Figure 12: Residential Demolition and Resubdivision Report: Dwelling increase on all demolition and resubdivision sites by Local Government Area, 2004 to 2010

It is important to note the **replacement rates of development** which have an influence on the effective dwelling density increases. Replacement rates are calculated by dividing the number of new dwellings constructed by the number of dwellings demolished. For example, on a site where one dwelling is demolished and replaced with two new dwellings, the replacement rate is 1:2 (2 / 1 = 2). This equates to an increase of one dwelling on the site. The City of Charles Sturt has one of the highest replacement rates when compared to other inner and middle metropolitan LGA's, at a rate of 1:1.8, where the City of West Torrens rate is 1:1.7 and Adelaide City Council is 1:1.6.

The dwelling increases in the City of West Torrens are most significant as the LGA makes up 88.39% of the study area. Of all LGA's in the SMP study area, West Torrens has the highest proportion of new dwellings (approx. 27%) on sites with replacement rates of 1:1. Despite this, approximately 71% of new dwellings in the LGA were on sites with replacement rates of 1:2 or more. The replacement ratio is an important measure for the calculations of impervious site area, and will be considered in further assessments.

Table 9 Residential Demolition and Resubdivision Report: Replacement Rates of demolition and resubdivision sites across Metropolitan Adelaide

Replacement Rate (1:?)												
	Dwelling Decrease	No Change	Dwelling increase									
	<1	1	1 - 2	2	2 - 3	3	3 - 4	4	5	6	>=7	Total Dwellings
Number of New Dwellings	69	2,506	888	5,984	225	1,611	42	488	120	126	102	12,161
Percentage	0.6%	20.6%	7.3%	49.2%	1.9%	13.2%	0.3%	4.0%	1.0%	1.0%	0.8%	100.0%

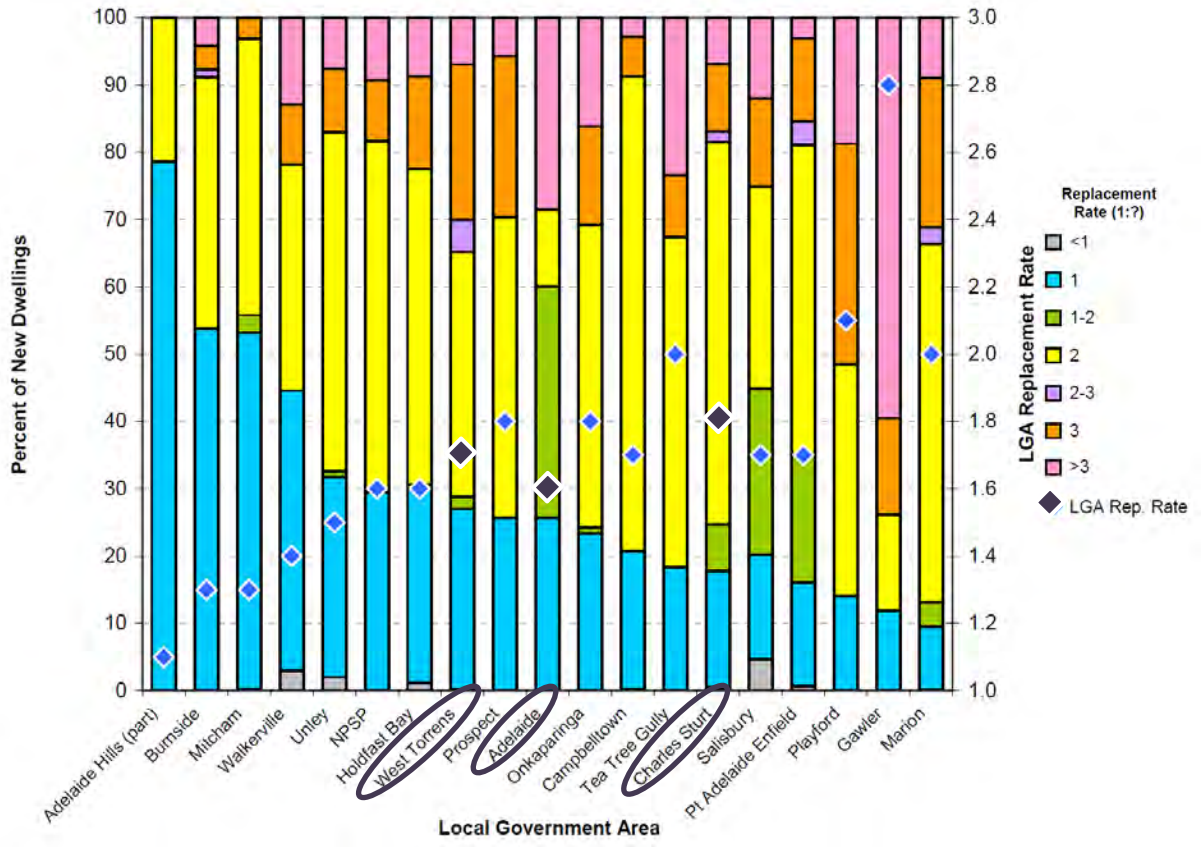


Figure 13 Residential Demolition and Resubdivision Report: Percentage of new dwellings by replacement rates by LGA

The 2004-2010 figures are the only publicly available and comprehensive data sets for dwelling increases and dwelling replacement ratios, however InfraPlan was provided with the net dwelling increase on residential demolition and resubdivision sites for 2008-2014. Table 10 provides a summary of this data, showing The City of West Torrens accounts for the vast majority of these dwellings (just less than 80%), with the City of Charles Sturt and the City of Adelaide accounting for 20% and 2% respectively.

Table 10: Net Dwelling Increase on Residential Demolition and Resubdivision Sites, 2008-14

LGA Name	Net Dwellings 2008-14	Average Annual Net Dwelling Increase
West Torrens	1,026	147
Charles Sturt	266	38
Adelaide City	28	4
Study Area (LGAs) Total	**1,320**	**189**

3.3 Recent building activity and housing type comparisons

It should be noted that building activity in the Stormwater Catchment over the last 15 years has been heavily influenced by changing development policies and does not represent a regular growth pattern. Figure 14 shows that building activity within the region has been fairly flat with exceptions in 2001, 2008 and to a lesser degree in 2012. The data shows that 2001 included development of a large number of row/maisonette dwellings, likely to be redevelopment of a small number of former industrial sites. Trends across metropolitan Adelaide show spikes in 2008 and 2012 to be in response to changes in financial market conditions, followed by development regulation changes causing reduced activity in years immediately following.

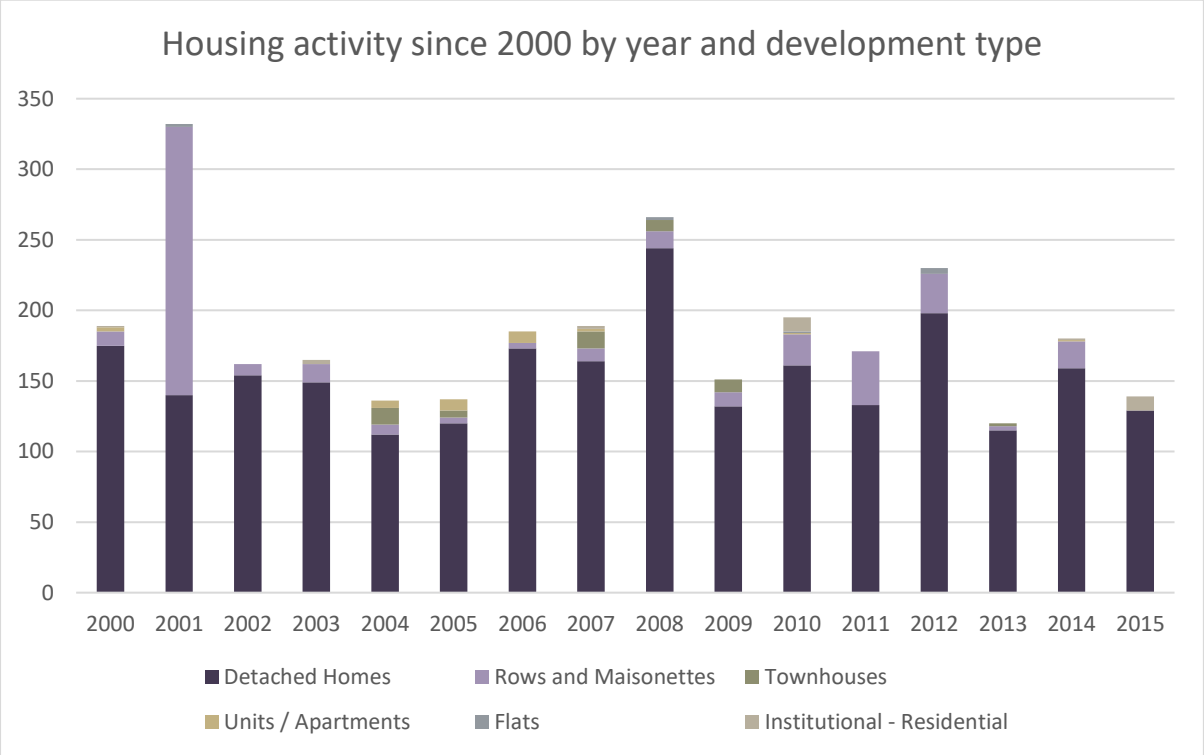


Figure 14: Recent house building activity by year and type

InfraPlan analysed the development types and associated land parcel sizes within the catchment as a whole and within the last 15 years. A summary of dwelling types across the study area includes:

- A majority of dwellings are houses (detached) accounting for over 88% of all parcels and more than 81% of all dwellings. Detached dwellings traditionally have low site coverage and the greatest potential for landscaping, lawned areas and other permeable surfaces. These parcels also offer the greatest potential for minor infill and increasing the yield per parcel (depending on land parcel size).
- Figure 15 shows that a large proportion of maisonette, Unit (flat) and townhouse development has occurred in agglomerated sites and many appear to be nursing home/aged care facilities or SAHT developments. Inner suburbs such as Mile End and Thebarton show a greater occurrence of these development types scattered throughout the residential areas.
- There are 317 vacant urban lots, which have a high potential for redevelopment. These lots are spread sporadically throughout the study area (see Figure 16: Vacant Lots).
- Within the last 16 years (2000-2015) the dwelling types being constructed have changed. A majority of dwellings being built are still detached houses (85.3%), yet there is an upward trend in the construction of row houses (which accounted for 7.4% of new dwellings between 2000-2015, compared to 1.1% of all dwellings) and townhouse dwellings (1.7% of new dwellings between 2000-

2015, compared to 0.7% of all dwellings). This is significant as the site coverage of these types of dwellings is likely to be greater than detached houses.

- Figure 15 shows the spatial distribution of these dwelling types across the catchment.

Table 11: dwelling type across SMP Study Area

Dwelling type	Total across study area	% across study area	Total of dwellings built since 2000	% across study area built since 2000
House	15497	88.7%	2401	81.1%
Units or Flats	324	1.9%	45	1.5%
Independent Living Unit	20	0.1%	27	0.9%
Retired and Aged Accommodation	30	0.2%	0	0.0%
Institutional Residential Accommodation N.E.C.	2	0.0%	0	0.0%
Maisonette	858	4.9%	159	5.4%
Townhouse - Defined as Home Unit With Both Ground and First Floor Areas	122	0.7%	48	1.6%
Row House	185	1.1%	218	7.4%
Private Hotels and Boarding Houses and Boarding Houses	3	0.0%	0	0.0%
Religious Quarters - Monasteries Etc.	5	0.0%	2	0.1%
Unfinished House	116	0.7%	0	0.0%
Vacant Land with Minor Improvements (Urban)	20	0.1%	0	0.0%
Vacant Land-Urban	297	1.7%	0	0.0%
OTHER	0	0.0%	60	2.0%

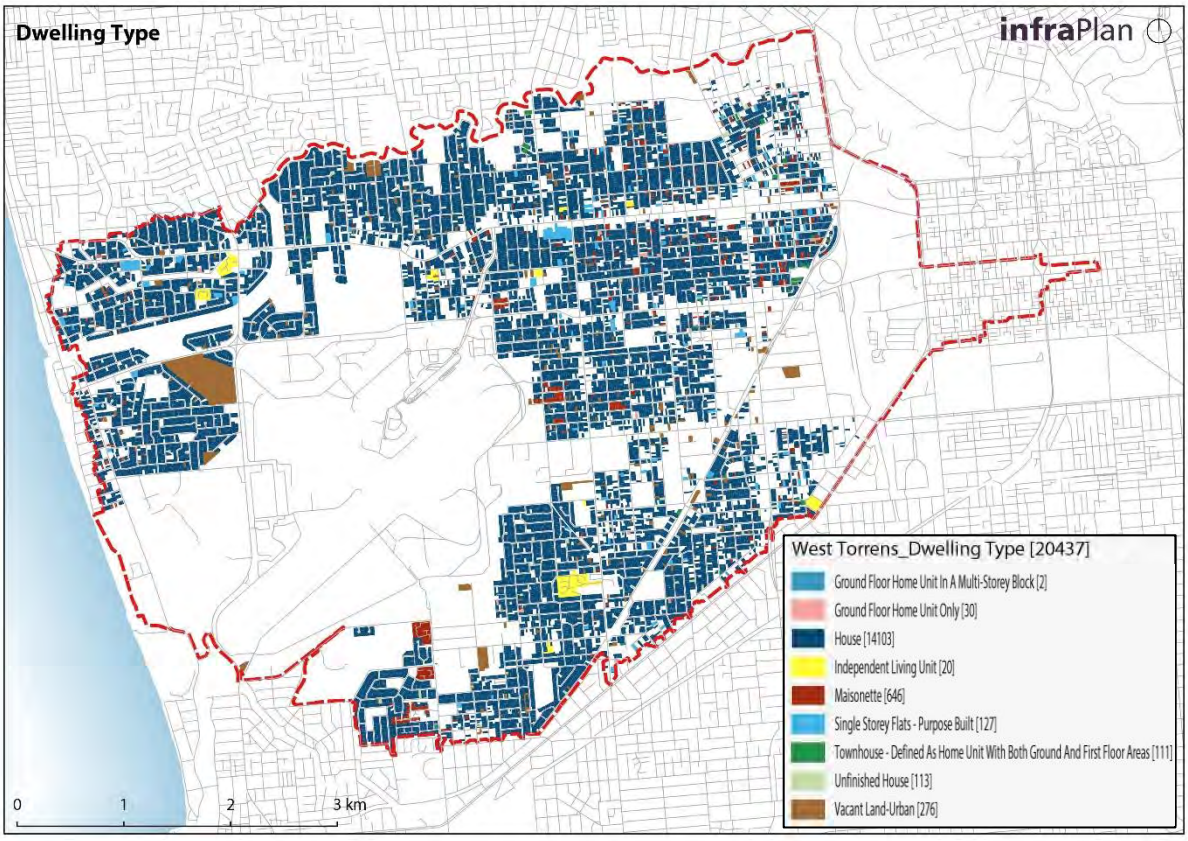


Figure 15 Dwelling type (all dwellings)

This shift in housing type is typical of inner-suburban areas across many of Australia's major cities as densification of established suburbs becomes more desirable than development on the fringe. The introduction of the Urban Growth Boundary for metropolitan Adelaide is anticipated to encourage more of this development in the coming years.

As would be expected within an established area, increased dwelling yields come at the cost of reduced average parcel sizes. Average parcel sizes are compared for recent and historic developments in in this part of the assessment.

Table 12 shows that site areas for detached homes and rows and maisonettes have, in the last 15 years, been below the historic average for the catchment. On the other hand, parcel size averages for Row and Maisonette developments for this period have been consistently above the historical average with the exception of anomalous data for 2001 and 2014 which reduce the recent average to a deceptively small 154m^2. These changes are reflective of changing desires in housing types and the way people use their homes, with less time spent in and caring for a home garden, resulting in reduced land parcels and increasing percentage of impermeable area on residential land parcels. Based on figures from the early 2000's, units and apartments have also become larger (though the 2010 average is misleading) as professionals begin to adopt this lifestyle option instead of the traditional detached home on a quarter-acre block, dictating change in the nature of housing stock in this category.

Parcel size data for townhouses, flats and institutional residential developments (e.g. retirement living) is flawed due to replicated parcel values for multiple dwelling developments. As a result, these dwelling types have not been included in this part of the assessment.

Table 12: Comparison of parcel sizes by development type

Parcel size (m^2) by year and development type - summary table

Year	Detached Homes	Rows and Maisonettes	Units / Apartments
2000	428.6	282.1	281.2
2001	407.1	5.7	
2002	419.5	316.7	
2003	489.6	194.3	
2004	449.6	409.6	444.8
2005	507.2	337.1	315.1
2006	484.5	344.1	429.6
2007	495.6	378.7	329.0
2008	478.6	371.5	
2009	453.0	346.9	
2010	467.4	367.2	888.9
2011	487.4	283.5	
2012	487.7	377.7	
2013	472.5	370.8	
2014	500.3	85.9	306.7
2015	413.9		
2000-2015 average	**466.4**	**154.0**	**388.5**
historical averages	642.6	254.6	335.4

Parcel size below 16 year average

Parcel size above 16 year average

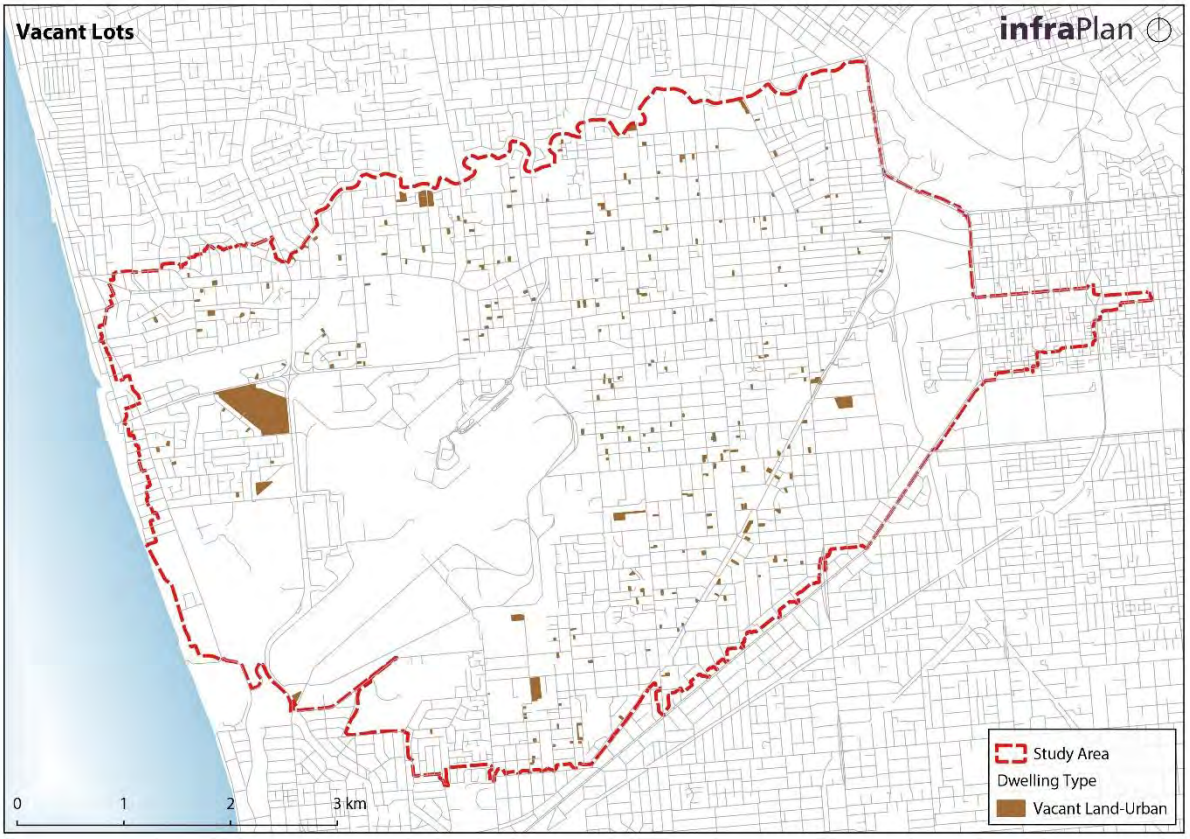


Figure 16: Vacant Lots

3.4 Population Projections (Forecasts)

The State Government develops population projections which are applied by State agencies for multiple uses including infrastructure assessment and planning, land use supply monitoring and fiscal policy.

Population forecasts are not assessed on small scale geographies (i.e. SA1 or SA2) therefore it is not possible to reproduce specific population forecasts for the study area. However, figures are based on an LGA level and provide some context for the potential population increase in a broader catchment which encompasses the study area.

The following tables outline the projected population growth under a medium growth scenario: "*The medium series is the likely outcome at the time of publication, while the high and low series enable management of risks if a population trend that is higher or lower than the medium series emerges*"[1].

Note: Population trends and forecasts must be reviewed with some caution, as they may not take into consideration some land use constraints, and development potential linked to historical dwelling growth. The development potential scenarios in Section 4 in this report provide the land use and policy context required to refine the possible population projections. The population projections released from the state government also note that "*Users of these projections should be aware that they represent only one possible*

[1] http://www.dpti.sa.gov.au/planning/population

future population outcome based on an assumption of continued population growth and a spatial distribution that is a reflection of current and likely government policies… Users of these projections should note that unforeseen policy, economic and societal changes may result in population outcomes different from those presented here"[2].

Table 13: Population Projections for South Australian Local Government Areas, 2011-31 (February 2016 release)

Local Government Area (LGA)	Population Projections: Population on 30 June				
	2011	2016	2021	2026	2031
West Torrens (C)	57,026	58,950	61,662	64,688	68,025
Charles Sturt (C)	108,680	115,715	122,152	128,301	133,477
Adelaide (C)	20,920	23,753	27,308	30,096	32,887
Total of Study Area (LGAs)	186,626	198,418	211,122	223,085	234,389
Greater Adelaide	1,345,080	1,416,420	1,488,821	1,560,468	1,628,083

Table 14: Population change between Census periods (persons) between 2011 and 2031

Local Government Area (LGA)	Population change between Census periods (persons)			
	2011 - 2016	2016 - 2021	2021 - 2026	2026 - 2031
West Torrens (C)	1,924	2,712	3,026	3,337
Charles Sturt (C)	7,035	6,437	6,149	5,176
Adelaide (C)	2,833	3,555	2,788	2,791
Total of Study Area (LGAs)	11,792	12,704	11,963	11,304
Greater Adelaide	71,340	72,401	71,647	67,615

Table 15: Percentage of population change between Census periods (2011 – 2031)

Local Government Area (LGA)	Percentage of population change between Census periods			
	2011 - 2016	2016 - 2021	2021 - 2026	2026 - 2031
West Torrens (C)	3.26%	4.40%	4.68%	4.91%
Charles Sturt (C)	6.08%	5.27%	4.79%	3.88%
Adelaide (C)	11.93%	13.02%	9.26%	8.49%
Total of Study Area (LGAs)	5.94%	6.02%	5.36%	4.82%
Greater Adelaide	5.04%	4.86%	4.59%	4.15%

Table 16: Average annual population growth 2011 - 2031

Local Government Area (LGA)	Average Annual Growth			
	2011 - 2016	2016 - 2021	2021 - 2026	2026 - 2031
West Torrens (C)	0.65%	0.88%	0.94%	0.98%
Charles Sturt (C)	1.22%	1.05%	0.96%	0.78%
Adelaide (C)	2.39%	2.60%	1.85%	1.70%
Total of Study Area (LGAs)	1.19%	1.20%	1.07%	0.96%
Greater Adelaide	1.01%	0.97%	0.92%	0.83%

[2] http://www.dpti.sa.gov.au/__data/assets/pdf_file/0015/253122/Explanatory_Notes_Projections_2011-2036.pdf

3.4.1 Population Forecast Summary

Based on the 2011 population, forecasts demonstrate that growth across the broader study area is expected at a rate of 1.28% per annum for the 20-year period between 2011 and 2031, resulting in an additional 47,763 persons. This growth is higher in comparison to the rest of Greater Adelaide which is expected to growth at a rate of 1.05% per annum, resulting in an additional 283,003 persons. The growth rate across the study area is expected to gradually climb from 2,358 persons per annum from 2011 to 2016, to 2,541 persons per annum from 2016 to 2021, falling to 2,261 per annum from 2026 to 2031.

Across the broader study area:

- The City of West Torrens is expected to have a population increase of 10,999 persons (23.0% of the total population growth across the broader study area). Population growth is expected to accelerate over the period between 2011 and 2031, from 384 persons per annum between 2011 and 2016 up to 667 persons per annum between 2026 and 2031. West Torrens expects to see moderate population growth compared to other LGA's within the study area
- The City of Charles Sturt is expected to have a population increase of 24,797 persons (51.9% of the total population growth across the broader study area). Population growth is expected to gradually decline from the period between 2016-2031, from a rate of 1407 persons per annum between 2011-2016 down to 1035 persons per annum between 2021 and 2026.
- The City of Adelaide is expected to have a population increase of 11,967 persons (25.1% of the total population growth across the broader study area). Population growth is expected to accelerate over the period between 2016 and 2021, from a rate of 567 persons per annum between 2011-2016 up to 711 persons per annum between 2016 and 2021. Growth is expected to decrease slightly between 2021 and 2031 to an average of 557 persons per annum.

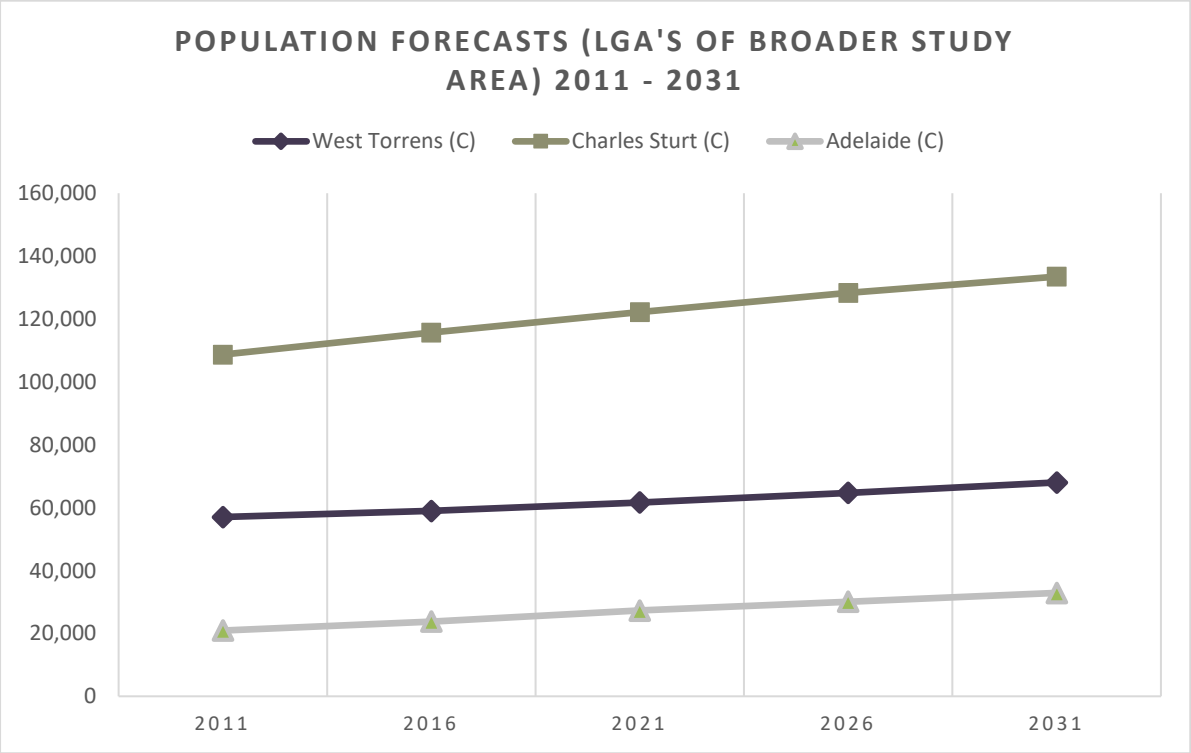


Figure 17: Population forecasts for LGA's of the Study Area (2011-2031): Line Graph

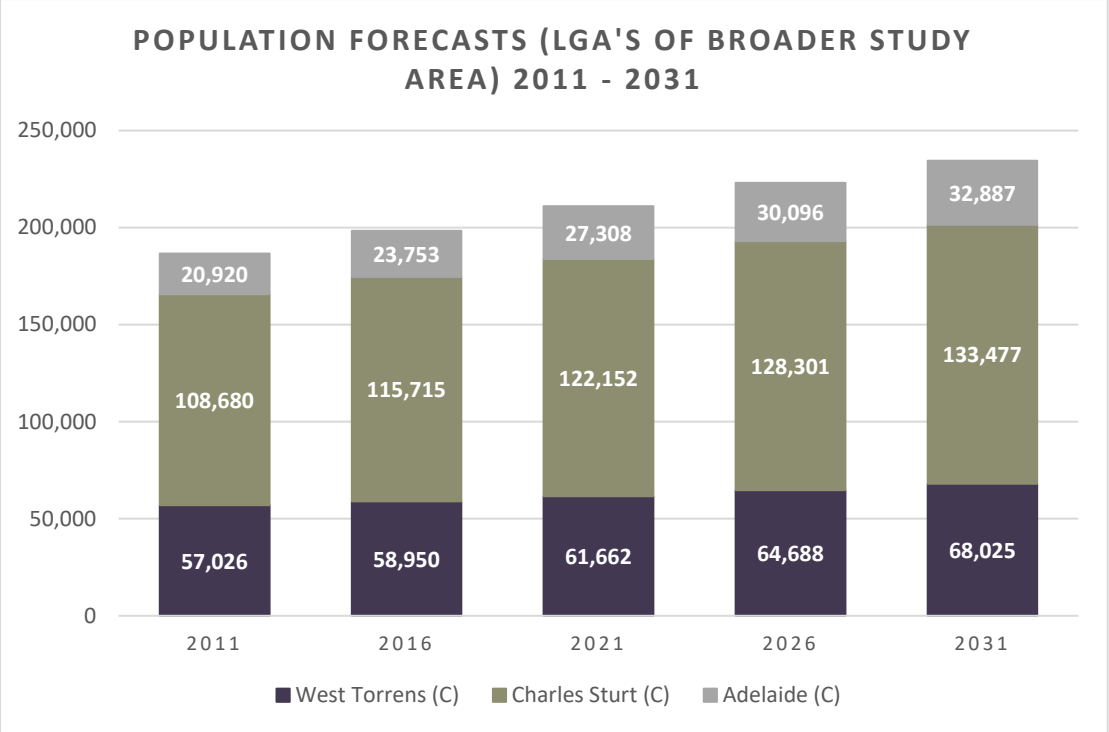


Figure 18: Population forecasts for LGA's of the Study Area (2011-2031): Stacked bar graph

4. Development Scenarios

InfraPlan have undertaken population and dwelling number projections for the Sturt Stormwater Catchment to estimate the overall number of new and additional dwellings to be built over the forecast period to 2046. A number of approaches have been utilised, based on various sources of data. These approaches reflect various industry practice and include an assessment founded on a market based, residential development assessment tool developed by infraPlan and ipData.

As with any forecasting and estimating exercise there are a range of supply and demand factors which will influence the eventual outcome. The following scenarios broadly respond to various supply and demand factors which will influence the future development outcomes for the Stormwater Catchment Area. The assessments result in several residential development yields which provides a range to apply to the stormwater calculations.

4.1 Scenario 1 - Projection on existing growth trends within the catchment

InfraPlan have estimated future development potential based on historic activity within the catchment but has applied two fundamental growth potential approaches to determine the overall dwelling increase over the forecast period to 2046. Scenario 1A applies analysis of building activity within the catchment since the year 2000 which shows that on average 182 homes have been built within the catchment each year. Applying the metropolitan Adelaide average dwelling replacement rate of 1.7 provides a nett figure of 107 additional dwellings per year. **Forecast to the year 2046, Scenario 1A equates to 3,320 additional homes within the catchment above the 2015 total.**

Scenario 1B considers an average rate of growth based on recent historical activity. InfraPlan graphed homes built in the catchment from 2001 to 2015 and projected a linear trendline to indicate future building activity, as shown in Figure 19. This analysis shows that new home builds within the catchment has remained consistent over the last 15 years with external factors being largely responsible for spikes of activity in 2008 and 2012. These spikes are observed throughout metropolitan Adelaide. A slowly increasing number of new builds per year, starting at 173 in 2016 to 178 in 2046 gives a total of 5,428 new builds to 2046. When calculated at the average metropolitan Adelaide replacement rate of 1.7, **Scenario 1B equates to 3,190 additional homes within the catchment compared to 2015 numbers**.

The projected trendline shown in Figure 19 is indicative only and has a reasonably limited statistical accuracy based on limited sample size and variability in recent data.

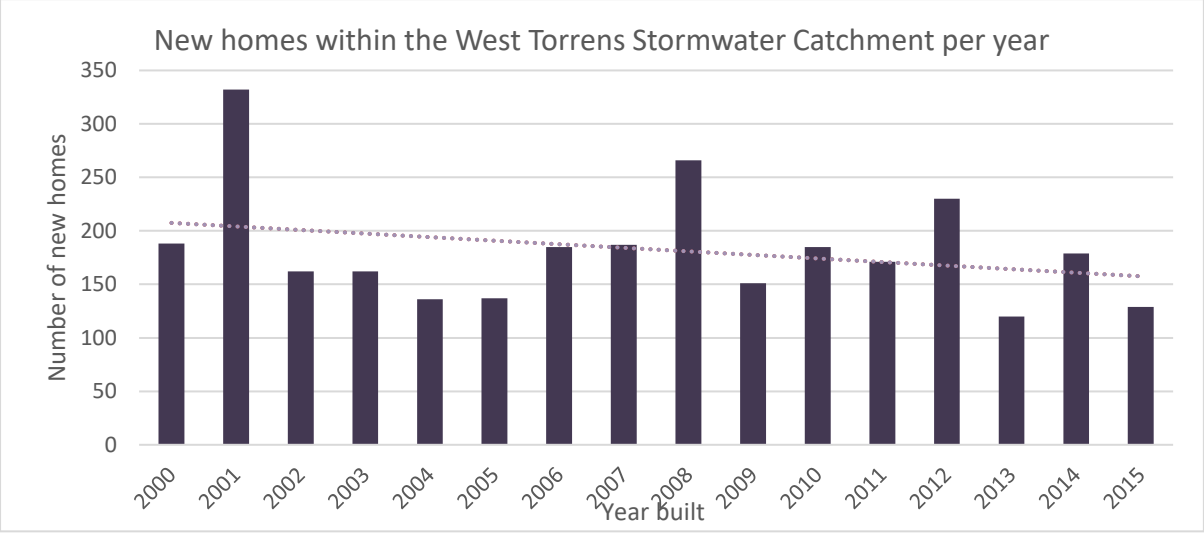


Figure 19: New home projections within the Catchment by year built, based on historical building activity and linear trendline

4.2 Scenario 2 – Projections based on Government Population Policy

Scenario 2 projections are based on data sourced from the ABS 2011 Census, 2015 dwelling data for the catchment and population growth projections contained within the South Australian Government's 30-Year Plan. Known population and household density data from the 2011 ABS Census has been combined with Government population projections for the Adelaide and Outer Adelaide Statistical Divisions (ASD/OASD) for Low, Medium and High growth scenarios and Medium growth scenarios for individual LGAs. After processing this large database, it was determined that at the end of 2015 there were 19,091 dwellings within the catchment boundaries.

The infraPlan household projections were calculated using the following procedure:

Step 1 – Projected growth rates for the ASD extended to 2046 based on the trendline from 2031 to 2041. This was applied to Low, Medium and High scenarios.

Step 2 – Published LGA growth rates were extended to 2046 assuming the published rate represents the Medium growth scenario. High and Low scenario rates were calculated from the Medium growth rate using ASD High and Low growth rate relationships to the ASD Medium rate. Each LGA now has an individual Low, Medium and High scenario growth rate projected to 2046.

Step 3 – Determine approximate 2015 catchment dwellings per LGA using known 2015 catchment dwelling numbers and 2011 proportions of homes within the catchment for each of the contributing LGAs (Adelaide, Charles Sturt and West Torrens).

Step 4 – Apply calculated single year growth rate to determine 2016 catchment dwellings per LGA and forecast every 5 years to 2046.

Step 5 – Produce overall catchment projections of population and dwellings for Low, Medium and High growth scenarios and therefore dwelling increase in each case to 2046.

Projected catchment populations for the Low, Medium and High growth scenarios are given in Table 17. The dwelling projections are broken down for each of the LGAs. These figures and the catchment total, under the three growth scenarios and shown in

Table 17: West Torrens Stormwater Catchment population projections to 2041 for Low, Medium and High population growth scenarios

Catchment population projections					2015 total 41,557		
	2016	**2021**	**2026**	**2031**	**2036**	**2041**	**2046**
Low	43,118	44,642	45,887	47,108	48,113	48,925	49,519
Medium	**43,212**	**45,341**	**47,586**	**49,985**	**52,227**	**54,337**	**56,289**
High	43,357	46,027	49,002	52,264	55,420	58,504	61,479

Table 18: Projected dwellings within the West Torrens Stormwater Catchment in 5-year intervals by LGA based on 2015 dwelling data

		2015	2016	2021	2026	2031	2036	2041	2046
Low growth scenario	**ADELAIDE**		1,237	1,353	1,425	1,492	1,548	1,595	1,630
	WEST TORRENS		16,683	17,209	17,662	18,117	18,492	18,793	19,013
	CHARLES STURT		1,408	1,462	1,501	1,532	1,557	1,577	1,591
	Total		**19,328**	**20,023**	**20,588**	**21,141**	**21,597**	**21,965**	**22,234**
Medium growth scenario	**ADELAIDE**	1,112	1,245	1,407	1,537	1,667	1,793	1,915	2,030
	WEST TORRENS	16,185	16,713	17,448	18,265	19,160	19,995	20,779	21,502
	CHARLES STURT	1,332	1,413	1,487	1,559	1,619	1,675	1,727	1,774
	Total	**18,629**	**19,371**	**20,342**	**21,360**	**22,447**	**23,463**	**24,420**	**25,306**
High growth scenario	**ADELAIDE**		1,256	1,461	1,637	1,820	2,005	2,192	2,378
	WEST TORRENS		16,760	17,681	18,760	19,973	21,142	22,280	23,375
	CHARLES STURT		1,420	1,514	1,608	1,691	1,769	1,844	1,916
	Total		**19,437**	**20,656**	**22,005**	**23,484**	**24,916**	**26,316**	**27,668**

shows an overall increase of 6,680 dwellings in the Medium growth scenario, 3,600 in the Low growth scenario and 9,040 in the High growth scenario. **Therefore Scenario 2 will result in a yield range of 3,600-9,040 additional residential dwellings, with a likely increase of 6,680 dwellings.**

Projection calculations show that 80% of growth in the catchment is expected to take place within the City of West Torrens, with 5,317 additional dwellings built to 2046 under the Medium growth scenario. 918 (14%) are forecast for the City of Adelaide and 442 (6%) within the portion of the City of Charles Sturt that lies inside the West Torrens Stormwater Catchment.

4.3 Scenario 3 – Capital Value / Site Value analysis

Government agencies have traditionally based residential development projections on a Capital Value to Site Value ratio assessment (CV/SV) which determines the likely development potential of a land parcel based on the relationship between Capital Value (capital improvements on a land parcel such as buildings) and Site Value, the inherent value of the land itself. Where Capital improvements are low in value (the CV/SV is less than 1.3) there is potential for short-term redevelopment, with development likelihood reducing as the CV/SV increases. Parcels with CV/SV of between 1.3 and 2 are considered medium-term prospects while a CV/SV of more than 2 is a long-term prospect. In the forecast period, 40% of properties with a CV/SV of less than 1.3 are anticipated to be redeveloped as well as 30% of those above 1.3.

The traditional approach to determining the overall development yield using the CV/SV approach is to make a basic assessment of the site area and frontage to determine the highest yielding development type; detached homes, semi-detached homes, group, row and flats developments. This approach consistently overstates the likely development potential as it defaults to the highest yielding development type (usually flats) so the 'rule of thumb' multipliers have been applied to reduce the growth projections to be in line with observed development rates.

After determining the likelihood of a land parcel being developed, the future yield is determined based on the parcel size. Figure 20 and Figure 21 show parcels within the catchment colour coded by CV/SV and Parcel Area respectively. It is notable that there is a strong correlation between parcels with a CV/SV above 2 and parcel areas above 1500m^2 and that the majority have a CV/SV value greater than 1.3. Note also that the areas of greatest character and historical value generally have CV/SV values over 1.3.

InfraPlan have applied an amended CV/SV approach, in part due to the inherent overstatement of yield from the traditional CV/SV model and also due to not having parcel frontage data with which to assess development types. It has been assumed that parcels less than 500m^2 will not be subdivided as Council policy generally prevents this through minimum parcel size requirements. Parcels between 500 and 800m^2 are assumed to yield 2 dwellings (an increase of 1), 800 to 1200m^2 parcels yield an increase of 2 and those from 1200 to 1500m^2 will yield an increase of 3 dwellings. Land parcels over 1500m^2 have not been considered in this assessment. Development of parcels over 1500m^2 are generally considered major projects which require internal roads and infrastructure and carry minimum public open space requirements. Analysis of the catchment also shows that the majority of these sites fall in protected watershed areas or are subject to policy restrictions. This assessment assumes that all existing parcels deemed developable currently have a single dwelling. The assessment process is documented below in Table 19.

Table 19: Capital to Site Value ratio assessment summary

		Land size (m2)					
		0	500	800	1200	1500	min
CV/SV		500	800	1200	1500	2000	max
min	max	0	+1	+2	+3	0	← Yield increase by area
1	1.3	1008	6679	2411	140	78	10316
1.3	2	3074	2867	598	51	26	6616
2	10	1373	500	163	31	22	2089
Totals by land size		5455	10047	3172	222	126	Totals by CV/SV

		Land size (m^2)				
Development potential		**Yield increase**				
CV/SV		0 to 500	500 to 800	800 to 1200	1200 to 1500	1500 to 2000
1 - 1.3	40%	0	2672	1929	168	0
1.3 - 2	30%	0	860	359	46	0
2 +	30%	0	150	98	28	0
		Total development potential				**6,310**

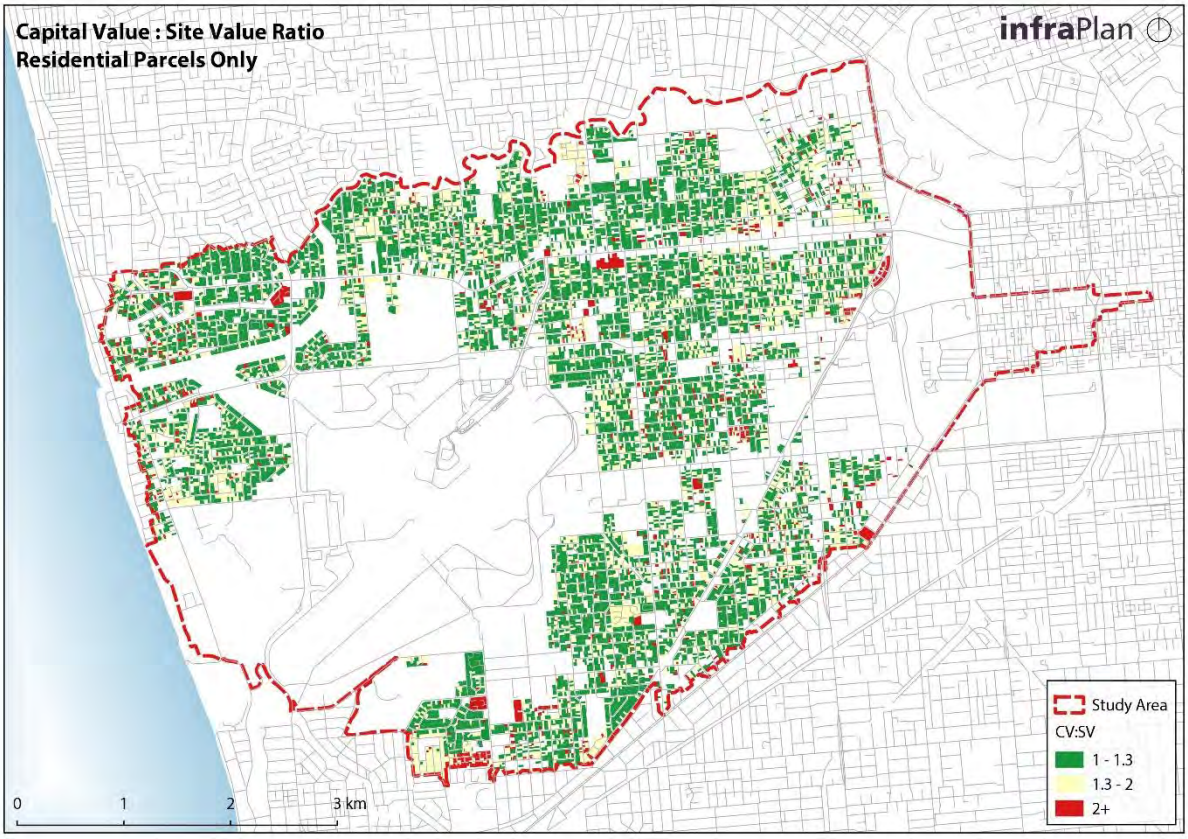


Figure 20: The catchment colour coded by CVSV Ratio

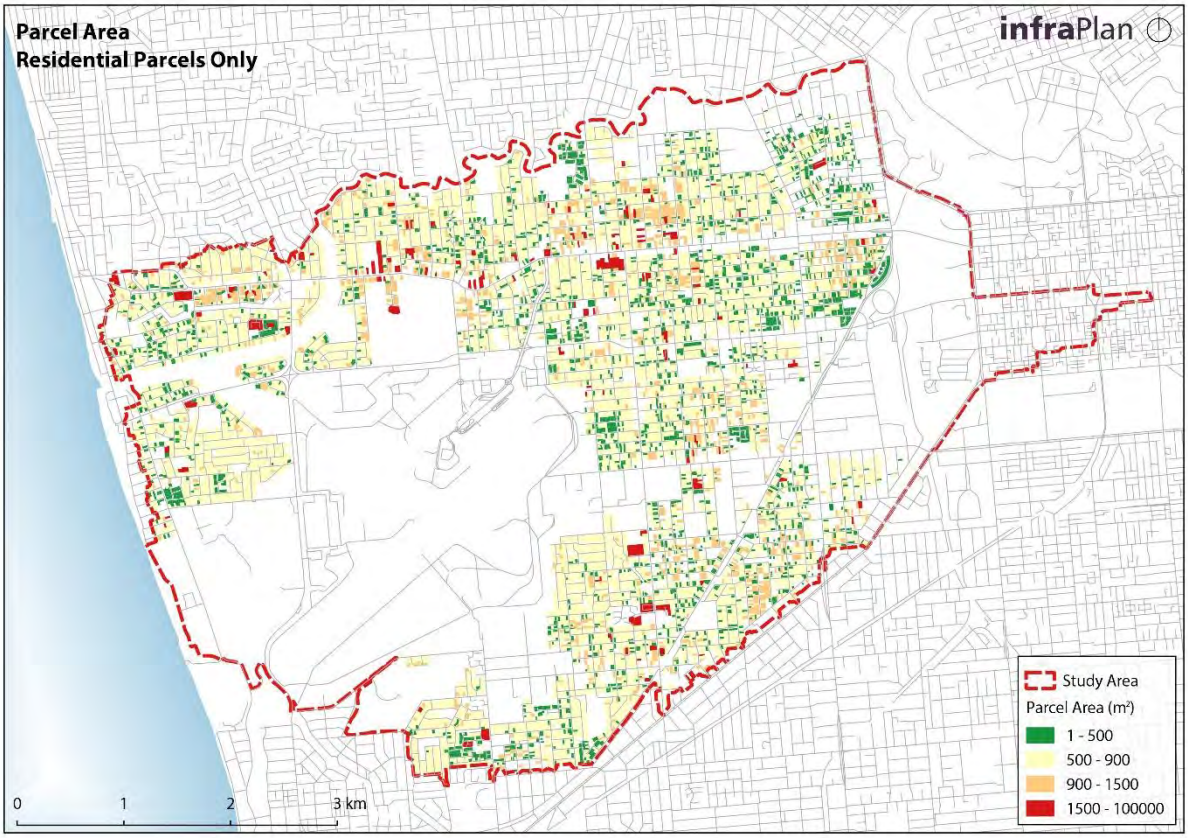


Figure 21: The catchment colour coded by Parcel Area

Using these assumptions and analysis conditions, **it has been calculated that the development potential under Scenario 3 will yield an additional 6,310 dwellings**. Note that a majority of these (4,769) are derived from parcels with existing CV/SV below 1.3.

InfraPlan have also provided for a flexible policy approach to this analysis allowing for changeable parcel size categories and 'rule of thumb' multipliers to be applied. If medium density row and townhouse dwellings were permitted such that parcels of between 800 and 1,200m^2 were assumed to yield an additional 3 dwellings and 1,200 to 1,500m^2 parcels yielded 4 additional dwellings, **the results show an increase of 10,360 dwellings above the 2015 numbers**.

4.4 Scenario 4 – the Residential Development Algorithm approach

InfraPlan and ipData have developed a market based tool using sales and development data to determine the redevelopment potential of individual land parcels. The Residential Development Algorithm was originally intended as an alternative to the Maximum Yield model which is based on CV/SV assessment and a rudimentary approximation of development potential based on fundamental dimensions of the land parcel. In practice, it has been shown that the Maximum Yield approach overstates the total number of developments and returns development types that are not reflective of actual market behaviour. As a result, arbitrary corrective factors have been applied to better approximate future development based on observed activity.

The Residential Development Algorithm applies complete Council policy dwelling footprint conditions to assess developability, the size and type of construction and saleability is determined using market cost and development profitability algorithms. As a result, infraPlan is able to more accurately predict the most likely development type per parcel (based on a profit model) and the volume of parcels across a council area or catchment likely to be subdivided. The overall dwelling increase across a study area is determined as a final output.

While the tool has not yet been applied to all parts of the West Torrens Stormwater Catchment, it has been used to assess other areas of metropolitan Adelaide and by identifying similar characteristics we have selected an area suitable for comparison. The City of Charles Sturt has been selected as a comparable area due to similar characteristics to the most developable parts of the Sturt Stormwater Catchment, including distance from the city, accessibility via major arterial routes and public transport coverage and housing stock type and age. Observations of the output from these assessments have been applied to the housing stock within the West Torrens Stormwater Catchment in order to draw some generalised conclusions with regard to the overall redevelopment potential within the catchment. Development policy differences will affect the total development outcome but the results of the study area serve as a reasonable indicator of development potential within the region.

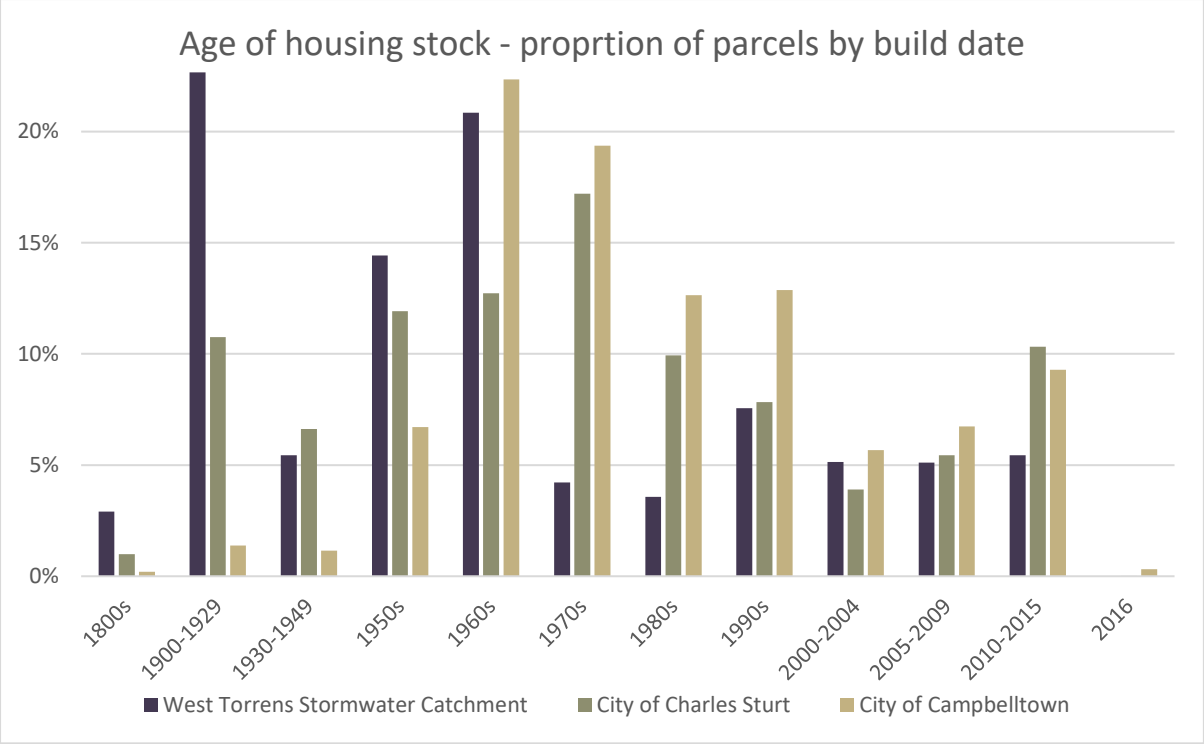


Figure 22: Comparison of housing stock by build date of the West Torrens Stormwater Catchment, the City of Charles Sturt and the City of Campbelltown

Figure 22 shows that a significant proportion of post-World War II development occurred in both the West Torrens Catchment and the City of Charles Sturt but that development continued at a high rate in the City of Charles Sturt throughout the 1970s and 80s whereas the West Torrens Stormwater Catchment area experienced little development in these decades. Since the 1990s the proportion of developments within the two areas is very similar until the last five years. Homes built between 1950 and 1990 are considered most likely to be redeveloped. Homes older than this are regarded as character homes of a region, are generally protected by historical or character zoning constraints and/or hold sufficient value within the home itself to negate redevelopment profitability. Homes constructed within 15-20 years are usually considered inappropriate for replacement as they generally carry high capital value in the home. The broad similarities within the redevelopable housing stock enables us to make comparison of the two regions.

Housing development within the catchment area in the decades following WWII make up a considerable volume of the overall existing stock in the Catchment and includes a range of house type and quality. Homes of lower quality construction and of lesser architectural value may provide additional profitable redevelopment opportunities in the catchment area and increase the overall potential yield from profitable subdivision and development. The City of Charles Sturt analysis assessed 53,949 residential parcels while the Catchment contains 19,091 residential parcels. Narrowing the assessment to parcels with homes built between 1950 and 2000 results in volumes of 32,166 for the City of Charles Sturt and 10,090 for the West Torrens Stormwater Catchment. This provides an overall parcel volume in the Catchment less than 1/3rd the assessment volume within the City of Charles Sturt.

Analysis of the City of Charles Sturt shows a projected profitable yield increase (forecast profit above 10%) of 11,048 additional dwellings on the filtered land parcels. The equivalent condition yields **5,001 additional dwellings within the West Torrens Stormwater Catchment**. This assessment is based on development plan policies and controls such as those in the City of Charles Sturt. If development plans are amended to permit greater density, such as in parts of the City of Campbelltown, and these average profiles included in development projections applied to the study catchment, the profitable redevelopment estimate is shown to rise to **10,359 additional dwellings**.

A full assessment of the catchment using the Residential Development Algorithm requires additional data on the parcels within the catchment, detailed inputs of building policy requirements and limitations and a comprehensive study of recent real estate sales data within the region. This assessment is intended as a comparative and indicative study only.

4.5 Residential Development Scenarios: Summary

As shown in the previous sections, the Scenarios result in a range of possible residential development outcomes for the West Torrens Stormwater Catchment Area. All the following assumptions are documented above and are forecast to the year 2046 above 2015 levels (i.e. a 30-year timeframe).

Scenario 1 (projection on existing trends) will result in 3,190 to 3,320 **additional dwellings.**

Scenario 2 (projections based on published Government Population Policy) will result in a yield range of 4,560-11,450 additional residential dwellings, with an average (medium population scenario) **increase of 8,460 dwellings.**

Scenario 3 (capital value / site value analysis) will result in an additional 6,310 dwellings or 7,580 in a medium density scenario.

Scenario 4 (Residential Development Algorithm approximation through comparison to the City of Charles Sturt) will result in an additional 5,000 dwellings or 10,360 where policies allow for medium density development**.**

4.6 Development Potential: Spatial Attribution

To develop an indicative distribution of redevelopment parcels throughout the catchment area, InfraPlan created an algorithm to assess the likely development location of the first 5,800 additional dwellings within the catchment area. This value was determined as the mid-range figure of the four scenarios stated in Section 4.5.

To calculate the likelihood of development of each eligible parcel, the algorithm includes assessments of the following characteristics:

- age of the existing dwelling(s)
- capital to site value ratio
- parcel size (m^2)
- parcel zoning
- existing land use
- development plan subdivision conditions
- historical significance

Parcels in Conservation Policy Areas were excluded from the assessment, while parcels in Urban Corridor Zones and Medium Density Policy Areas were given a higher loading to reflect Council preference for development in these zones. Parcels in exclusively Commercial and Industrial zones were not included in this assessment. This has excluded some Urban Corridor Zone frontages which could be developed as mixed-use developments. Generally, these types of developments will not increase permeable areas due to the nature and scale of existing land uses and structures.

The calculation allowed for varying development density and scale depending on the precinct and the conditions of the Development Plan (2016). It should be noted that due to existing redevelopment conditions affecting parcels within the catchment, those parcels within the City of Charles Sturt were excluded for this assessment. Parcels within the City of Adelaide were excluded due to the existing impermeable area percentage being high and therefore less likely to change with densification.

Infill potential was assessed for each parcel throughout the stormwater catchment and all parcels were ranked according to a weighted score representing developability and potential profitability. This determined an indicative proportional split across the zones and an indicative number of redevelopment parcels and resulting additional dwellings within each zone. The top ranked parcels within each zone were then chosen to meet the projected new dwelling calculation for each zone. The outcome of this analysis identified a total of 1,917 parcels with a projected yield increase of 5,780 new dwellings with an average replacement rate of 4. The average replacement rate by region varied from 2.0 in Low Density Residential Zones to 10.7 in Urban Corridor Zones.

The result of these calculations and projections is shown as an indicative development spatial distribution in Figure 23. This figure shows two major regions of development, aligned to major arterial roads and around Urban Corridor Zones. This map is designed to be indicative only for the purposes of calculating impermeable area increase and should not be taken to indicate the precise location of future development.

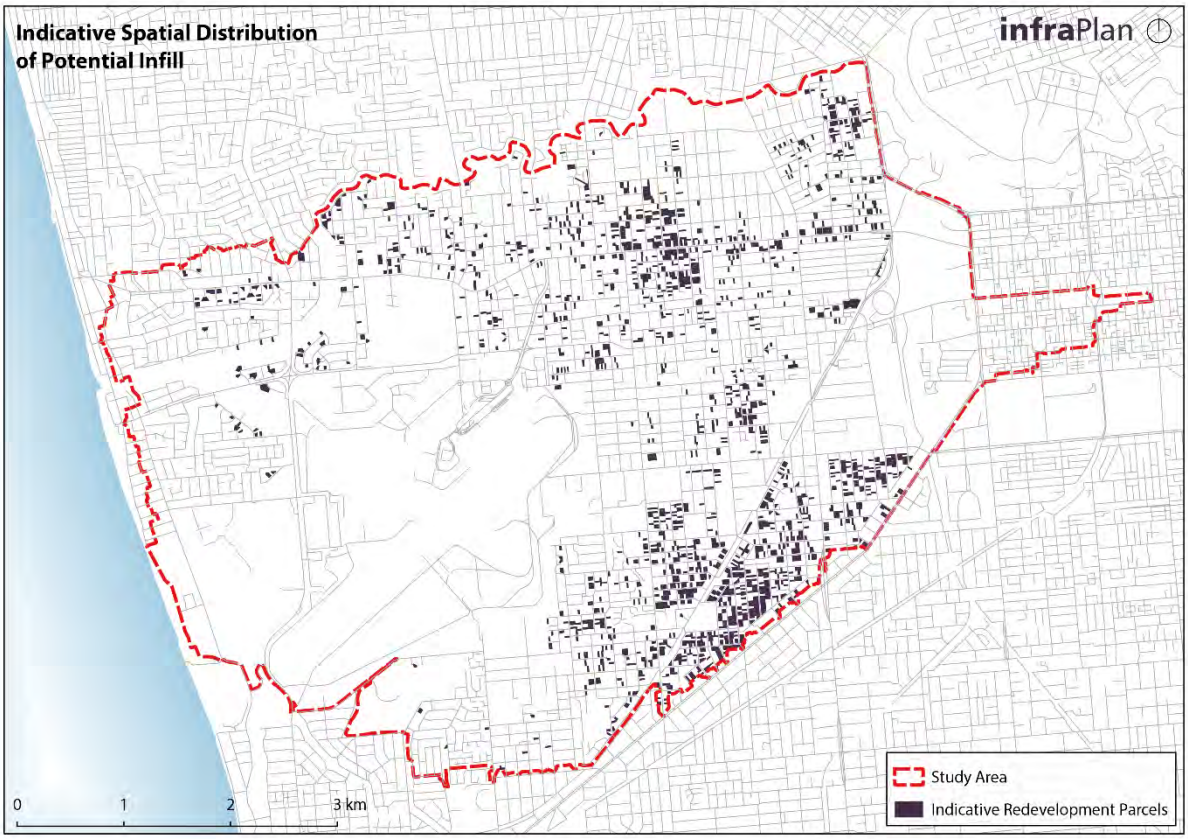


Figure 23 Indicative spatial distribution of redevelopment parcels

5. Transport and Infrastructure Assessment

Transport infrastructure requires consideration for stormwater management, especially in the context of urban infill and development. Increased housing density within the catchment may result in increased traffic loading on major arterials and cross-catchment routes, which may require road infrastructure: however, the catchment is relatively well served by public transport with bus routes covering all major arterial roadways. Major cycle routes connect to the city and local centres. As such, this catchment provides good opportunities to increase density and if focussed around transport hubs, it may be possible to minimise traffic impacts to the road network and thereby delay the need for additional road capacity.

Despite this, to determine the most likely locations for transport improvements, a review of The Integrated Transport and Land Use Plan released by the State Government in 2015 outlines many of the intended transport/infrastructure projects across the West Torrens Stormwater Catchment Area.

The following is a list of the key transport investments proposed within the Integrated Transport and Land Use Plan with relevance to the Sturt Stormwater Management Plan.

- Progressively upgrade South Road as part of a strategy to develop the non-stop North-South Corridor, including grade separation with key east-west arterial routes and provision of at-grade service roads, any interim works and detour works during construction (including North-South Corridor – Darlington, and Complete the North-South Corridor – Anzac Highway to Darlington);
- West*LINK* – trams along Henley Beach Road and to Adelaide Airport. The tram network (Ade*LINK*) is currently the subject of a detailed Business Case;
- Partner with local councils to complete the Airport Bikeway, including crossings of arterial roads;
- Upgrade intersections along Sir Donald Bradman Drive to reduce congestion and improve reliability of travel times to the airport, and provide upgrades for taxi, commercial vehicle and bus access via Richmond Road; and
- Area Wide: Supply of additional and expanded Park and Rides at key nodal points on the train, tram and bus networks.

Transport infrastructure upgrades have the potential to increase impermeable surface areas within the catchment area, particularly if road widening is required. However, land acquisition (potentially required for road widening) also presents unique opportunities to employ stormwater retention basins and other Water Sensitive Urban Design devices in the remaining land reserve following the completion of road projects.

The following maps provide a spatial annotation of the above list of projects identified in ITLUP:

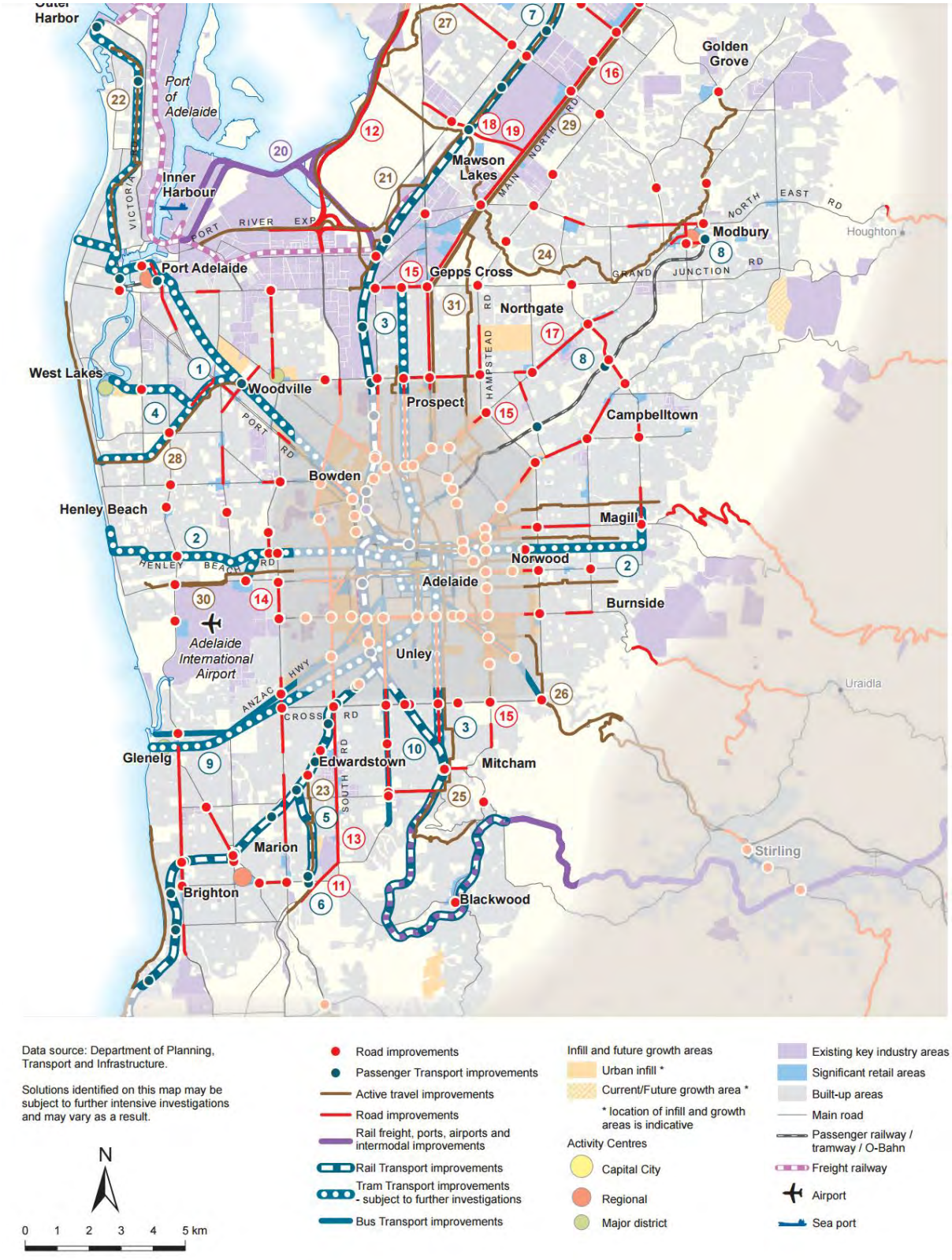


Figure 24 Infrastructure, Transport and Land Use projects within the Adelaide Metropolitan area as shown in ITLUP, 2015



Figure 25 Infrastructure, Transport and Land Use projects within the City of Adelaide and inner suburban areas as shown in ITLUP 2015

South Road Corridor (North South Corridor):

The proposed upgrades along the North South Corridor (the South Road), are likely the most significant infrastructure works to occur within the catchment areas. Development on the North South Corridor, beginning with the Darlington Precinct and in future extending the length of South Road within the catchment, is likely to result in an increased impervious surface area due to road widening and additional lane creation. Stormwater collected on this future roadway presents possible risks in increased volume, concentrated peak flows and increased pollutants carried in stormwater collected from roadways. Upgrades to South Road may also present more opportunity to install WSUD features within the roadways, providing source control, treatment and retention, reducing the overall scale of treatment sites within the catchment.

Risks to stormwater and catchment flooding associated with the North-South Corridor project are two-fold. Up-stream flow paths and system connections to the downstream components are likely to be affected if a lowered road option is constructed. This arrangement has been employed in the under-construction Torrens to Torrens Project and the proposed Darlington scheme. Increased impermeable areas in the North-South Corridor project site at South Road will also produce increased collected stormwater volumes, potentially increasing peak flow volumes and carrying larger pollutant loads. However, should the stormwater discharge from future South Road projects be mitigated and managed prior to entering the existing stormwater system, these works could deliver solutions to existing capacity and flow rate problems, mitigating flooding risks downstream of the project site. Upstream flooding risks will need to be managed by ensuring the flow regime within and around future South Road Project sites is retained at the current capacity at a minimum and if this is not sufficient, improvements to flow patterns and the stormwater network may be undertaken at this stage to improve the upstream capacity.

Metropolitan Adelaide Road Widening Program

Some roads within the catchment area are also subject to the provisions of the Metropolitan Adelaide Road Widening Program (or MARWP). This Plan requires all proposed developments to obtain consent from the Commissioner of Highways and that all new developments to be set back from the existing street frontage: each corridor subject to MARWP has different setback requirements, specified in meters. This requirement is imposed so that there is provision for future road purposes. Given that the road improvements identified in ITLUP, MARWP requires consideration, if a road is identified in MARWP it does not necessarily mean that it is intended to be widened. The region does not include a lot of road widening allowances under MARWP but does include numerous intersections identified where widening may be required. Affected intersections within (or immediately adjacent to) the West Torrens Stormwater Catchment area are found on Grange Road, Henley Beach Road, Sir Donald Bradman Drive and Richmond Road.

The MARWP plans also show possible future connections from William Street, Beverley to Holbrooks Road and through Underdale to Marion Road. These road diversion projects would both require suburban land acquisition. Some of the identified intersections (such as South Road intersections at Grange Road and Port Road) and sections of Richmond Road have been subject to road projects recently or ongoing that address the allowances provided under MARWP. Figure 26 and Figure 27 show the parts of the study area affected by MARWP.

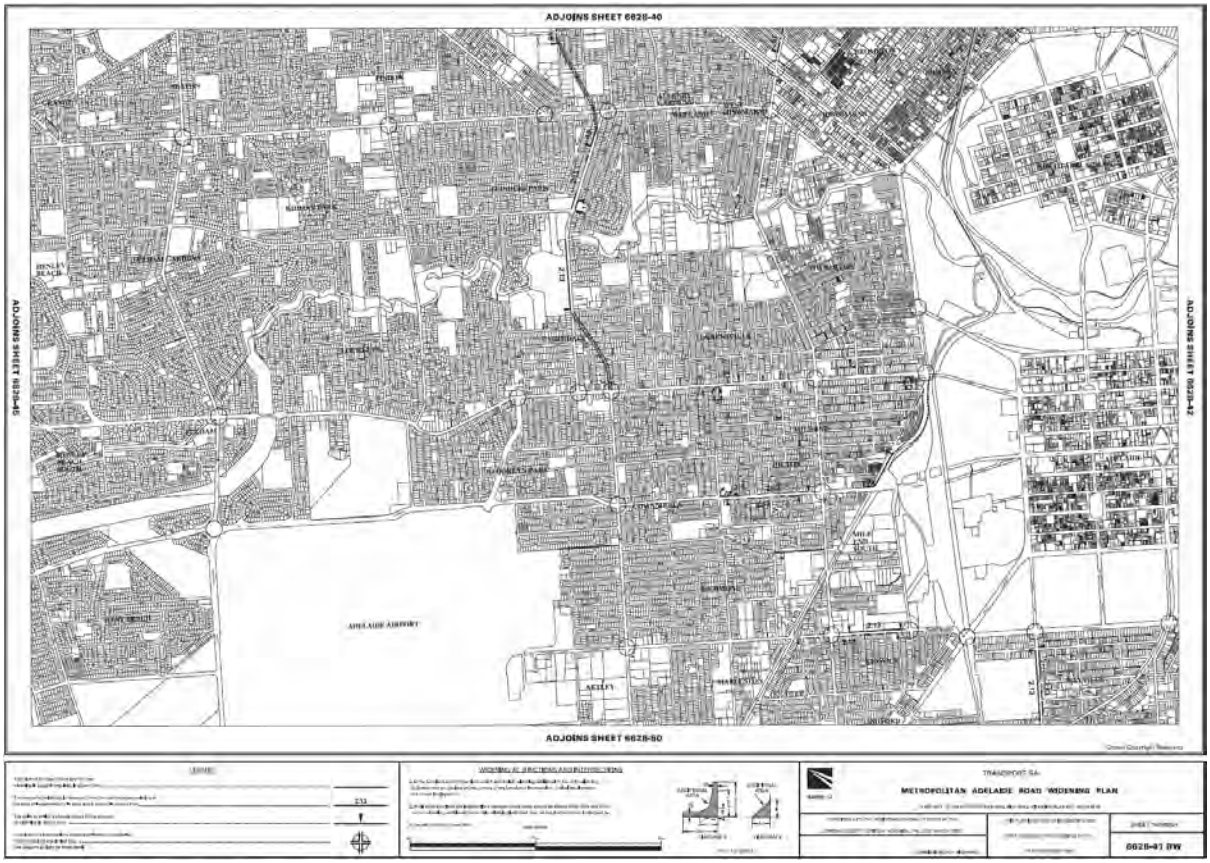


Figure 26: MARWP requirements (Sheet 6628-41, western suburbs)

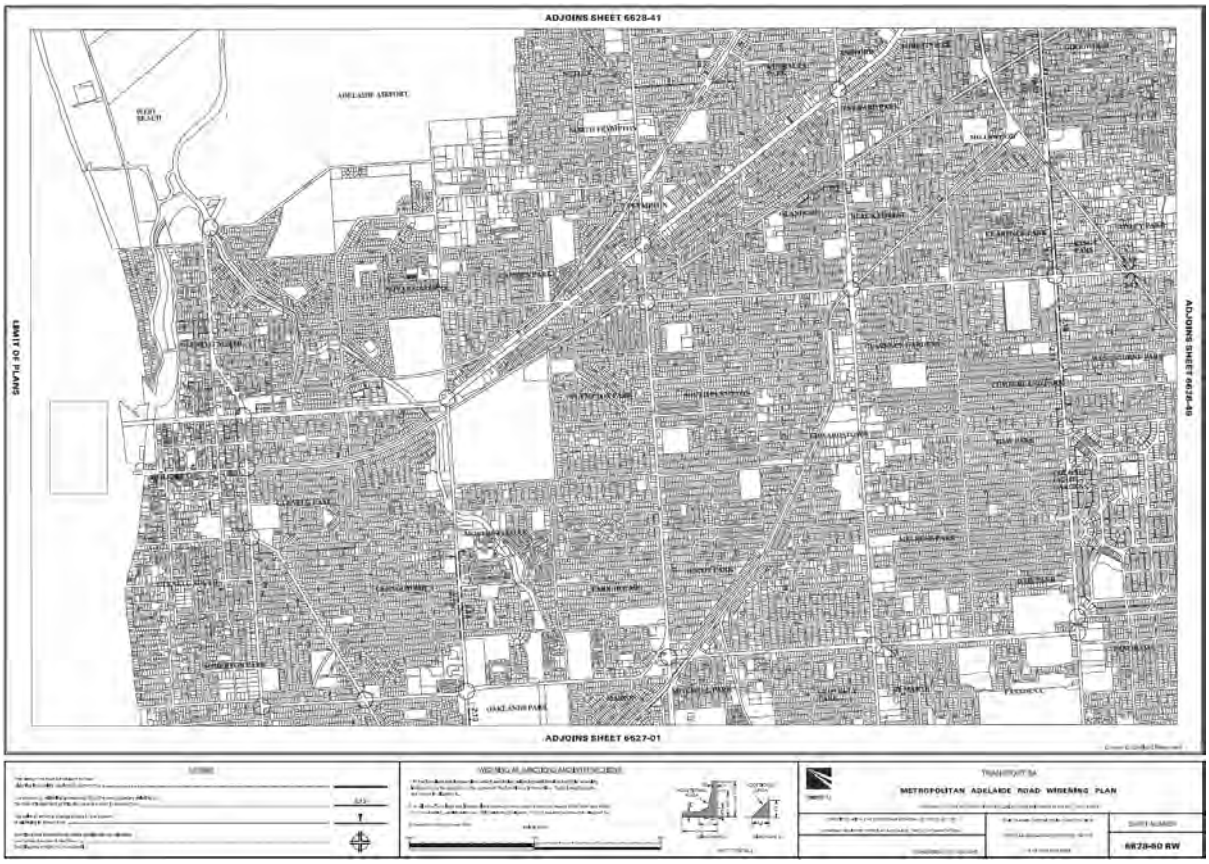


Figure 27 MARWP requirements (Sheet 6628-50, south-western suburbs)

6. Conclusion

The assessments contained within this report have been commissioned for application into the West Torrens Catchment Stormwater Management Plan. Flow models will be applied by Southfront using the calculations and assumptions developed by InfraPlan. Based on the outputs of this report InfraPlan will continue to work with Southfront in the application of:

- Infill/development scenarios (outlined in section 4)
- Spatial distributions of dwellings (outlined in section 3)
- General increase in impervious areas based on the refinement outputs (outlined in section 4.6)
- Transport infrastructure potential (outlined in section 5)

Although InfraPlan has applied its professional judgement in developing this report, it should be noted that the development scenarios and spatial distribution assumptions are an approximate judgement of how development might occur across the West Torrens Stormwater catchment. The prediction of development potential is especially difficult, and is subject to many external and uncontrollable factors. For example, it is difficult to predict future market conditions (both in the housing industry as well as broader economic conditions) which will have a significant bearing on infill development. It is also difficult to predict the future policy directions of councils and the State Government which may have significant bearing on the outcomes of development across not only the West Torrens Stormwater Catchment area, but metropolitan Adelaide in general.

For the purposes of this report, InfraPlan has applied industry best practice assessment and calculations for development potential and urban infill, as well as its own assessment methods and investigations developed specifically for this report. Despite this, actual future populations/development potential and infill locations will likely vary from these projections, especially given the assessments have been applied over a 30-year timeframe. Therefore, it is recommended that the outputs of this report be reviewed on a semi-regular basis and be recalibrated using updated relevant data to ensure that the Development Potential Scenarios (section 4) and Spatial Distribution of Dwellings (section 3) remain relevant. This is especially important given the likely implications on infrastructure investment and resource suitability for the West Torrens Stormwater Catchment assets.

7. Appendices

7.1 Appendix A: Development Plan Zones within the Study Area

*Dev. Plan Code – **AD** (Adelaide City), **CHST** (Charles Sturt) and **WETO** (West Torrens).*

DEV. PLAN CODE*	ZONE	ZONE MEANING	POLICY	POLICY MEANING	PRECINCT	PRECINCT MEANING	DEV. CATEGORY
AD	CC	Capital City Zone	13	Central Business Policy Area			COMMERCIAL
AD	CC	Capital City Zone	14	Main Street Policy Area			COMMERCIAL
AD	CC	Capital City Zone					COMMERCIAL
AD	CF	City Frame Zone					RESIDENTIAL
AD	CiL	City Living Zone	32	South Central Policy Area			RESIDENTIAL
AD	CiL	City Living Zone	33	South West Policy Area			RESIDENTIAL
AD	MS(A)	Main Street (Adelaide) Zone					COMMERCIAL
AD	PL	Park Lands Zone	22	Southern Park Lands Policy Area			RECREATION
AD	PL	Park Lands Zone	23	Western Park Lands Policy Area			RECREATION
AD	PL	Park Lands Zone	24	River Torrens West Policy Area			RECREATION
AD	Rb	Riverbank Zone	27	Medical Policy Area			COMMUNITY FACILITIES
CHST	AdSh	Adelaide Shores					RECREATION
CHST	Af	Airfield					INFRASTRUCTURE
CHST	CstOS	Coastal Open Space					ENVIRONMENTAL CONSTRAINT
CHST	LCe	Local Centre					COMMERCIAL
CHST	LCe	Local Centre	7	Local Shopping			COMMERCIAL
CHST	MOSS	Metropolitan Open Space System	8	Linear Park (River Torrens/Karrawirra Parri)			OPEN SPACE
CHST	R	Residential	16	Mid Suburban			RESIDENTIAL
CHST	R	Residential	17	Western Edge			RESIDENTIAL
WETO	AdSh	Adelaide Shores					RECREATION
WETO	Af	Airfield					INFRASTRUCTURE
WETO	BG	Bulky Goods					COMMERCIAL

WETO	C	Commercial	1	Arterial Roads			COMMERCIAL
WETO	C	Commercial	1	Arterial Roads	1	Intersection	COMMERCIAL
WETO	C	Commercial	1	Arterial Roads	2	Richmond Road	COMMERCIAL
WETO	C	Commercial	1	Arterial Roads	3	Sir Donald Bradman Drive (Mile End)	COMMERCIAL
WETO	C	Commercial	1	Arterial Roads	4	South Road (Keswick)	COMMERCIAL
WETO	C	Commercial	1	Arterial Roads	5	South Road (Mile End)	COMMERCIAL
WETO	C	Commercial	1	Arterial Roads	6	South Road (Mile End South)	COMMERCIAL
WETO	C	Commercial	2	District Commercial			COMMERCIAL
WETO	C	Commercial	3	Local Commercial			COMMERCIAL
WETO	C	Commercial	4	Office Park			COMMERCIAL
WETO	CstMar	Coastal Marina					ENVIRONMENTAL CONSTRAINT
WETO	CstOS	Coastal Open Space					ENVIRONMENTAL CONSTRAINT
WETO	Cu	Community	5	Recreation	7	Mile End	COMMUNITY FACILITIES
WETO	Cu	Community	5	Recreation	8	Open Space	COMMUNITY FACILITIES
WETO	Cu	Community	5	Recreation			COMMUNITY FACILITIES
WETO	Cu	Community					COMMUNITY FACILITIES
WETO	DCe	District Centre	6	Brickworks			COMMERCIAL
WETO	DCe	District Centre	7	Kurralta Park			COMMERCIAL
WETO	In	Industry	9	Netley			INDUSTRIAL
WETO	In	Industry	10	Mixed Use			INDUSTRIAL
WETO	In	Industry					INDUSTRIAL
WETO	LCe	Local Centre					COMMERCIAL
WETO	NCe	Neighbourhood Centre	11	Hilton			COMMERCIAL
WETO	NCe	Neighbourhood Centre	12	Marleston			COMMERCIAL
WETO	NCe	Neighbourhood Centre	13	Novar Gardens			COMMERCIAL
WETO	NCe	Neighbourhood Centre	14	Richmond			COMMERCIAL
WETO	NCe	Neighbourhood Centre	15	Tennyson Street			COMMERCIAL
WETO	NCe	Neighbourhood Centre	16	Thebarton			COMMERCIAL

WETO	OS	Open Space					OPEN SPACE
WETO	R	Residential	18	Medium Density			RESIDENTIAL
WETO	R	Residential	19	Medium Density			RESIDENTIAL
WETO	R	Residential	20	Low Density			RESIDENTIAL
WETO	R	Residential	21	Low Density			RESIDENTIAL
WETO	R	Residential	22	Ashford Character			RESIDENTIAL
WETO	R	Residential	23	Cowandilla / Mile End West Character			RESIDENTIAL
WETO	R	Residential	25	Lockleys Character			RESIDENTIAL
WETO	R	Residential	26	Novar Gardens Character			RESIDENTIAL
WETO	R	Residential	27	Thebarton Character			RESIDENTIAL
WETO	R	Residential	28	Torrensville Character			RESIDENTIAL
WETO	R	Residential	29	Elston Street Conservation			RESIDENTIAL
WETO	R	Residential	30	Mile End Conservation			RESIDENTIAL
WETO	R	Residential	31	Richmond Conservation			RESIDENTIAL
WETO	R	Residential	32	Rose Street Conservation			RESIDENTIAL
WETO	R	Residential	33	Torrensville East Conservation			RESIDENTIAL
WETO	UrC	Urban Corridor	34	Boulevard			COMMERCIAL
WETO	UrC	Urban Corridor	35	High Street			COMMERCIAL
WETO	UrC	Urban Corridor	36	Transit Living			COMMERCIAL
WETO	UrC	Urban Corridor	37	Business			COMMERCIAL

Appendix C

West Torrens Catchment SMP - Hydrogeological Assessment WGA (2020)



WALLBRIDGE GILBERT AZTEC

Southfront

West Torrens Catchment SMP - Hydrogeological Assessment

Project No. WGA201812
Doc No. WGA201812-RP-HG-0001
Rev. A

25 September 2020

Revision History

Rev	Date	Issue	Originator	Checker	Approver
A	25/9/2020	Draft for Comment	R Martin	M Gogoll	R Martin

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1 INTRODUCTION

1.1 BACKGROUND

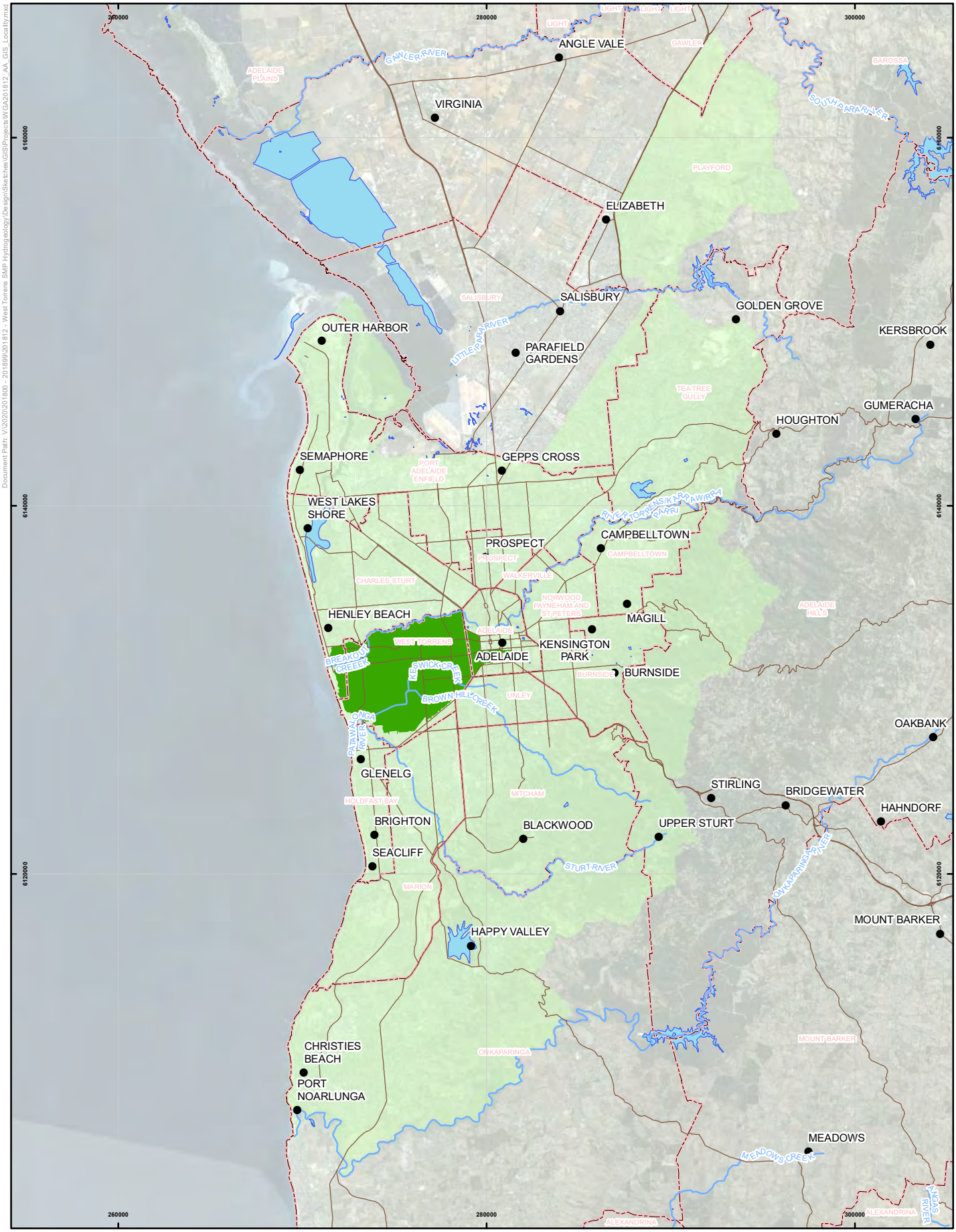
Southfront Pty Ltd (Southfront) engaged Wallbridge Gilbert Aztec (WGA) to complete a desktop review of the local hydrogeology and assess the potential for Managed Aquifer Recharge (MAR) as part of the development of the West Torrens Catchment Stormwater Management Plan (SMP). The hydrogeological assessment provides a summary of the local groundwater system to assist in developing an integrated approach to managing stormwater in the area.

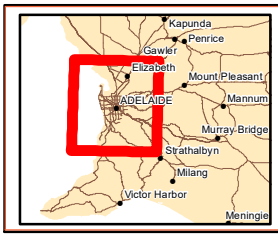
The West Torrens Catchment (Figure 1) originates from within the Adelaide CBD and extends west to the coast. Three local government areas overlap across the catchment. The head of the catchment is located within the Adelaide Central Business District (CBD) within the Local Government Area (LGA) administered by the City of Adelaide. The northeast portion of the catchment known as Breakout Creek/River Torrens lies within the LGA administered by the City of Charles Sturt, whilst the bulk of the catchment falls within the City of West Torrens LGA.

1.2 SCOPE OF SERVICES

The scope of services for the delivery of this work has included:

- A review of the geology within the study area.
- A hydrogeological review which incorporated interrogation of the government's groundwater database and publicly available information.
- An estimate of groundwater use within the study area.
- Assessment of MAR feasibility within the study area.
- Comment on operational MAR systems and potential for new MAR systems in the study area.
- Summary of the current MAR regulatory framework.





N

0 2 4 6 8 km

Scale 1:275,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2020

LEGEND

- Locality
- Main Highway
- Watercourse
- LGA Boundary
- SMP Catchment Area
- Surfacewater Areas
- Central Adelaide PWA

WGA
WALLBRIDGE GILBERT AZTEC

Figure 1

West Torrens SMP Hydrogeology

Locality Plan

Document Path: V:\2020\201800 - 201899\201812 - West Torrens SMP Hydrogeology\Design\Sketches\GIS\Projects\WGA201812_AA_GIS_Locality.mxd

2 PHYSIOGRAPHY

2.1 STUDY AREA

The West Torrens Catchment covers an area of approximately 39 km^2 (**Figure 1**). Prior to European settlement, the lower reaches of the River Torrens spread out across the plains to form a range of swamps, wetlands and reedbeds (Kraehenbuehl 1996) extending south and north of the present-day Torrens River discharge point through Breakout Creek. Post European settlement, the catchment has been heavily engineered to manage stormwater runoff from the built environs. The main drainage lines of Keswick Creek and Brownhill Creek, which transect the catchment, have been heavily engineered to transport water quickly toward the coast where it is discharged through the Patawalonga River.

The River Torrens marks the northern boundary of the catchment. Keswick Creek flows westerly from the confluence of Park Lands Creek and Glen Osmond Creek before entering the West Torrens Catchment at Anzac Highway, opposite the Keswick Army Barracks. Keswick Creek is a heavily engineered concrete lined channel and drains through the suburbs of Keswick, Mile End, Hilton, Richmond and finally around the eastern side of Adelaide Airport to its confluence with Brown Hill Creek.

Brownhill Creek has its headwaters in the Mount Lofty Ranges and drains through the suburbs of Mitcham and Unley before entering the West Torrens Catchment at Ashford, south of the Keswick Army Barracks (**Figure 1**). The confluence of Brownhill Creek and Keswick Creek occurs at Beare Reserve located on the eastern border of Adelaide Airport. Brownhill Creek flows along the southern boundary of Adelaide Airport and joins with Sturt Creek in the southwestern corner of the catchment. The confluence of Brownhill Creek and Sturt Creek forms the head of the Patawalonga Creek which is the exit point to sea for water draining the West Torrens catchment and adjacent Sturt River Catchment.

A large portion of the catchment (approximately 7 km^2) comprises the Adelaide Airport and associated commercial buildings whilst the combined open areas of the Glenelg Golf Course (south of the Airport); West Beach Parks Golf, West Beach Caravan Park, Barratt Reserve and Adelaide University Sports Fields (West of Adelaide Airport) have a combined open area of approximately 2.1 km^2 and Kooyonga Golf Course (north of Adelaide Airport) has an open area of approximately 0.58 km^2. The combined area comprising large open spaces (excluding smaller sporting ovals) is approximately 9.7 km^2 or 25% of the 39 km^2 catchment area.

2.2 TOPOGRAPHY

Along the western coastal margin of the catchment remnant sand dunes rise from the shore line to heights of 10 m above Australian Height Datum (m AHD) before dropping to around 2 m AHD at Military Road which runs parallel with the shoreline along the back of the dunes. Pre-European settlement the dunes most likely acted as a barrier to stormwater discharge associated with large storm events and resulted in the formation of swamps and marshes across the lower lying landscape behind the dunes.

Most of the vacant land immediately east of Military Road, including the Adelaide Airport, has a typical elevation of approximately 2 m AHD. Drainage trenches have been constructed around Adelaide Airport to prevent waterlogging of the lower lying land.

From the eastern boundary of Adelaide Airport, the topography rises to approximately 42 m AHD in the Adelaide CBD. The steepest change in elevation (20 m AHD to 30 m AHD) occurs along the rail line at Keswick which fringes the Adelaide CBD. This change in elevation aligns along the approximate axis of the Para Fault in this location. From the rail line west to the coast along fault axis there is no evidence of any significant elevation change which would indicate surface expression of the fault line.

2.3 CLIMATE

The Adelaide region experiences cool, wet winters and hot, dry summers. Higher rainfall is recorded in winter, typically during the months of April and October however significant variations in intensity and distribution are observed seasonally. Due to the sharp increase in elevation of the Mount Lofty Ranges, rainfall typically increases across the Adelaide Plains because of the orographic influence of the ranges

Various rainfall gauging stations have been in operation at one time or another either within or surrounding the West Torrens Catchment. **Table 1** presents a list of the currently active climate stations within and immediately surrounding the West Torrens Catchment. Historically there have been multiple stations in operation but many of them have been closed. Adelaide Airport (BoM Station number 023034) has continuous daily rainfall records from 1955 to present.

Table 1: Currently Active Bureau of Meteorology BoM Climate Stations in and Around the West Torrens Catchment

BoM Station Number	Station Name	Easting (GRS80 2020)	Northing (GRS80 2020)	Period of Record
23034	Adelaide Airport	273533.82	6129692.977	1955 – Aug 2020
23011	Nth Adelaide	280760.813	6133199.207	1883 – Aug 2020
23024	Seaton	272482.364	6135216.829	1912 – Aug 2020
23098	Morphettville RC	275415.167	6127519.501	1947 - Aug 2020
23115	Keswick	279013.983	6129827.302	2001 – Aug 2020
23140	Mitchell Park	277349.868	6123127.059	2007 - Aug 2020
23137	Regency Park	277885.104	6138679.482	2007 - Aug 2020
23090	Kent Town [1]	282588.173	6133242.866	1977 – Jun 2020

Notes: [1] Kent Town station closed end Jun 2020

The average annual rainfall for the period of record for the eight gauging stations presented in **Table 1** ranges from 346.8 mm at Regency Park (BoM Station No. 23137) through to 547.1 mm at Kent Town (BoM Station No.23090). The period of record for the Regency Park BoM gauging station starts in 2007 and it is considered that the record for this site may be skewed by the lower than average rainfall experienced across Adelaide over the past decade.

Comparison of the average annual rainfall across all stations listed in **Table 1** for their period of record against the period 2007 to August 2020 show the annual mean rainfall at North Adelaide and Morphettville Racecourse has decreased by 72 and 61 mm. The annual average rainfall recorded at Adelaide Airport and Kent Town for the period 2007 to August has decreased by 37 and 26 mm respectively when compared against the average annual rainfall for the period of record. The remaining stations show no appreciable change in average rainfall as the period of record starts in 2001 or 2007.

Figure 2 presents the average monthly rainfall for the period January 2007 to August 2020 for the eight closest BoM gauging stations to West Torrens Catchment. In general rain fall is lower in the north west increasing across the catchment south easterly in response to the orographic influence of the Mount Lofty Ranges.

Figure 3 presents the rainfall isohyets for the eight active BoM gauging stations for the period 2007 to August 2020. A common period has been selected for all records to reflect the most recent rainfall trends rather than using the entire period of record. The general rainfall pattern from the isohyet contours shows rainfall increasing from north west to south east across the catchment.

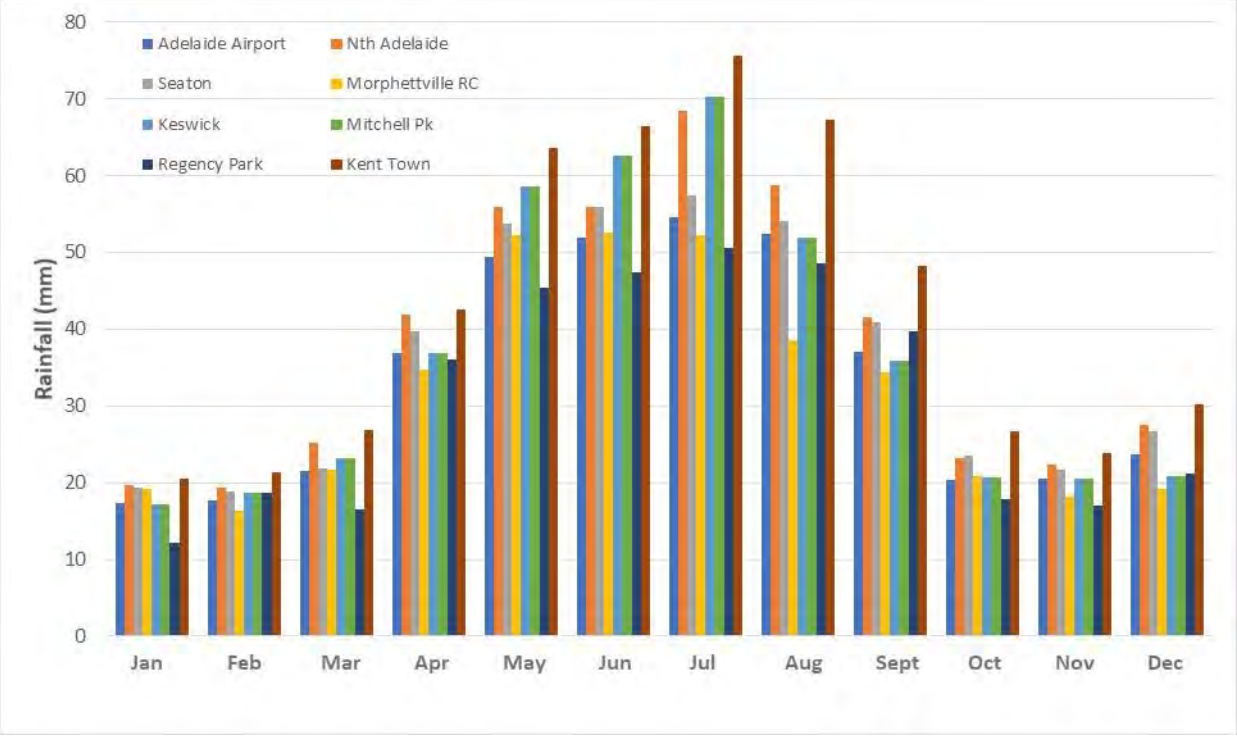
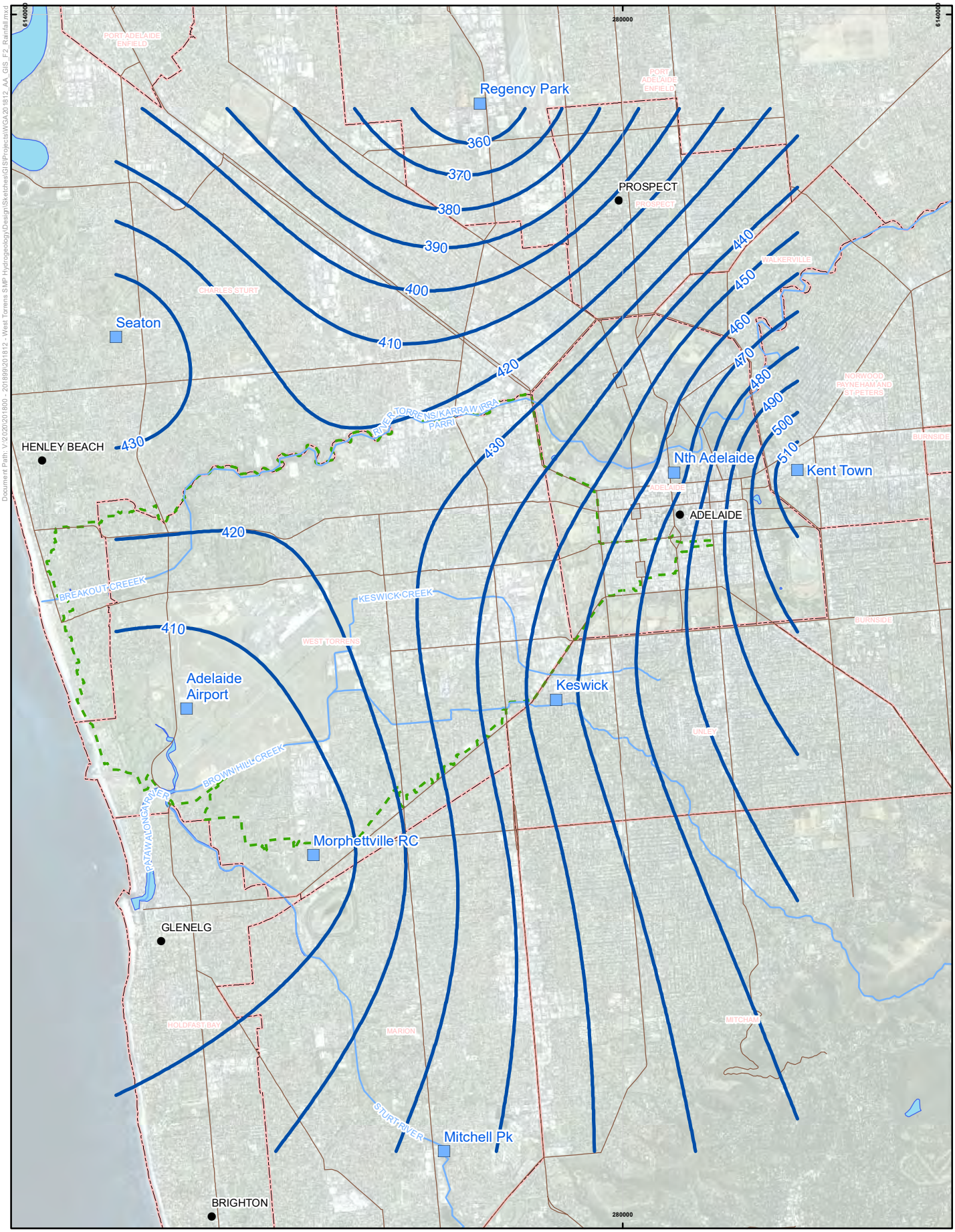


Figure 2: Average Monthly Rainfall for Period Jan 2007 to June 2020 for the Active BoM Stations





N

0 500 1,000 1,500 2,000 m

Scale 1:75,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

LEGEND

- Locality
- Rainfall Station
- Rainfall Isohyets
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2020

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Figure **3**

West Torrens SMP Hydrogeology

Average annual rainfall (2007-2020)

Document Path: Y:\2020\201800 - 201899\201812 - West Torrens SMP Hydrogeology\Design\Sketches\GIS\Projects\WGA 201812_AA_GIS_F2_Rainfall.mxd

2.4 WATER RESOURCES MANAGEMENT AREA

The portion of the River Torrens/Karrawirra Parri that flows across the Adelaide Plains and forms the northern boundary of the West Torrens Catchment is a Prescribed Watercourse under the Western Mount Lofty Ranges Water Allocation Plan. A licence is required to take water from the Torrens River for irrigation or industrial purposes.

The West Torrens Catchment lies within the Central Adelaide Prescribed Wells Area (CA PWA). The CA PWA was officially prescribed on 7 June 2007. Prescription establishes a water allocation and licensing framework to protect water resources from overuse and to ensure water users are not adversely affected by other water users.

The Prescription covers the groundwater (bores/wells) resources of the region but does not apply to the use of water from wells for domestic purposes, including the irrigation of less than 0.4 hectares (backyard bores), or for watering stock.

Although the CA PWA is prescribed, at the time of preparing this report, licences to take groundwater had not yet been issued and there is currently no comprehensive metering of extractions. The most recent estimate of use from all aquifers across the CA PWA is about 10,000 to12,000 ML/a. Groundwater extraction from the T1 aquifer is concentrated near Thebarton, where there is industrial extraction, and in the West Lakes / Grange area where there is seasonal irrigation. Long-standing cones of depression in the potentiometric (pressure) level surface have formed in these areas but long-term groundwater level trend appears to have stabilised suggesting a new equilibrium has been reached.

3 GEOLOGY / HYDROGEOLOGY

3.1 REGIONAL GEOLOGICAL SETTING

3.1.1 Regional Geology and Stratigraphy

The West Torrens Catchment occurs mainly within the St Vincent Basin, an intracratonic sedimentary basin formed by rejuvenated Palaeozoic faults during the continental separation of Australia and Antarctica in the Eocene (Cooper, 1979). Basin strata are up to 700 m thick and were laid down in a shallow graben bounded by folded and block-faulted Proterozoic and Palaeozoic rocks (Drexel and Priess, 1995).

St Vincent Basin has been subdivided into several sub-basins, the largest being the Adelaide Plains Sub-basin. The Golden Grove, Noarlunga and Willunga Embayment's are asymmetric tectonic valleys in which the wedge of sediments dip gently southwards and thicken towards their faulted south eastern margins (Drexel and Priess, 1995). The West Torrens Catchment is bisected by the northeast/southwest trending Para Fault which separates the Adelaide Plains sub basin from the Golden Grove Embayment (**Figure 4**).

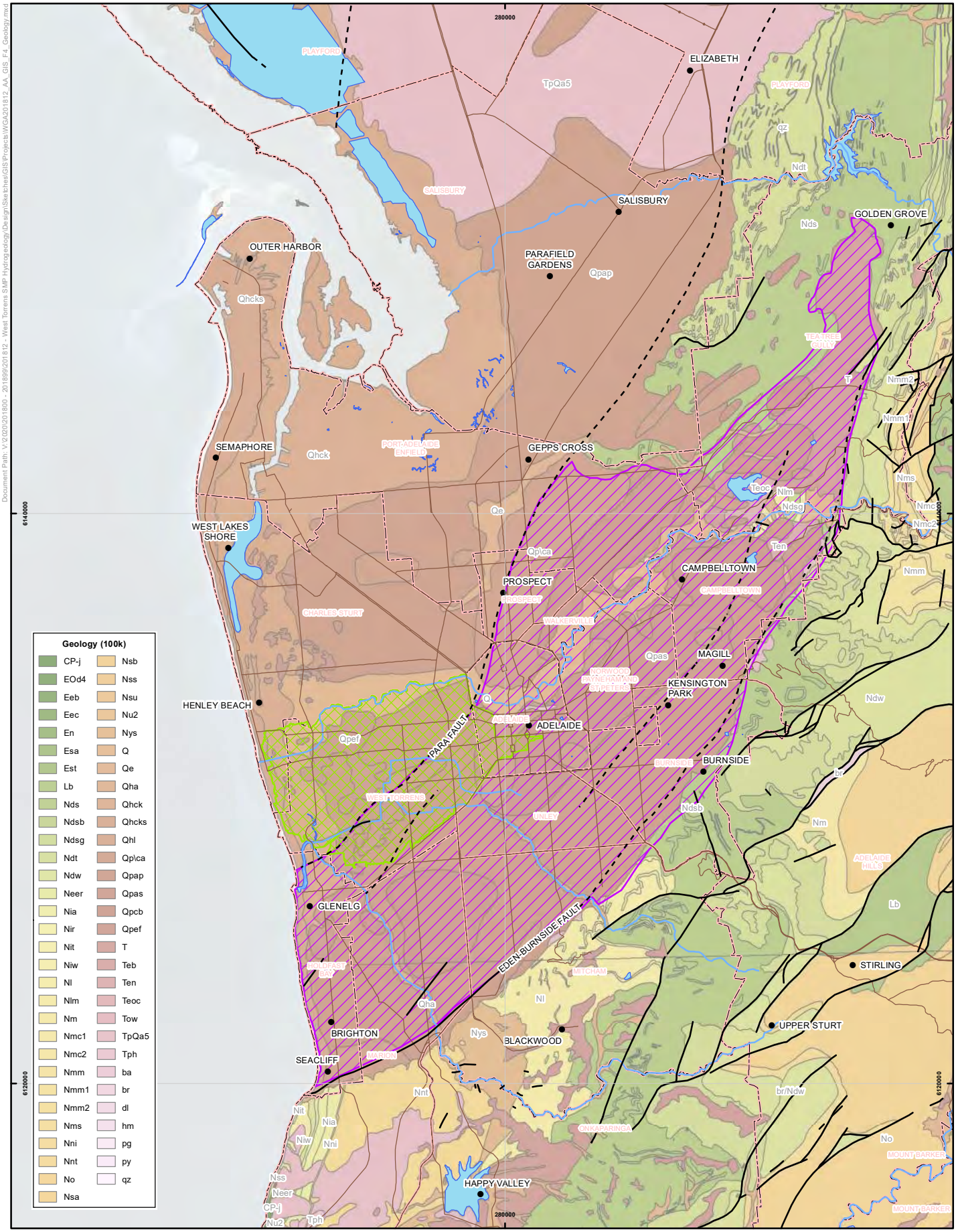
The major stratigraphic and equivalent hydrostratigraphic units of the Adelaide Plains sub-basin and the Golden Grove Embayment are presented in **Table 2**.

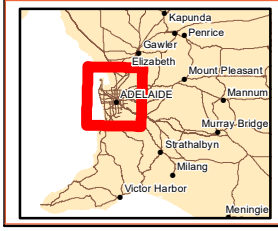
The Tertiary sedimentary aquifers constitute the largest and most important groundwater resource in terms of general use in the Adelaide Plains Sub-basin and Golden Grove Embayment. The Quaternary aquifers are relatively thin and of limited extent. They have typically been developed for abstraction by small-scale users for stock and domestic purposes in areas where the groundwater has favourable salinity.

The hydrostratigraphy of the Adelaide Plains Sub-basin uses the same nomenclature as the Golden Grove Embayment (**Table 2**) but is less complex because of the greater aquifer continuity and uniformity. The Q4 aquifer consists entirely of the sandy Carisbrooke Sand formation, and in some locations (e.g. throughout Golden Grove Embayment) can be in direct hydraulic connection with the underlying first Tertiary (T1) aquifer.

The Adelaide Plains Sub-basin is the most extensive portion of the St Vincent Basin and extends from the Para Fault in the south and east to beyond the northern limit of the Northern Adelaide Plains Prescribed Well Area (NAP PWA). The Golden Grove Embayment extends south from the Para Fault and is bounded in the east by the Eden Burnside Fault which marks the boundary for the uplifted Mount Lofty Ranges which delineate the western margin of the Adelaide Geosyncline

Quaternary and Tertiary sediments thicken to the south, reaching a maximum thickness of about 120 and 500 m in the metropolitan area between the River Torrens and the Para Fault. The hydrostratigraphy of the Adelaide Plains Sub-basin is much simpler than the Golden Grove Embayment because of the greater uniformity and extent of the key geological units.





N

0 1 2 3 4 km

Scale 1:177,612 @ A4

Coordinate System: GDA2020 MGA Zone 54

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

Note: The information shown on this map is a copyright of WGA 2020

LEGEND

- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas
- Golden Grove Embayment

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Figure **4**

West Torrens SMP Hydrogeology

Extent of the Adelaide Plains sub-basin and Golden Grove Embayment

Document Path: V:\2020\2201800 - 2018892201812 - West Torrens SMP Hydrogeology\Design\Sketches\GIS\Projects\WGA2018812_AA_GIS_F4_Geology.mxd

Table 2. Stratigraphy and Hydrostratigraphy of the Adelaide Plains Sub-Basin and Golden Grove Embayment (source Gerges 2006 and Zulfic et. al. 2008)

Age		Adelaide Plains Sub-Basin				Golden Grove Embayment			
		Stratigraphy		Hydrostratigraphy	Description	Stratigraphy		Hydrostratigraphy	Description
QUATERNARY	Holocene	Semaphore Sand, modern alluvium, overbank sands, and beach gravels. Saint Kilda Formation		Perched / Unconfined Aquifer Unconfined Aquifer	Thin sand aquifers near coast and perched aquifers in the overbank sediments adjacent to Gawler River. Thin sand, shell aquifer near coast	Semaphore Sand, modern alluvium, overbank sands, and beach gravels.		Unconfined Aquifer	Thin sandy aquifers restricted mainly to coastal areas
	Pleistocene	Pooraka Formation Keswick Clay		Aquitard	Alluvial deposit with interbeds of clay, sand, gravel, and pebbles Green/grey clay with reddish/brown mottling	Pooraka Formation		Aquitard	Alluvial deposit with interbeds of clay, sand, gravel, and pebbles
						Keswick Clay			Green/grey clay with reddish/brown mottling
		Hindmarsh Clay		Aquitard Q1 to Q3 Aquifers	Mainly clay aquitard with discrete laterally discontinuous interbedded sandy aquifers.	Hindmarsh Clay		Aquitard Q1 to Q6 Aquifers	Mainly clay aquitard with discrete laterally discontinuous interbedded sandy aquifers.
	Pliocene?	Carisbrooke Sand		Q4 Aquifer	Confined sandy aquifer, most significant along eastern margin of NAP. Typically comprises thick (10 m) shell layer at base. Direct hydraulic connection with PWF (T1 and T2 Aquifers) north of Gawler River.	Carisbrooke Sand		T1 Aquifer	Confined sandy aquifer medium- to fine- grained calcareous **sand** with some ferruginous and possibly some inter-bedded silt layers
TERTIARY	Pliocene	Hallett Cove /Dry Creek Sand		T1 Aquifer: T1a Aquifer	Confined sandy aquifer thickening to the south-west	Hallett Cove /Dry Creek Sand		T1 Aquifer	Shelly dark grey to brownish-grey sand, silt, and clay. Highly fossiliferous sandstone. Occurs over whole area west of Para Fault in a restricted area between Brown Hill Creek and the coast
		Croydon Facies		T1 Aquifer: Semi confining bed	Fossiliferous sand and silt, glauconitic. Thin shelly and sandstone interbeds occur over whole area west of Para Faut	Croydon Facies		Semi confining bed	Fossiliferous sand and silt, glauconitic. Thin shelly and sandstone interbeds occur over whole area west of Para Fault
	Miocene to Oligocene	Port Willunga Formation	Upper Limestone	T1 Aquifer: T1b Aquifer	Confined aquifer thickening to the south and south west	Port Willunga Formation	Upper Limestone	T1 Aquifer	Yellow fossiliferous sand, limestone grading to white hard limestone. Occurs over area west of Para Fault and west of Sturt River as a thin strip along the coast
			Munno Para Clay Member	Confining bed (Absent north of the Gawler River) Dark grey, stiff, calcareous clay. Comprises beds of clay separated by two bands of white to grey limestone.			Munno Para Clay Member	Confining bed limited to western areas. Dark grey, stiff, calcareous clay. Comprises beds of clay separated by two bands of white to grey limestone	
			Lower Limestone	T2 Aquifer	Thick confined aquifer with 3 facies variants mainly sandy at the base, thinning in north and north east of NAP where it is undifferentiated from T1 and in direct hydraulic connection with Q4 Aquifer.		Lower Limestone	T2 Aquifer	Thick confined aquifer with 3 facies variants consists of coarse **sands** and gravels bound with limestone with varying lignitic content
			Ruwarung Member	T2 Aquifer: Confining bed	Pale grey glauconitic rich marl/clay, pyritic		Ruwarung Member	T2 Aquifer: Confining bed	Pale grey glauconitic rich marl/clay, pyritic
			Aldinga Member	T2 Aquifer	Aquitard Clay Unit Sandy Unit T3 Aquifer		Aldinga Member	T2 Aquifer	Clay, stiff, grey to dark grey, carbonaceous. Glauconitic, pyritic. Shell remains grading to sand and silt

	Eocene	Chinaman Gully Formation	Confining bed	Mainly confining bed with minor thin sandy aquifer	Chinaman Gully Formation	Confining bed	Grey to black carbonaceous silt and clay. Highly pyritic, lignitic
		Blanche Point Formation		Grey, friable shelly siltstone grading to alternating hard and soft siltstone bands (cherty). Glauconitic, large *Turritella* shells	Blanche Point Formation	Confining bed	Grey, friable shelly siltstone grading to alternating hard and soft siltstone bands (cherty). Glauconitic, large *Turritella* shells.
		Tortachilla Limestone	T3 Aquifer	Thin confined aquifer	Tortachilla Limestone	T3 Aquifer	Thin confined fine sandy aquifer thickest in north east areas
		South Maslin Sand			South Maslin Sand		Dark grey carbonaceous sand and silt. Pyritic and glauconitic
		Clinton Formation	Confining bed (not laterally extensive across NAP)		Clinton Formation	Confining bed	Pale grey, white clay, sandy. Pyritic. Highly carbonaceous, lignite layers
		North Maslin Sand	T4 Aquifer	Confined sandy aquifer.	North Maslin Sand	T4 Aquifer	Thin confined sandy aquifer Pale grey, yellow and brown, clayey, silty, and gravely pyritic sand

Within the Adelaide Plains Sub-basin, the T1 aquifer can be subdivided into two sub-aquifers, which, whilst often in direct hydraulic connection, have different lithological properties. The T1a sub-aquifer is a sandy unit and requires well screening, whilst the T1b sub-aquifer occurs as semi-consolidated or consolidated limestone. The T1b sub-aquifer is preferred by many groundwater users because of typically higher well yields and the ability to complete the well with an open-hole production interval (Hodgkin, 2004).

The Golden Grove Embayment is defined as that portion of the St Vincent Basin bounded by the Eden-Burnside and Para faults. The most recent detailed hydrogeological studies of the embayment have been by Gerges (1996 and 1999). Tertiary and Quaternary sediments within the Golden Grove Embayment thicken to the southwest and reach over 400 m near the coast. However, they are typically only 10 to100 m thick north and east of the Adelaide CBD and between 100 to 250 m thick south of the CBD.

The hydrostratigraphy of the Golden Grove Embayment is complicated because of erosional and depositional boundaries, lateral facies changes and faulting. Consequently, multiple geological formations can be juxtaposed together and form effectively single aquifer systems or result in aquifers laterally abutting against aquitards.

3.1.2 Structural Controls

The Para Fault is aligned along a northeast/southwest axis and bisects the West Torrens Catchment. The Para Fault splinters as it crosses the eastern catchment boundary at the northern extent of the Keswick Rail Terminal (Figure 4). The southern splinter extends offshore south of Glenelg. The northern splinter runs along the approximate line of the Adelaide Airport southern boundary and extends offshore north of Glenelg.

Depending on the nature of the bounding faults, the T1 aquifer in the Golden Grove Embayment can be hydraulically connected to Quaternary or Tertiary aquifers west of the Para Fault.

The major fault systems are transmissive in many areas, permitting significant lateral groundwater throughflow from fractured rock aquifers in the Adelaide Hills westwards into the adjoining Tertiary aquifers (Gerges, 1996). Over the western portion of the West Torrens Catchment there is an approximate offset of 25 to 30 m on the downthrown Adelaide sub-basin side of the Para Fault. Closer to the Adelaide CBD the offset is some 70 m on downthrown Adelaide Plains Sub-basin side of the Para Fault (Gerges 2006). Generally, through the Adelaide CBD on the upthrown side of the Para Fault the T1 aquifer is absent and the Port Willunga Formation that hosts the second Tertiary (T2) aquifer throughout the Adelaide Plains Sub-basin is intersected at depths of less than 10 m below ground level.

3.2 HYDROGEOLOGICAL SETTING AND AQUIFER DESCRIPTIONS

3.2.1 Quaternary Aquifers – Hindmarsh Clay

The mottled reddish brown and yellow Hindmarsh Clay is the major Quaternary sedimentary unit across the Adelaide Plains Sub-basin and Golden Grove Embayment.

In coastal margins, thin unconfined aquifers or perched watertable aquifers can occur within quartz-sand sediments of the Semaphore Sands (dune sands) or shelly sands of the St Kilda Formation. These aquifers have been predominantly accessed by small-scale stock and domestic users in areas of low salinity. The aquifers beneath the dunes can be in direct connection with the sea and consequently at risk of seawater intrusion.

In the western metropolitan area, the Hindmarsh Clay consists of mottled clays and silts of fluviatile and estuarine origin and may host up to six thin confined aquifers. The continuity and extent of individual aquifers is uncertain, but it is considered that they represent the now buried drainage lines associated with the creeks and rivers that meandered across the plains emanating from the Mount Lofty Ranges (WGA 2018) .

These aquifers are designated Q1 to Q6 in order of increasing depth (Gerges, 1996). Within the Hindmarsh Clay sequence, the aquifers occur as interbeds of sand and gravel that range in thickness from 1 to18 m but are rarely much thicker than two metres. Note that not all six Quaternary aquifers are intersected in drillholes at all locations across the Adelaide Plains sub-basin and Golden Grove Embayment.

The most transmissive sections of the Q1 aquifer and areas of lower salinity are usually located adjacent to major surface drainage lines or beneath the sand dunes. Away from the present-day drainage lines the salinity in the Q1 aquifer typically exceeds 2,000 milligrams per litre (mg/L). The Hindmarsh Clay generally forms a confining layer to the underlying Quaternary Carisbrooke Sand aquifer (Martin and Hodgkin, 2005).

Reported airlift yields for wells completed within the Quaternary aquifers range from 0.1 litres per second (L/s) up to 20 L/s. Of the 695 potentially active domestic wells (refer section 3.3.2) that take groundwater from the Quaternary aquifers, 434 have a reported yield. The average reported airlift yield for the 434 wells is 2 L/s. Four percent of the wells have a reported yield greater than 10 L/s.

Of the 695 potentially active domestic wells completed in the Quaternary aquifers 639 have a recorded salinity. The reported salinity ranges from 300 (mg/L) to in excess of 5,000 mg/L. Six percent of the wells have a reported groundwater salinity greater than 5,000 mg/L. Care needs to be taken when interpreting salinity information as the information will be biased towards areas of lower groundwater salinity.

The Carisbrooke Sand Formation (Q4 aquifer across the Adelaide Plains Sub-basin) is up to 20 m thick in some places but more typically around 10 m thick. This unit is not well differentiated in the West Torrens Catchment study area and is lumped into the group of Quaternary Aquifers.

Wells within the Carisbrooke Sand is aquifer are typically low yielding (>5 L/s) and require screening and extensive development to minimise the production of fine sands. There are no reported aquifer hydraulic properties available for this unit.

Zulfic (2002) and Zulfic, *et. al*., (2008) identify the Carisbrooke Sand to be present over large areas of the Adelaide Plains Sub-basin and suggest that in some areas the Carisbrooke Sand is hydraulically connected to the overlying Quaternary aquifers, however; there is no conclusive evidence to support this hypothesis and further work is required.

Salinity of the groundwater in the Carisbrooke Sand is highly variable and reported to be in the range of 800 mg/L to greater than 7,500 mg/L (Gerges 1996, 2006, Hodgkin, 2004 and Zulfic, *et. al*., 2008).

Groundwater flow in the Quaternary aquifers is not well understood due to the poor definition of these aquifer units spatially and vertically throughout the Hindmarsh Clay. The general hypothesis is that flow in the upper Q1 aquifer across the plains occurs towards the present-day drainage lines. In the coastal areas discharge from the perched aquifers within the dunes occurs as seepage along the foreshore. Flow in the deeper confined Quaternary aquifers is thought to occur from east to west.

3.2.2 Dry Creek – Hallett Cove Sand and Upper Port Willunga Formation (T1/T1a/T1b Aquifer)

Within the Golden Grove Embayment and Adelaide Plains Sub-basin, the T1 aquifer is defined as the shallowest Tertiary aquifer system present. Within the embayment, the T1 aquifer can consist of any one or several formations of the entire Tertiary sequence comprising the Hallett Cove Sand, Dry Creek Sand and Port Willunga Formation.

The Hallett Cove Sandstone and Dry Creek Sand are of shallow marine origin and comprise shelly, dark grey to brown sand, silt, and clay, often highly fossiliferous (Gerges, 1996) have a combined thickness of 30 to 50 m. Where the Dry Creek and Hallett Cove Sand are separated from the underlying Upper Port Willunga Formation they are collectively referred to as the T1a aquifer.

The Upper Port Willunga Formation is a confined aquifer consisting of sand and limestone and where the unit is separated from the Hallett Cove Sandstone and Dry Creek Sand by the Croydon facies it is referred to as the T1b Aquifer (Gerges 1996 and 2006).

Elsewhere, if the Croydon facies is absent this unit, inclusive of the Hallett Cove Sandstone and Dry Creek Sand, is referred to as the T1 aquifer. The T1 aquifer, inclusive of the Hallett Cove Sandstone and Dry Creek Sand, has a thickness of 30 to 50 m.

Across the West Torrens Catchment there are 141 wells reported in the WaterConnect database to be completed in the T1 aquifer. 109 of the wells have a reported airlift yield which ranges from 0.15 L/s up to 30 L/s with an average of 10 L/s.

The WaterConnect database contains records on groundwater salinity for 121 of the 141 wells reported to be completed in the T1 aquifer in the West Torrens Catchment. The reported salinity ranges from 400 mg/L up to 3,500 mg/L. It should be noted that the salinity results are likely to be biased towards the lower salinity groundwater areas as the low salinity groundwater has been sought to meet large scale irrigation or industrial demands.

Groundwater flow in the T1 aquifer west of the Para Fault in the Adelaide Plains Sub-basin occurs from east to west. Flow in the Golden Grove Embayment east of the Para Fault is more complex. From the CBD the apparent direction of groundwater flow occurs in a south-westerly direction before trending in a more east to west direction where the Tertiary sediments are more closely aligned each side of the Para Fault.

At some distance offshore, in the Gulf St Vincent, the Tertiary aquifers are thought to crop out or be overlain by a thin layer of marine sediments allowing discharge of groundwater through the sea bed, or conversely, infiltration of seawater from/to the Tertiary aquifers. Little information exists to identify the exact distance offshore, a large-scale drilling investigation program or offshore geophysics would be required to address this data gap.

3.2.3 Munno Para Clay Confining Bed

The Munno Para Clay member consists of a stiff blue-grey calcareous clay and contains two thin (<30 cm) interbeds of white to grey limestone. It is typically 5 to 10 m thick and acts as a highly effective regional confining bed across most of the Adelaide Plains sub-Basin and Golden Grove Embayment separating the overlying T1 aquifer from the underlying second Tertiary (T2) aquifer. Bresciani *et. al.* (2015) estimate the vertical hydraulic conductivity of the Munno Para Clay to be $<3.4x10^{-6}$ m/day. Gerges (2006) estimates the vertical hydraulic conductivity of the Munno Para Clay across the NAP to range from $1.2x10^{-6}$ to $2.6 x10^{-7}$ m/d. DWLBC (2008) reports vertical hydraulic values for the Munno Para Clay between $1.7x10^{-5}$ to $2.6x10^{-7}$ m/d. Typically, the vertical hydraulic conductivity is a 10th of the horizontal conductivity.

3.2.4 Lower Port Willunga Formation (Second Tertiary (T2) Aquifer)

Throughout most of the Adelaide Plains Sub-basin area and Golden Grove Embayment, the T2 aquifer consists of well-cemented limestone of the lower Port Willunga Formation which underlies the Munno Para Clay. Martin and Gerges (1997), Martin (1999 and 2005) and Gerges (2001) recognise three facies subunits within the T2 aquifer:

1. T2a Sub-Aquifer: mostly pale-grey to white well cemented limestone / sandstone.
2. T2b Sub-Aquifer: a pale yellow to orange brown limestone / sandstone, friable to moderately cemented and occasionally interbedded with highly calcareous fossiliferous sand; and
3. T2c Sub-Aquifer: mainly interbedded sand (possibly the Aldinga Member) and very friable limestone with occasional silt and clay.

The basal unit of the T2 aquifer comprises the Ruwarung and Aldinga Members; however, only a few drillholes intersect these units. The Ruwarung Member is a glauconite rich fossiliferous marl containing chert nodules. It is not well differentiated and currently most mapping incorporates this sub-unit as part of the overall T2 aquifer; however, it has the properties of a regional confining bed (WGA, 2018).

The combined thickness of the main three sub-aquifer facies units identified by Martin and Gerges (1997) Martin (1999 and 2005) and Gerges (2001) is 30 to 40 m.

In the West Torrens catchment study area only 18 wells are reported to be completed in the T2 aquifer in the WaterConnect database. Five of the 18 wells are used for managed aquifer recharge (MAR). Reported groundwater salinity in the T2 aquifer ranges between 450 mg/L to 5,580 mg/L. Fourteen of the 18 wells have a reported airlift yield and the reported range spans 1.3 to 30 L/s. The average yield for the 14 wells is 15 L/s.

Groundwater flow in the T2 aquifer west of the Para Fault in the Adelaide Plains Sub-basin occurs from the recharge area in the Mount Lofty Ranges to the coast (east to west). Groundwater flow east of the Para Fault in the Golden Grove Embayment is more complex. From the CBD the apparent direction of groundwater flow occurs in a south-westerly direction before trending in a more east to west direction where the Tertiary sediments align along the Para Fault offset.

3.2.5 Maslin Sands (Third Tertiary (T3/T4) Aquifer)

The Blanche Point Formation acts as an aquitard between the T2 aquifer and the underlying South (T3 aquifer) and North Maslin Sands (T4 aquifer). Little is known about these aquifers or their lateral extent as very few wells penetrate these aquifers across the Adelaide Plains sub-basin. No wells penetrate these units within the West Torrens Catchment study area. Although only a limited number of wells penetrate these units across the Adelaide Plains Sun-basin they are described as predominantly fine-grained marine sediments with a combined thickness that ranges from about 50 to 150 m.

Both the T3 and T4 aquifers are reported to be hyper saline with recorded salinity up to 80,000 mg/L in the deeper T4 aquifer. Yields, where reported, are typically less than 10 L/s and flow is inferred to be from east to west however there are insufficient wells to construct a reliable potentiometric surface to confirm flow directions.

4 GROUNDWATER DEMAND

4.1 GROUNDWATER WELLS

Publicly available groundwater information from the Department for Environment and Water (DEW) WaterConnect database was sourced and interrogated. The downloaded dataset returned 1702 wells constructed within the West Torrens Catchment boundary. It should be noted that the database may not capture all the wells across the study area. Often domestic wells into the shallow aquifer are installed without being captured in the database as landowners are unaware that a licence to construct a bore is required. A summary of the well information is presented in Table 3.

Table 3: Groundwater Wells by Target Aquifer and Purpose for Construction in the West Torrens Catchment (*source: WaterConnect September 2020*).

Aquifer	Purpose	Total No of wells.	Number Abandoned (ABD) Wells	Number Backfilled (BKF) wells	Total Potentially "Active" Wells
Quaternary Wells	UNK	405	7	45	372
	DOM/IRR	429	8	4	417
	MON/OBS	134	2	1	131
	INV/ENV	473	0	33	440
	DRN	63	1	0	62
	ENG	102			102
Total Number of Wells Completed in Quaternary Aquifer		**1606**	**18**	**64**	**755**
Tertiary T1 Wells	UNK	79	2	11	67
	DOM/IRR	9	0	2	9
	MON/OBS	25	5	10	23
	IND	17	0	3	16
	DRN	2	0	0	2
	GTH	5	0	5	0
	MAR	2	0	0	2
Total Number of Wells Completed in The Tertiary (T1) Aquifer		**139**	**6**	**24**	**119**
Tertiary T2 Wells	UNK	5	0	1	4
	MON/OBS	3	1	0	3
	IND	3	1	0	3

	INV	2	0	0	2
	MAR	5	0	0	5
Total Number of Wells Completed in The Tertiary (T2) Aquifer		**18**	**2**	**1**	**17**

Key: UNK = Unknown; DOM/IRR = Domestic/Irrigation; MON/OBS = Monitoring / Observation
INV/ENV = Investigation / Environmental; DRN = Drain; ENG = Engineering
IND = Industrial; GTH = Geothermal; MAR = Managed Aquifer Recharge

4.1.1 Quaternary Aquifers

To determine the number of potentially operational wells to support estimating the groundwater use in the study area the data was filtered based on well purpose. This approach may still overestimate the number of "active" wells.

The Quaternary aquifers are not differentiated in the study area and the results identify 1606 of the 1763 wells are completed in one of the Quaternary aquifers (Q1 to Q6). The information in **Table 3** is summarised as follows:

- Of the 1606 wells 405 do not have a purpose assigned (Unknown (UKN)) but for the purpose of this evaluation are assumed to be active unless they are identified in the database as abandoned (ABD) – 7 wells or backfilled (BKF) - 45 wells

- 429 of the wells are identified in the database to be constructed for the purpose of Domestic (DOM) or Irrigation (IRR) and considered to be active unless they are identified in the database as abandoned (ABD) 8 wells or Backfilled (BKF) - 4 wells

Without a detailed field survey to assess the state and condition of all the wells it is assumed that there are a total of 770 wells that are potentially operational and have the capacity to take groundwater from the Quaternary aquifers.

- 134 of the wells are identified in the database for the purpose of Monitoring (MON) or Observation (OBS) and 437 are identified to be Investigation (INV) or Environmental (ENV) wells.

These four descriptions for the well purpose are used to describe wells constructed to complete detailed site investigation surveys for environmental purposes. These wells are usually only active for the duration of the site investigations which may be a few months or up to less than 5 years. Generally, they are used to monitor groundwater levels or to collect samples for water quality analysis for the duration of the site investigation study.

63 wells have been constructed for the purpose of drainage (DRN) and groundwater is not actively taken from these wells.

The database records 102 wells have been constructed for the purpose of engineering (ENG). Such wells are usually constructed to inform site geotechnical investigations for buildings, footings, or roads. Like the INV/ENV wells these types of wells only have a life for the duration of the project (usually months).

Under the *Landscape South Australia Act* (2019), formerly the *Natural Resources Management Act* (2004) wells should be backfilled by a licenced well driller under Permit. The permit along with a drillers Schedule 8 form would then be returned to the department and the records updated. Unfortunately, the process for decommissioning wells is not often followed and wells are backfilled without Permits.

4.1.2 Tertiary Aquifers

A total of 139 wells are identified in the database to be completed in the T1 aquifer in the study area. The MON/OBS wells may be associated with Environmental site assessments or they may be former Engineering and Water Supply Department (now SA Water) wells that were used up until the late 1950s as part of Adelaide's Water Supply. After 1960 these wells were converted to groundwater level or salinity monitoring wells. At one time 33 wells completed in the T1 aquifer were used as part of the T1 aquifer groundwater monitoring network. Currently only 9 wells are actively monitored to support resource condition assessments.

107 wells are assumed to be actively taking water from the T1 aquifer and include wells with the purpose identified to be IND, IRR, UNK, and MAR (refer Table 3). At present there are no licenced allocations for taking water assigned to these T1 wells and use is not metered.

In the study area 18 wells are reported to be completed in the T2 aquifer (refer Table 3). Fewer wells are completed in the T2 aquifer due to the greater depth and increased cost of drilling. In general, the quality of water in the T1 and the yields meet the required demands of users and therefore there is no requirement to drill deeper.

Table 4: Groundwater Information Summary (*source: WaterConnect September 2020*)

Aquifer	Salinity Range, Total Dissolved Salts (mg/L)	Standing Water Level (m bgl)	Airlift Yield (L/s)
Quaternary (Q1 to Q6)	Of the 789 potentially active wells completed in the Quaternary aquifer 690 have a recorded salinity value: • 131 record a salinity <1200 mg/L • 452 record a salinity <3,000 mg/L • 107 record a salinity >3,000 mg/l	Maximum drilled depth <5 m the average SWL is 2.1 m bgl. Maximum drilled depth <10 m the average SWL is 4.0 m bgl. Maximum drilled depth <20 m the average SWL is 7.3 m bgl. Maximum drilled depth <50 m the average SWL is 9.0 m bgl. >50 m Maximum drilled depth the average SWL is 10.8 m bgl.	460 wells return a result for airlift yield. The average yield is 2 L/s
T1 Aquifer	Of the 139 wells reported to be completed in the T1 aquifer 121 have a reported salinity result. • 104 record a salinity value less than 1,200 mg/L	The average SWL for the T1 aquifer is 12.9 m bgl.	109 wells have a reported result for the airlift yield. The average yield is 10.6 L/s.

	• 35 have a recorded salinity <3,000 mg/L		
T2 Aquifer	Of the 18 wells reported to be completed in the T2 aquifer 17 have a reported salinity result. • 15 record a salinity value less than 1,200 mg/L • 1 have a recorded salinity <3,000 mg/L • 1 has a recorded salinity >3,000 mg/L.		14 wells have a reported result for the airlift yield. The average yield is 14.5 L/s

Using the filtered information sourced from the WaterConnect database and presented in **Table 3** and **Table 4**, **Figure 5** through **Figure 13** have been prepared to show the spatial distribution of groundwater wells, groundwater quality and yield within in the study area.

4.2 ESTIMATED GROUNDWATER USE

Groundwater use is not currently metered in the West Torrens Catchment. An estimation of groundwater use by aquifer has been made using typical volumes from areas where use is metered in South Australia. Groundwater use is presented in **Table 5** and has been estimated for the Quaternary aquifers based on the potential number of active wells identified in **Table 3**.

The estimated used presented in Table 5 for the Quaternary aquifers assumes that on average a typical suburban house block uses 500 L/year. A salinity of 3,000 mg/L is the upper limit of tolerance for domestic use which would typically be for garden irrigation or non-contact internal house use. Therefore, wells with a reported salinity greater than 3,000 mg/L have been excluded from the calculation of use presented in Table 5.

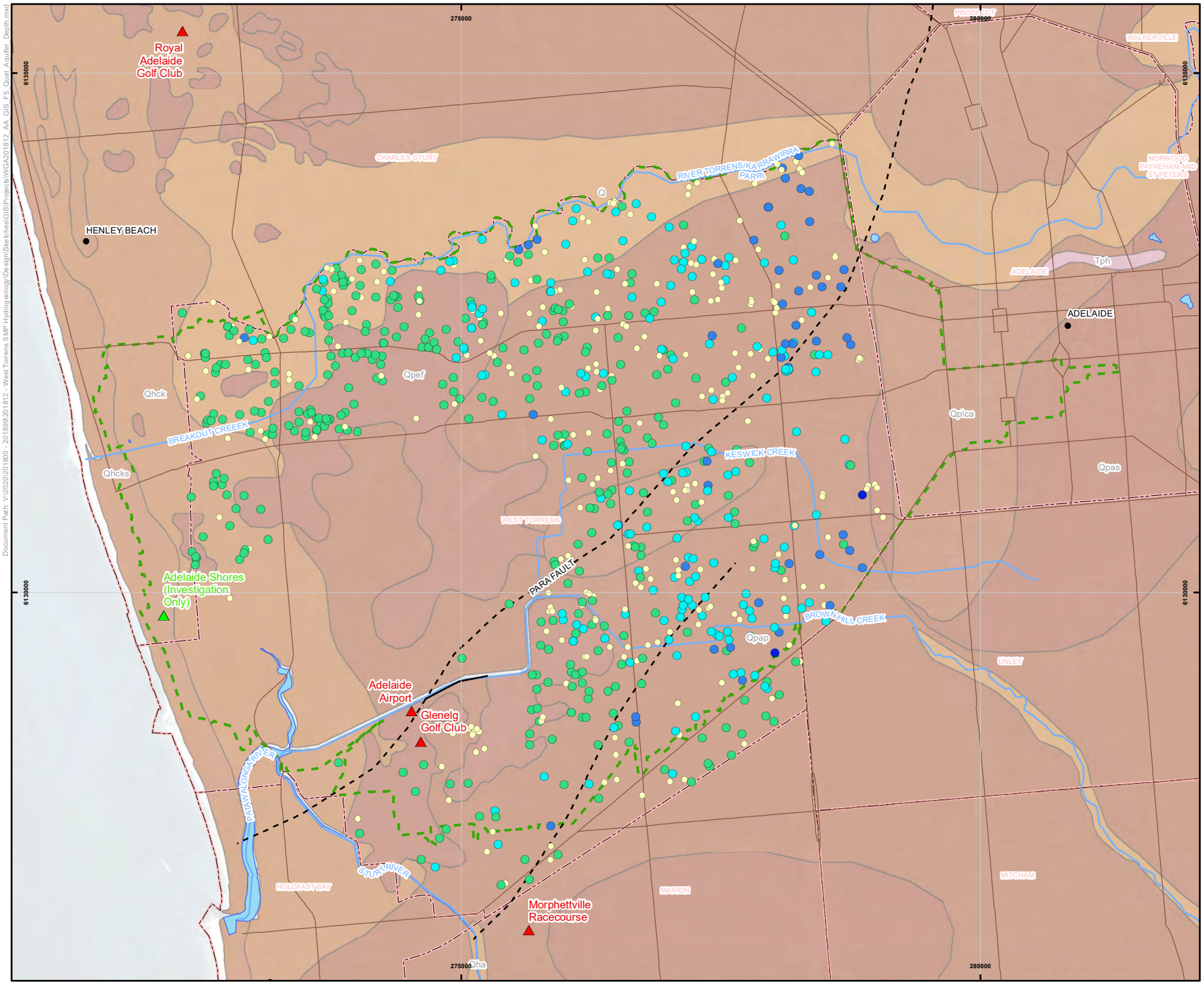
Wells completed in the T1 aquifer typically support irrigation demand for sporting ovals or schools where the demand ranges between 4 to 6 ML/year/hectare depending on the prevailing climate conditions. Most of the irrigation wells in this area are on golf courses and sporting ovals. In section 2.1 the golf courses and sporting ovals cover an estimated area of 2.68 km2 (268 ha) in the catchment. The estimated area for golf courses and sporting ovals has been used to determine the groundwater take from the T1 aquifer.

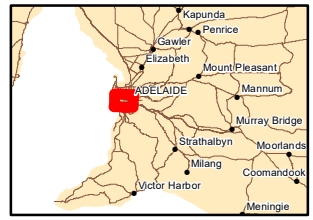
There are a reported 14 active industrial wells taking water from the T1 aquifer. In the absence of any metered data a broad estimate of use has been made based on the average yield (10 L/s) and an assumed pumping schedule of 8 hrs per day per 5 day week which equates to approximately 75 ML/well/a. The same assumptions of pumping from Industrial wells and irrigation wells completed in the T2 aquifer has been applied.

Table 5: Estimated Groundwater Use

Aquifer	Estimated Number of "Active" Taking Wells	Estimated Taking (ML)	Estimated Total Groundwater Use (ML)
Quaternary (Q1 to Q6)	583[1]	0.0005 per well	0.29
T1 Aquifer	75 IRR	5 ML/ha over 268 ha	1,340
	14 IND	75 ML/well	1,050
T2 Aquifer	5 IRR	5 ML/ha over ~10 ha	50
	3 IND	75 ML/well	225

Note: [1] 583 wells return a reported salinity result less than 3,000 mg/L. This is assumed to be the upper limit of salinity for domestic use.





LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

Standing Water Level

- Unknown
- 0 - 5
- 5 -10
- 10 - 20
- > 20

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
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Figure **5**

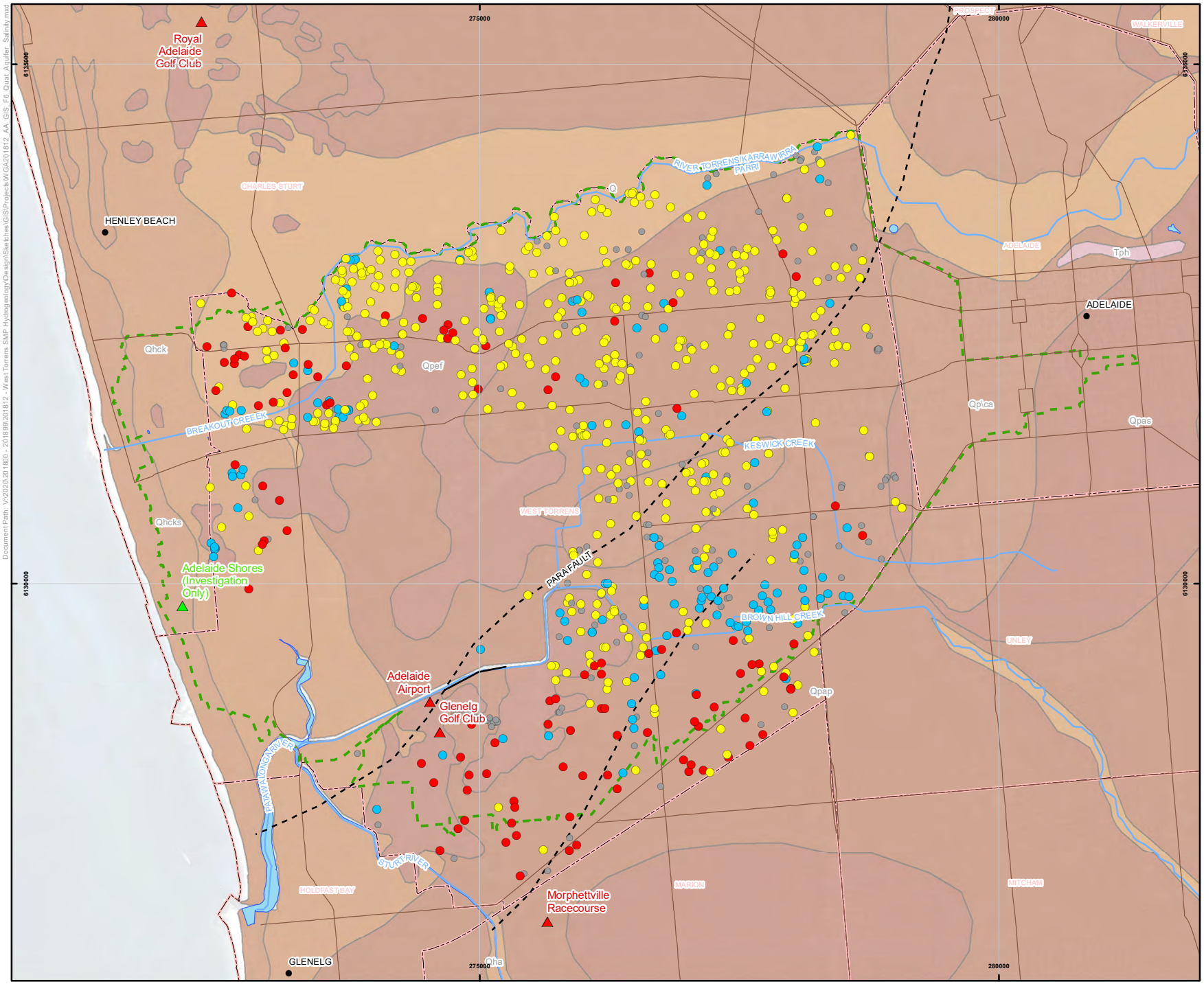
West Torrens SMP Hydrogeology

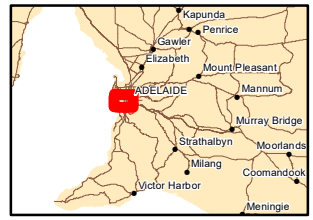
Quaternary aquifer depth to standing water level

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

TDS (mg/L)

- Unknown
- 0 - 1200
- 1200 - 3000
- > 3000

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **6**

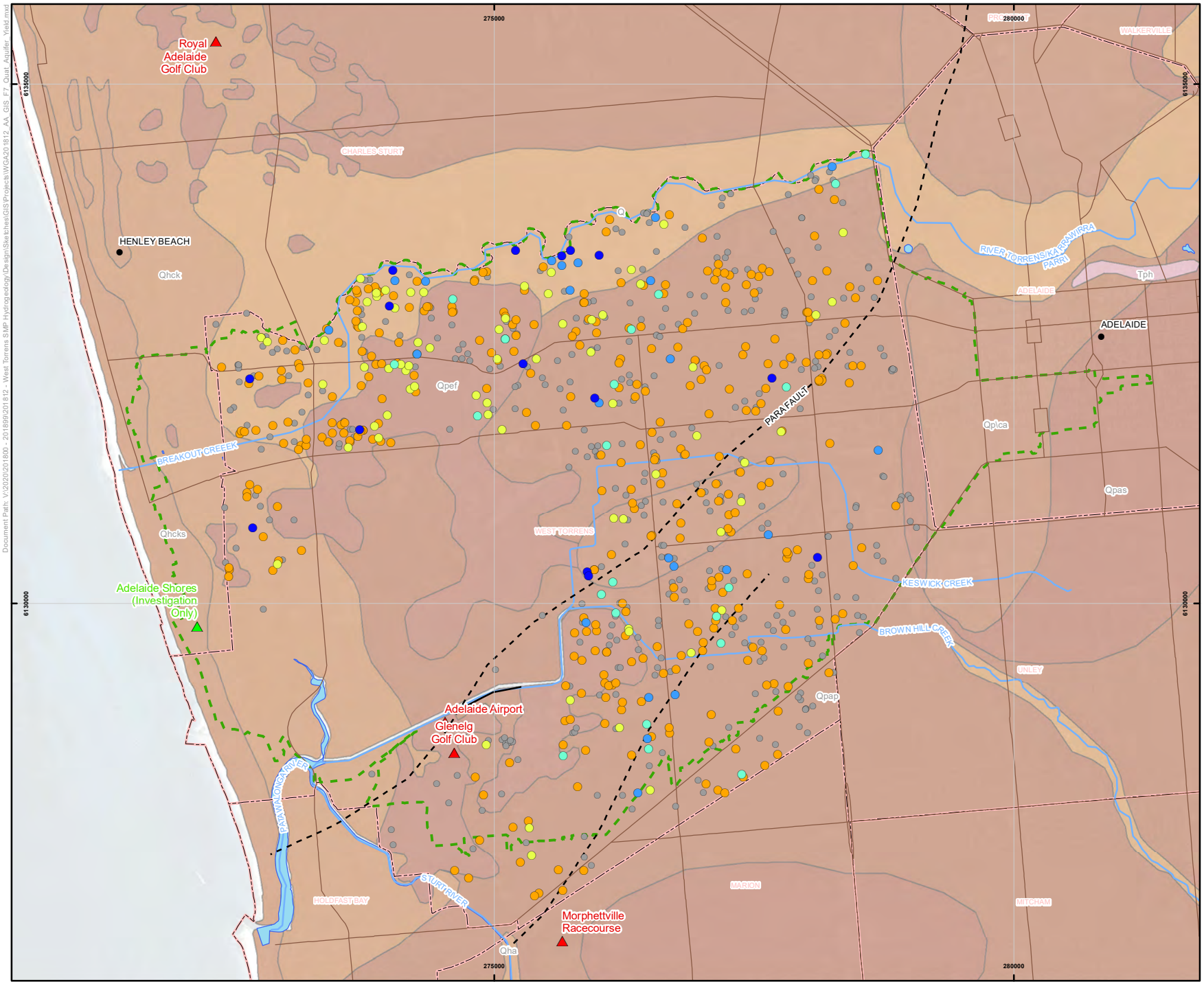
West Torrens SMP Hydrogeology

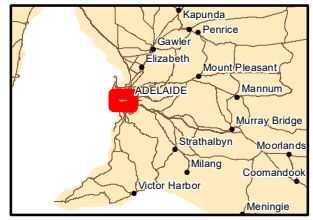
Quaternary aquifer salinity

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

Yield (L/s)

- Unknown
- 0 - 1
- 1 - 2
- 2 - 5
- 5 - 10
- > 10

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure 7

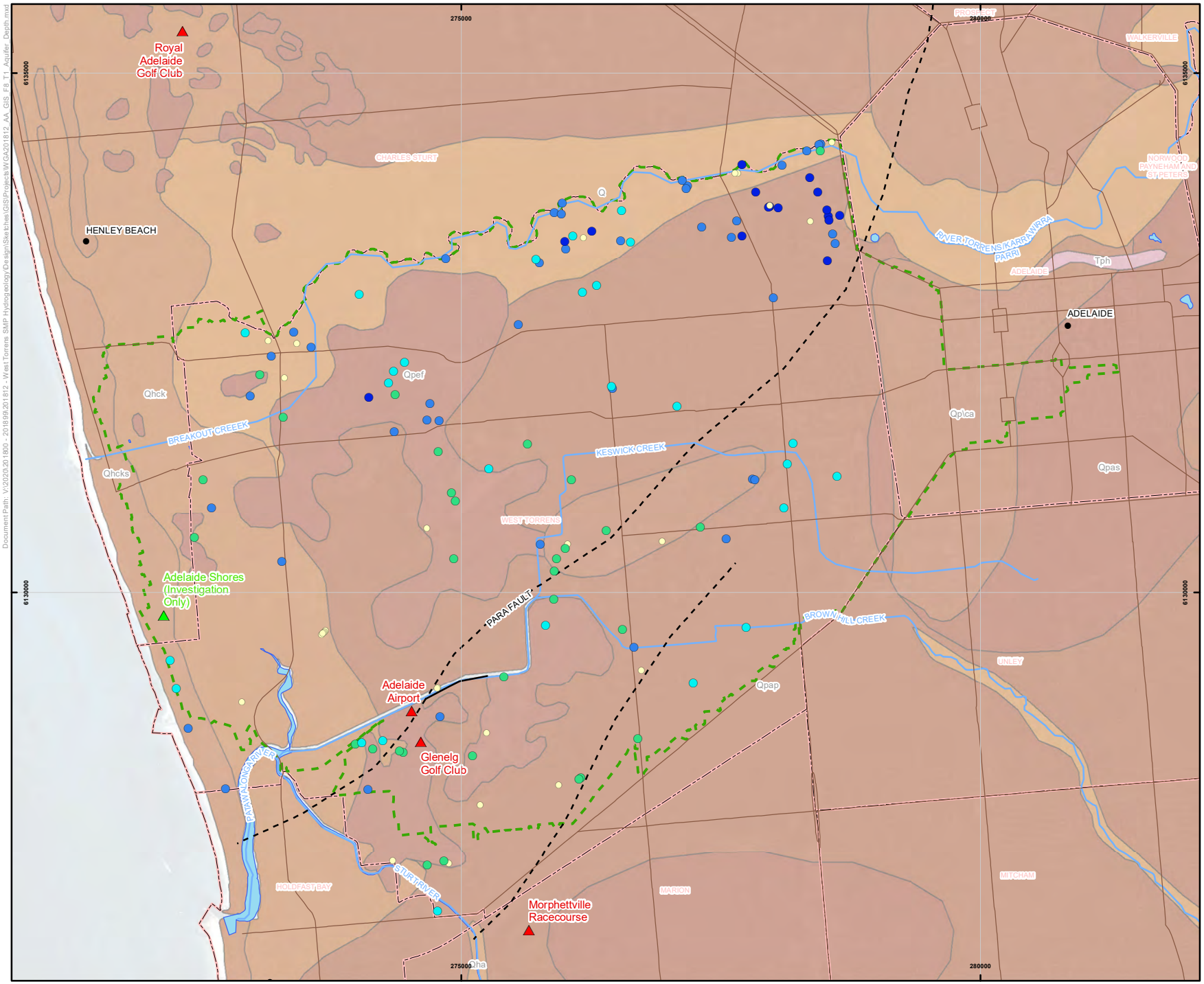
West Torrens SMP Hydrogeology

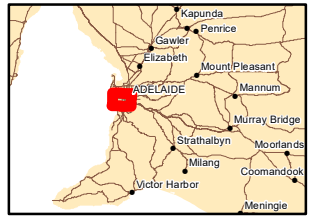
Quaternary aquifer yield

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

Standing Water Level

- Unknown
- 0 - 5
- 5 -10
- 10 - 20
- > 20

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **8**

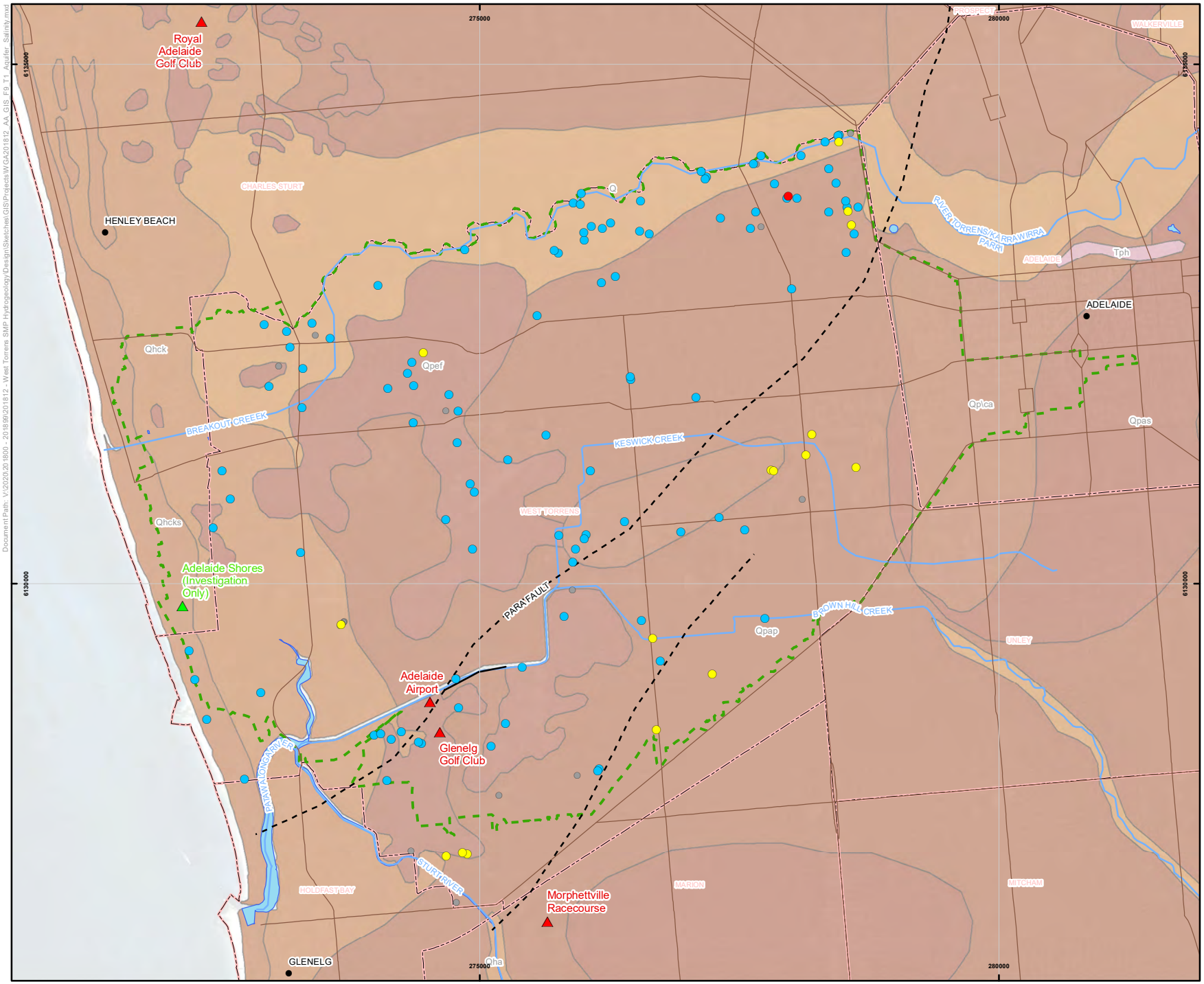
West Torrens SMP Hydrogeology

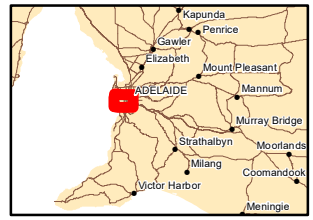
T1 aquifer depth to standing water level

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

TDS (mg/L)

- Unknown
- 0 - 1200
- 1200 - 3000
- > 3000

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **9**

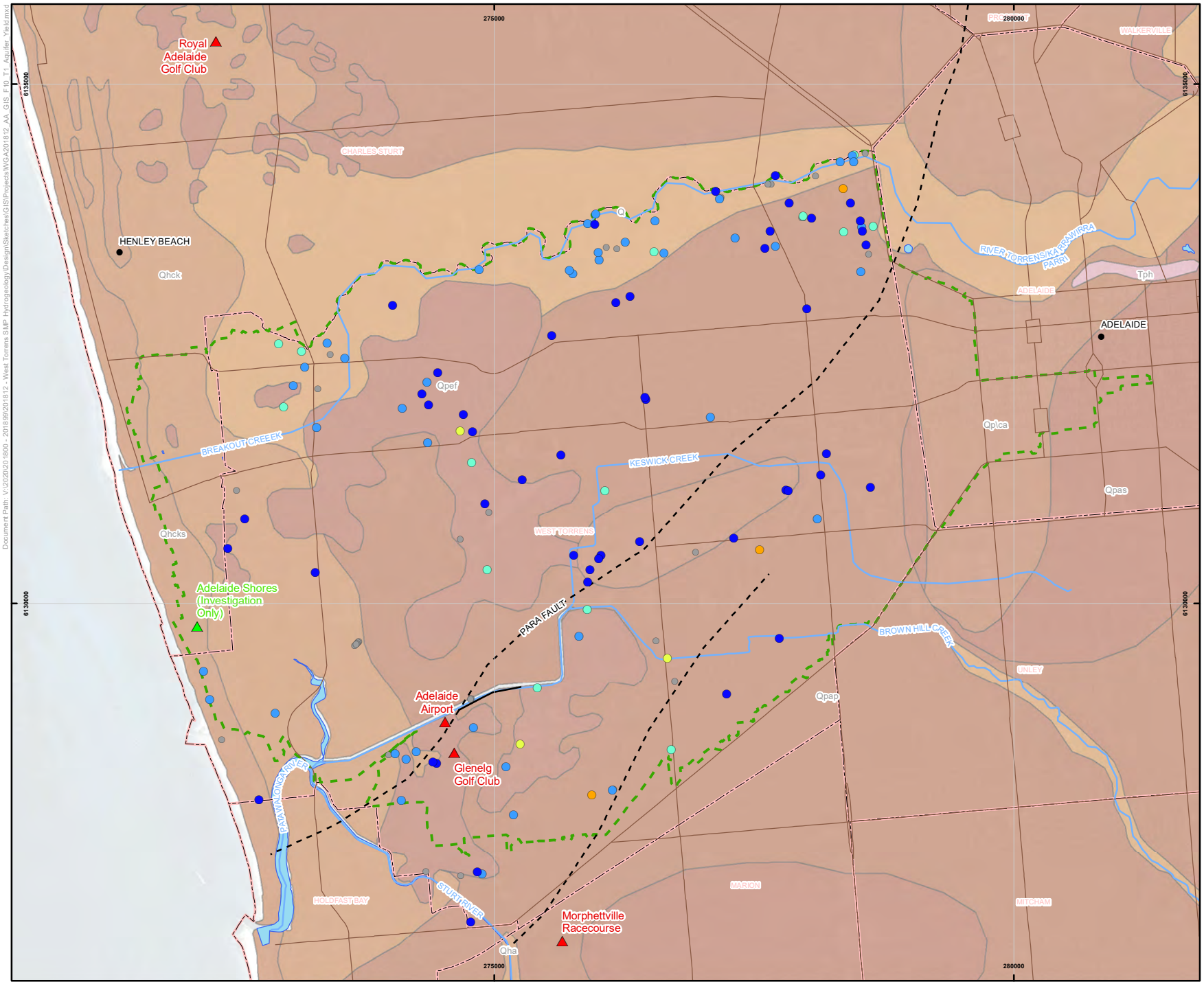
West Torrens SMP Hydrogeology

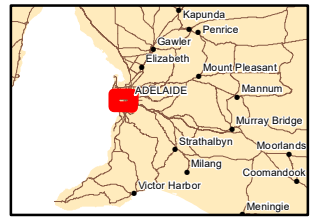
T1 aquifer salinity

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q, Qhcks, Qpas, Qha, Qp\ca, Qpef, Qhck, Qpap, Tph

Yield (L/s)

Unknown, 0 - 1, 1 - 2, 2 - 5, 5 - 10, > 10

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **10**

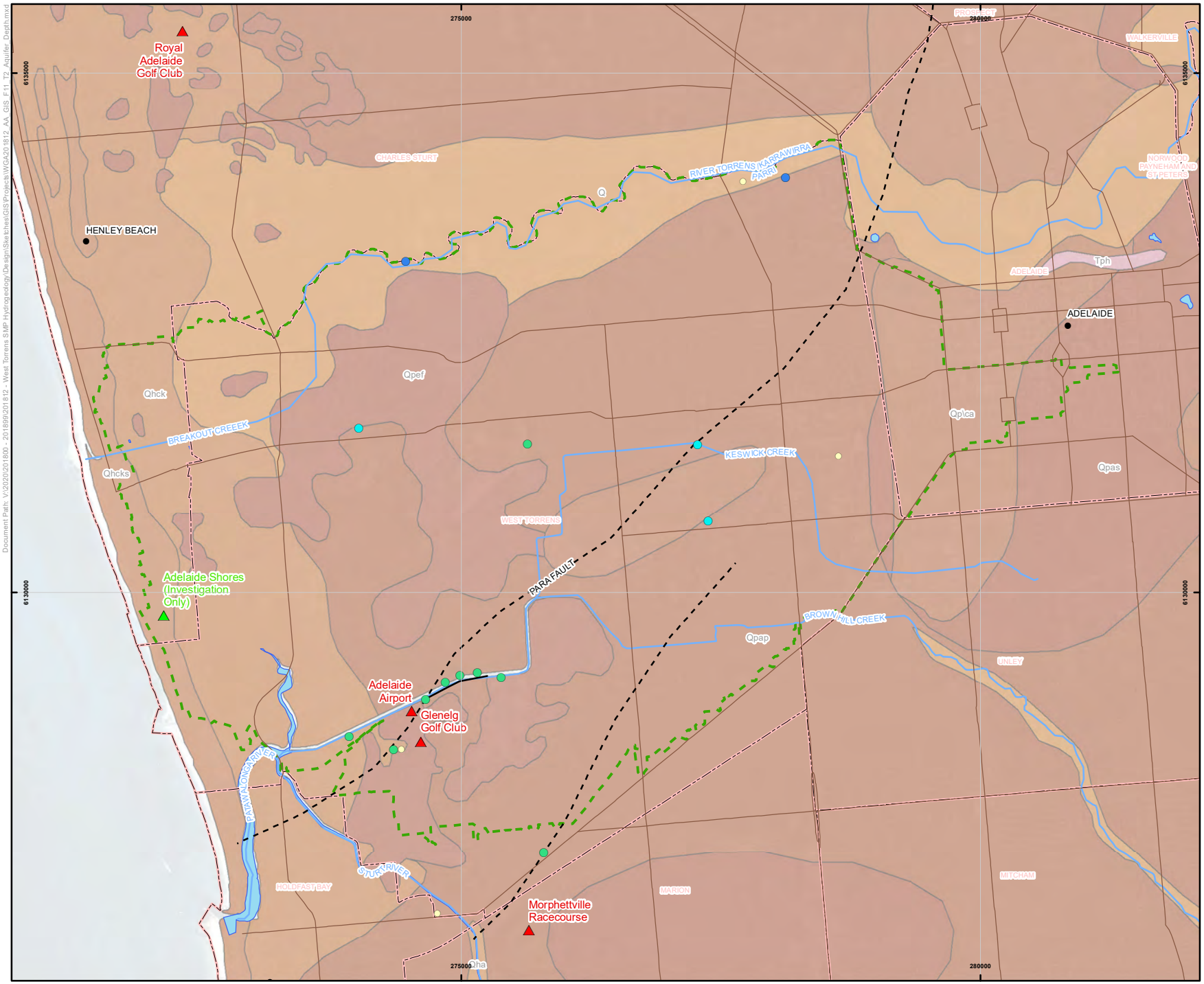
West Torrens SMP Hydrogeology

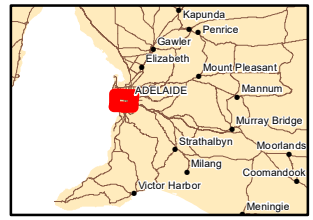
T1 aquifer yield

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

Standing Water Level

- Unknown
- 0 - 5
- 5 -10
- 10 - 20
- > 20

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **11**

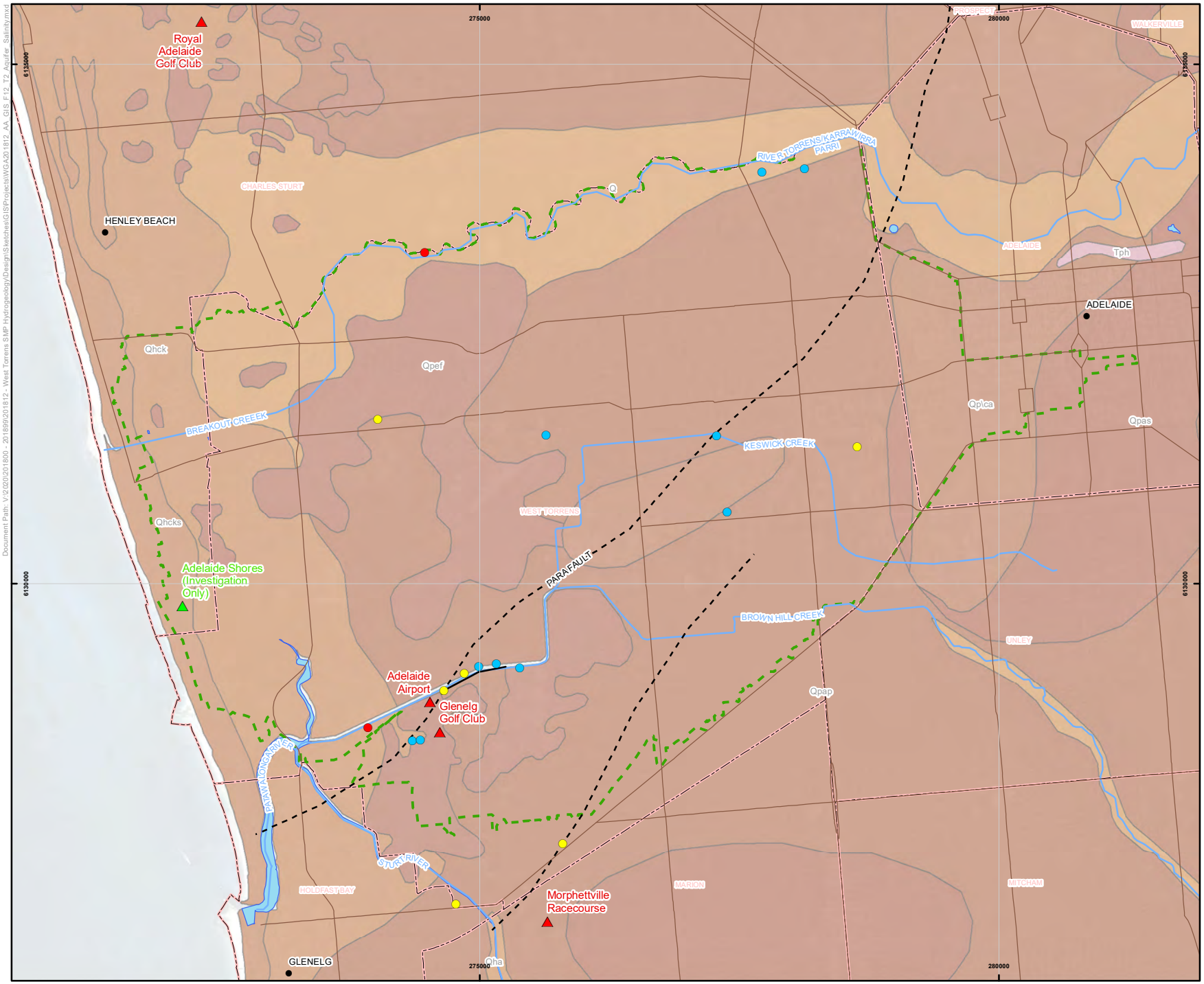
West Torrens SMP Hydrogeology

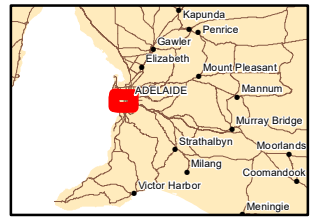
T2 aquifer depth to standing water level

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q	Qhcks	Qpas
Qha	Qp\ca	Qpef
Qhck	Qpap	Tph

TDS (mg/L)

- Unknown
- 0 - 1200
- 1200 - 3000
- > 3000

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **12**

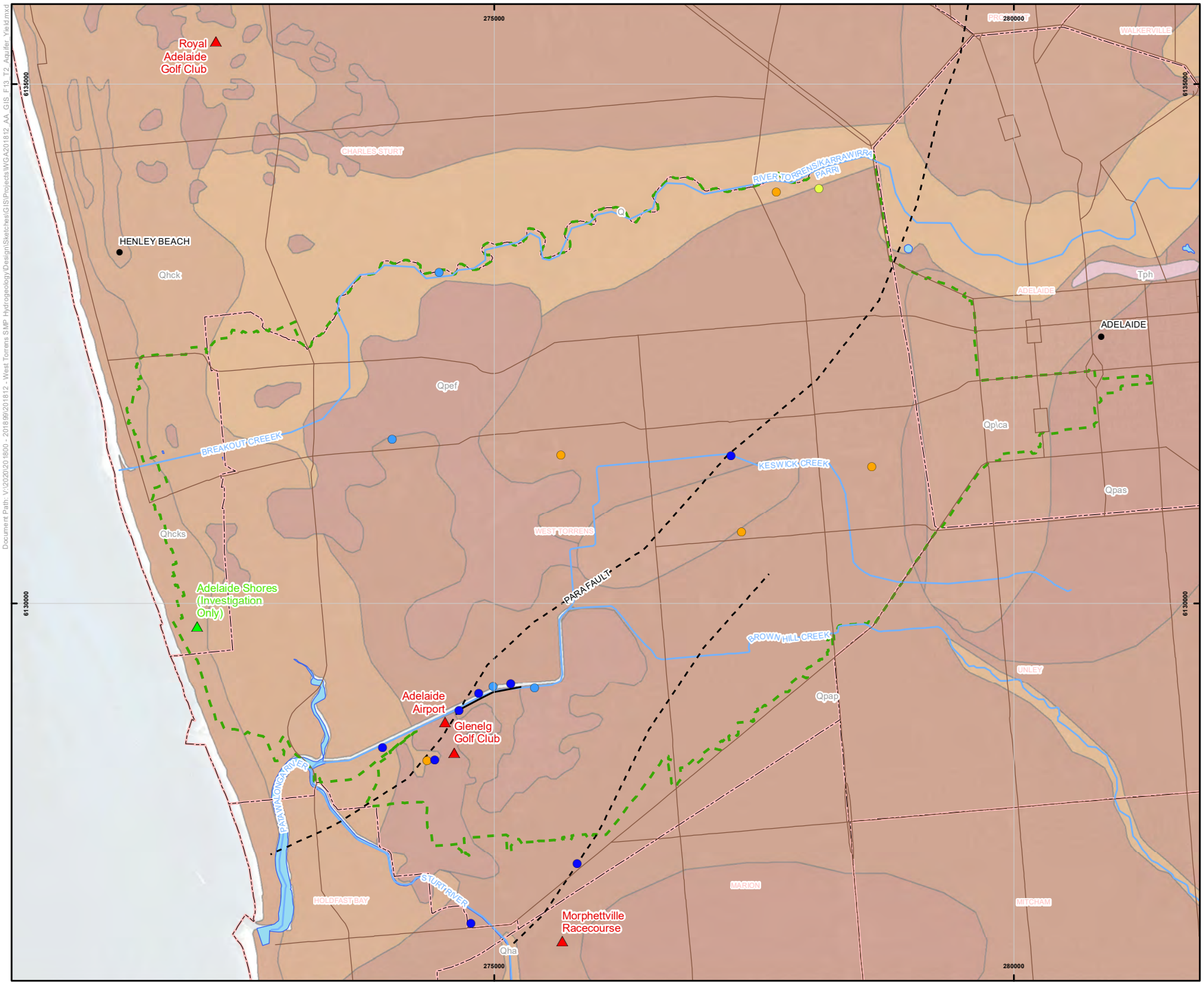
West Torrens SMP Hydrogeology

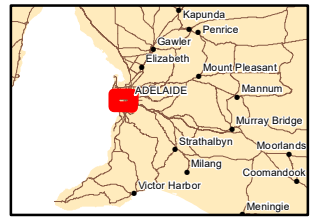
T2 aquifer salinity

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, no guarantee is given that the information portrayed is free from error or omission. Any relevance placed on such information shall be at the risk of the user.

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LEGEND

- MAR Scheme (Operational)
- MAR Scheme (Investigation Only)
- Locality
- Fault (position accurate)
- Fault (position approximate)
- Main Highway
- Watercourse
- SMP Catchment Area
- LGA Boundary
- Surfacewater Areas

Geology (100k)

Q, Qhcks, Qpas, Qha, Qp\ca, Qpef, Qhck, Qpap, Tph

Yield (L/s)

Unknown, 0 - 1, 1 - 2, 2 - 5, 5 - 10, > 10

N

0 250 500 750 1,000 m

Scale 1:50,000 @ A4

Coordinate System: GDA2020 MGA Zone 54

WGA
WALLBRIDGE GILBERT AZTEC

Figure **13**

West Torrens SMP Hydrogeology

T2 aquifer yield

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5 MAR FEASIBILITY

5.1 EXISTING MAR SYSTEMS

Two operational MAR systems occur within the West Torrens Catchment located at Adelaide Airport and Glenelg Golf Club (refer Figure 5). A brief description of the two schemes is presented below from Kretschmer (2017).

5.1.1 Adelaide Airport

The Adelaide Airport scheme is located on James Melrose Road on the southern side of the airport. The scheme commenced injection in 2014.

The scheme has four wells which target the T2 aquifer and a designed injection capacity of around 300 ML/a. The wells are between 220 to 280 m deep and the native groundwater salinity varies significantly between 970 to4,300 mg/L. Salinity does increase with depth in some areas of the T2 aquifer which explains some of this variability, however this site is made more complex because it is bisected by the Para Fault.

The scheme is operated by SA Water and sources water from Brown Hill Creek, which has largely been constrained to a manmade concrete-lined drain. The creek has a large catchment extending to the hills resulting in good flows in wet years which can maintain high injection rates. The water is treated through vertical infiltration biofilters and sand filters.

5.1.2 Glenelg Golf Club

The MAR scheme is operated by the Glenelg Golf Club and commenced injection in 2011. This scheme is unusual because it injects water into two separate aquifers. Of the three MAR wells, two target the T1 aquifer and one targets the T2 aquifer. This came about because the Para Fault, bisects the site. Notably the T2 well located south of the fault is 210 m deep and open between 150–210 m, which is not dissimilar in depth to the T1 well north of the fault which is 196 m deep and open between 155–196 m. The T2 well can yield approximately 13 L/s compared to 8 to 9 L/s in each T1 well.

The scheme captures water from the Brown Hill Creek diversion drain located along the southern boundary of Adelaide Airport. The creek's large catchment maintains periods of steady stormwater flow which is captured to supply the scheme. Harvested stormwater initially flows into a gross pollutant trap, then a deep sedimentation pond, before flowing through two large wetlands. The wetlands treat the stormwater to a standard sufficient to avoid clogging of the injection wells without any additional treatment such as media filters.

In recent years, the scheme has injected in the order of 110 ML/a., with the maximum scheme capacity in a high rainfall year of the order of 200 ML/a.

5.2 MAR INVESTIGATION SITES

5.2.1 West Beach Parks Golf

In 2007 investigations into the feasibility of MAR at the West Beach Parks Golf (formerly Adelaide Shores) was undertaken by Resource and Environmental Management (REM) and included the construction and testing of a well (6628-23539) completed in the T1 aquifer. Source water for recharge and reuse was to include stormwater runoff and drainage water from Adelaide Airport.

The preliminary investigations confirmed that the aquifer at this location was suitable for MAR however, lack of funding and uncertainty about the reliable harvest volumes of drainage water from the airport catchment resulted in the project not progressing beyond the feasibility stage. At the same time water from the Adelaide to Glenelg Pipeline (GAP) water became available for the West Beach Parks Golf course.

5.3 POTENTIAL FOR MAR

This assessment is limited to the evaluation of the aquifer capacity only. It is noted that opportunities for developing additional MAR schemes in the West Torrens Catchment that harvest urban stormwater runoff are constrained by the following factors:

- The Para Fault which bisects the study area and may limit opportunities for recharge on the upthrown side of the fault (Golden Grove Embayment) in the eastern quadrant of the study area.
- The availability of open space to install large holding basins to maximise capture of stormwater flows especially where the drainage network is designed to enable rapid conveyance of stormwater through the catchment.
- Potential demand nodes for using the captured stormwater especially where schemes already exist and there is competition from other water supply sources e.g. GAP Water.
- The concentration of schemes along the coastal margin between Glenelg and Grange has resulted in increased pressures in the aquifer and impacts on existing users. Further MAR schemes along the coastal margin may increase the problem.
- Potential to intercept water in the upper catchment impacting on the opportunity to harvest water by the schemes (Adelaide Airport and Glenelg Golf Course) located in the lower catchment.

Whilst the above factors present constraints they do not necessarily preclude the development of further MAR schemes within the catchment. On the downthrown side of the Para Fault the aquifer characteristics are more favourable as evidenced by successful schemes already in operation.

Feasibility criteria developed by WGA to evaluate the suitability of an aquifer for MAR are set out in Table 6. These criteria only assess the hydrogeological conditions; the economic feasibility, source water supply reliability and demand need to be considered and would be an independent study completed as a standalone project.

Table 6: Desirable Aquifer Criteria to Support the Successful Implementation of MAR Schemes.

Criteria	Preferred	Reason
Groundwater Gradient	Low	Depending on the ambient groundwater salinity, groundwater flow velocity is important to an MAR scheme as it largely determines the recovery efficiency (which quantifies how much of the injected water (that is suitable for the intended end-use) is actually recovered during extraction.
Well Yield	>10 L/s, lower injection rates are acceptable depending on the volume target of the scheme	Well yield of a groundwater extraction bore provides a good approximation of the rate at which surface water can be injected into that bore. The well construction also impacts on the yields, not just the aquifer characteristics.
Depth to Water	> 10 m bgl	Depth to groundwater is important when considering MAR in an unconfined aquifer because it helps to determine the available storage volume. A sufficient depth to groundwater should be maintained when injecting water to avoid losses due to evaporation or issues associated with potential water logging in an unconfined aquifer. In an unconfined aquifer, the aquifer pressure impacts the engineering requires to overcome the head pressure plus also the requirement to manage artesian conditions.
Groundwater Quality	Poorer or equal quality of injected water	Ambient groundwater needs to be equal or poorer quality to the injected surface water to avoid polluting the ambient groundwater.
Aquifer Characteristics	High storage (>200 ML) High effective porosity Competent rock Permeability Aquifer thickness Unconfined or confined	Aquifer characteristics are important as they determine well completion/ yield and influence the ongoing operation of the scheme in the form of levels of pre-treatment and operational intervention.

From the information presented in Section 3 and the criteria set out in **Table 6**, the suitability of the aquifers underlying the study area for MAR is presented in **Table 7**.

Table 7: Aquifer Feasibility Assessment for MAR

Hydrogeological Zone	Aquifer	Groundwater Gradient	Yield (L/s)	SWL (m bgl)	TDS (mg/L)	MAR Feasible
Criteria		Low	>10 L/s	>10	>300	
Adelaide Plains	Quaternary Aquifer	✓	×	×	✓	×
	T1 Aquifer	✓	✓	✓	✓	✓
	T2-T3 Aquifer*	? unknown	✓	✓	✓	✓
Golden Grove Embayment	Quaternary Aquifer	✓	×	×	✓	×
	T1 Aquifer	✓	✓	✓	✓	✓
	T2-T3 Aquifer*	? unknown	✓	✓	✓	✓

The Quaternary aquifer is not considered a viable aquifer for moderate to large volumes, however; may be suitable for small scale systems requiring less than 20 ML/a. Groundwater contamination has been reported in various locations across the West Torrens Catchment, which is an additional risk that would require evaluation if the Quaternary aquifers were to be considered for MAR. The SA EPA would be a key contact if considering MAR in the Quaternary aquifers to ensure known contaminated areas are avoided.

The potential for MAR at any location is governed by three main variables:

1. A suitable aquifer to store the harvested water.
2. A reliable supply of source water (stormwater, wastewater, groundwater).
3. A demand for the harvested water.

Each of the above variables have sub elements that need to be investigated to an appropriate level of detail to quantify potential risks before committing to a MAR system. For example, under variable 2 above, sub elements that need to be investigated include:

- The timing regarding the availability of the source water through flow modelling.
- Quality of the raw source water and level of treatment required.
- Volumes that can be reliably captured through flow modelling.

A challenge for any new scheme will be finding a suitable location for detention of any captured water. However, detention sites do not need to be co-located with the recharge site if the MAR method is via aquifer storage and recovery wells. The most promising open spaces that could be utilised for detention are along the coastal stretch of the catchment and the lower Torrens River (Breakout Creek). Opportunities for detention could consider capture of stormwater runoff in constructed box culverts located beneath footpaths or medium strips along major roads. Cost benefit analysis of the various detention options and scheme configurations would need to be undertaken.

6 REGULATORY REQUIREMENTS

6.1 MANAGED AQUIFER RECHARGE REGULATORY REQUIREMENTS

In South Australia there are legislative requirements to construct and operate a MAR system. The requirements are implemented to mitigate against adverse harm to the environment or human health. The following legislation or guidance should be reviewed as part of the planning, design, construction, and operations process for a MAR system:

- Occupational Health and Safety and Welfare Act, 2012
- Protection of Marine Waters (Prevention of Pollution from Ships) Act, 1987
- South Australian Public Health Act, 2011
- Native Vegetation Act, 1991
- Environment Protection Act, 1993
- Environment Protection (Water Quality) Policy, 2015
- Agricultural and Veterinary Chemicals Code Act, 1994
- Petroleum Products Regulation Act, 1995
- State Records Act, 1997
- The Landscape South Australia Act, 2019 which replaced the Natural Resources Management Act, 2004
- Aboriginal Heritage Act, 1988
- Water Service Association of Australian Codes (WSAA)
- Dangerous Substance Act, 1979
- Adelaide and Mount Lofty Ranges Natural Resources Management Board, Natural Resources Management Plan
- Local Government (Stormwater Management) Amendment Act, 2007
- Water Industry Act, 2012
- Office of Technical Regulator Policies

- Essential Services Commission of South Australia Codes and Guidelines
- Australian Guidelines for Water Recycling: Managing Health and Environmental Risks Phase 1 (NWQMS, 2006)
- Australian Guidelines for Water Recycling: Stormwater Harvesting and Re-use (NWQMS, 2009)
- Australian Guidelines for Water Recycling: Managed Aquifer Recharge (NWQMS, 2009).

Key stakeholders associated with the regulation of MAR systems in South Australia include:

Department of Health

- South Australian Environment Protection Authority
- Department for Environment and Water
- Adelaide and Mount Lofty Ranges Natural Resources Management Board
- Stormwater Management Authority
- Local municipal council

The study area is located within the Central Adelaide prescribed wells area, a Water Allocation Plan for this area is currently being developed and aims to:

- Protect the groundwater resources for all water users, now and into the future
- Provide greater certainty for water users
- Ensure water is provided to groundwater-dependent ecosystems

The implementation of a MAR system in this area is likely to be considered as a water affecting activity. If the MAR approach is to use a well to recharge and recover water (aquifer storage and recovery) a permit to construct a well will be required. A drainage and discharge permit will be required to carry out any pre commissioning testing and a MAR licence (issued by the EPA) to operate the scheme will be required.

If the water for the MAR scheme is to be sourced from the River Torrens an allocation to extract the water from the Prescribed watercourse will be required. If a dam or weir is to be installed in any of the water courses to support diversion a water affecting activity permit will be required.

In the absence of an endorsed water allocation plan for the region, MAR allocations are being issued under Section 105 of the *Landscape South Australia Act, 2019.* MAR licences are issued by the SA EPA.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

This report presents an overview of the hydrogeological setting of the aquifer systems that lie beneath the West Torrens Catchment area to support the development of the stormwater management plan. The hydrogeological framework is complicated by the Para Fault that bisects the catchment area separating the Adelaide sub-basin from the Golden Grove Embayment. There is up to a 30 m displacement across the Para Fault between the upthrown Golden Grove Embayment and the downthrown Adelaide Sub-basin.

Up to six aquifers can be intersected in drillholes in the Quaternary sediments the most significant aquifer in the Quaternary sequence is the Carisbrooke Sands Formation. A large proportion of wells take water from the first or second Quaternary aquifers for domestic use either garden watering or non-contact use within the house.

There are two main Tertiary confined aquifers T1 and T2 which support large scale irrigation, typically of sporting ovals and golf courses, or Industrial demands.

An evaluation of the available drill hole data sourced from the WaterConnect database was undertaken to estimate the total groundwater taking from the various aquifers in the study area. Filters were applied to the data to provide a reasonable approximation of the number of operational wells in each aquifer. Groundwater use is not metered in this area and therefore assumptions based on metered use from other similar locations (i.e. Northern Adelaide Plains and typical irrigation demands) were applied to provide a reasonable estimate of groundwater use by aquifer.

Estimated groundwater use from the Quaternary aquifers is approximately 0.3 ML/a (rounded); 2,390 ML/a. from the Tertiary T1 aquifer and 275 ML/a. from the Tertiary T2 aquifer. The extraction volumes from the Tertiary T1 aquifer should be used with caution as some of the wells may no longer be operational therefore the estimated extraction volume may be overestimated.

Using the available information an assessment concerning the suitability of the aquifers for MAR was completed. This evaluation looks specifically at the aquifers and does not consider source water supply, source water quality, potential demand, or source water reliability. Such studies would be completed as part of a detailed MAR site feasibility assessment.

The Tertiary aquifer system on the downthrown side of the Para Fault (i.e. north western side) is the most prospective aquifer if additional MAR systems were to be implemented in the West Torrens Catchment. Implementation of additional MAR systems in this catchment will face several challenges, and careful evaluation concerning viability would be required. The challenges include:

- The availability of open space to install large holding basins to maximise capture of stormwater flows especially where the drainage network is designed to enable rapid conveyance of stormwater through the catchment.

- Potential demand nodes for using the captured stormwater especially where schemes already exist and there is competition from other water supply sources e.g. GAP Water.

- The concentration of schemes along the coastal margin between Glenelg and Grange has resulted in increased pressures in the aquifer and impacts on existing users. Further MAR schemes along the coastal margin may increase the problem.

- Potential to intercept water in the upper catchment impacting on the opportunity to harvest water by the schemes (Adelaide Airport and Glenelg Golf Course) located in the lower catchment.

Whilst the above factors present constraints they do not necessarily preclude the development of further MAR schemes within the catchment. On the downthrown (northwest) side of the Para Fault the aquifer characteristics are more favourable as evidenced by successful schemes already in operation.

Challenges for any new scheme will be finding a suitable location for detention of any harvested water. However, detention sites do not need to be co-located with the recharge site if the MAR method is via aquifer storage and recovery wells.

Innovative opportunities for detention could consider capture of stormwater runoff in constructed box culverts located beneath footpaths or medium strips along major roads.

7.2 RECOMMENDATIONS

If MAR were to be implemented the following studies would need to be completed to further assess the viability of the scheme:

- Studies to determine the optimum location for detention basins and treatment facilities

- Water quality evaluation to determine the required levels of pre-treatment

- Demand analysis to confirm market and a price survey to determine what third party users may be prepared to pay.

- Reliability modelling to confirm stormwater harvest volumes.

- Cos benefit analysis on the various detention, treatment, and transmission options.

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APPENDIX A

GROUNDWATER WELL INFORMATION

Quaternary Wells

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662800355	278698.82	6131476.33	-9999	19.49			-9999	1385	2/06/1950	9.47	1/01/1917	8.89	27/03/1915	16/09/1914	49.68	49.68
662800695	276414.73	6130944.27	-9999	9.09	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	4	8/01/1990	8/01/1991	10	10
662800722	275105.17	6132748.3	-9999	9.79			-9999	2278	31/08/2005	2.5	31/08/2005	6	31/08/2005	31/08/2005	31	33
662800724	277125.73	6129953.26	15	22.13629	OPR	DOM	-9999	-9999	<Null>	0.7	14/09/1982	6.7	14/09/1982	14/09/1982	13.4	13.4
662800725	278740.7	6131234.27	-9999	19.35			-9999	-9999	<Null>	-9999	<Null>	6.1	10/04/1915	10/04/1915	48.16	48.16
662800726	278751.73	6131224.21	-9999	19.42	ABD		-9999	1300	11/03/1915	-9999	<Null>	1.22	11/03/1915	11/03/1915	90.4	90.4
662803921	275896.69	6130303.32	6	11.808653			-9999	1956	6/04/1934	18.95	6/04/1934	4.57	6/04/1934	<Null>	9.14	9.14
662807547	276437.7	6133758.28	-9999	10			-9999	1430	24/11/1961	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807548	276234.58	6129049.13	-9999	15.866148			-9999	2995	23/11/2009	0.333	23/11/2009	5	23/11/2009	23/11/2009	20	20
662807550	278143.78	6132134.64	-9999	15.18		DOM	-9999	1311	7/12/2001	0.8	7/12/2001	10	7/12/2001	7/12/2001	22	24
662807551	273911.89	6132308.29	-9999	6.12		DOM	7.6	2426	25/08/2001	1	7/09/1995	4.6	7/09/1995	7/09/1995	16.5	16.5
662807554	275673.76	6133008.18	-9999	10.27		DOM	7.2	2233	24/03/1993	-9999	<Null>	-9999	<Null>	22/03/1993	15	15
662807559	278868.38	6130241.65	-9999	32.370894			-9999	-9999	<Null>	-9999	<Null>	14	10/08/2015	10/08/2015	18	18
662807560	275057.75	6132288.3	-9999	9.82			-9999	3084	6/10/1934	-9999	<Null>	-9999	<Null>	<Null>	14.02	14.02
662807564	277916.86	6130518.2	-9999	17.63		DOM	-9999	1586	29/07/1997	0.125	29/07/1997	9	29/07/1997	29/07/1997	18	18
662807565	277936.77	6128814.23	-9999	22.11			-9999	-9999	<Null>	-9999	<Null>	3	1/01/1983	1/01/1983	10	10
662807566	276383.76	6129560.26	-9999	11.46			-9999	1613	12/02/1947	-9999	<Null>	9.14	12/02/1947	<Null>	13.41	13.41
662807567	277322.77	6129777.25	-9999	17.19			-9999	-9999	<Null>	-9999	<Null>	6	18/09/1982	18/09/1982	13	13
662807575	272489.73	6131892.23	-9999	4.38			-9999	1542	13/03/1936	-9999	<Null>	2.44	13/03/1936	<Null>	-9999	-9999
662807577	273144.73	6131840.26	-9999	5.01			-9999	10224	16/03/1936	-9999	<Null>	1.83	16/03/1936	<Null>	-9999	-9999
662807578	274146.76	6132241.28	-9999	7	OPR	DOM	7.8	2194	29/10/1992	1.5	26/10/1992	5	29/10/1992	26/10/1992	15.2	15.2
662807581	276170.77	6128799.25	-9999	9.62	OPR	DOM	7.3	3007	12/02/1992	-9999	<Null>	2	12/02/1992	7/02/1992	12	12
662807585	275116.76	6132713.33	-9999	9.88		DOM	6.8	2437	1/11/1994	-9999	<Null>	-9999	<Null>	1/11/1994	16	16
662807587	272998.7	6132430.26	-9999	5			-9999	1559	9/01/1914	-9999	<Null>	8.53	9/01/1914	9/01/1914	121.01	121.01
662807589	273789.72	6132184.27	5	13.709621	OPR	DOM	7.5	2227	16/10/1989	1	23/09/1989	2.4	16/10/1989	23/09/1989	9.7	9.7
662807590	274257.73	6132400.32	6	11.993894			7.8	1923	13/02/1981	6.82	6/02/1981	2.13	6/02/1981	6/02/1981	10.97	10.97

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807594	274041.82	6132843.08	-9999	6.44		DOM	7.4	2210	13/02/1996	2	13/02/1996	-9999	<Null>	13/02/1996	18	18
662807595	273953.14	6133020.02	-9999	7.19		DOM	-9999	2245	22/11/2000	2.5	22/11/2000	-9999	<Null>	22/11/2000	13.5	13.5
662807597	273988.73	6132860.3	6	12.808446			-9999	1744	2/01/1946	12.63	2/01/1946	3.66	2/01/1946	<Null>	-9999	-9999
662807598	273439.77	6131993.22	-9999	5	OPR	DOM	7.4	3511	14/03/1992	1	14/03/1992	3	14/03/1992	14/03/1992	6	6
662807599	276465.69	6133754.3	-9999	10.06			7	1955	27/10/1967	-9999	<Null>	-9999	<Null>	<Null>	6.71	6.71
662807602	277258.74	6130854.24	13	19.314734			7.6	2301	12/02/1980	1	12/02/1980	3	12/02/1980	12/02/1980	12.45	12.45
662807603	277151.77	6128203.36	-9999	17.33		DOM	6.7	11074	27/01/1995	0.25	27/01/1995	-9999	<Null>	27/01/1995	18	18
662807604	277001.83	6129548.31	-9999	15		DOM	-9999	2460	21/08/1999	0.5	21/08/1999	9	21/08/1999	21/08/1999	32	32
662807606	273419.68	6131561.27	-9999	4.98			6.5	1295	26/10/1971	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807611	272775.75	6129947.29	-9999	4.67			-9999	5840	1/11/1942	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807613	275981.85	6129738.32	-9999	8.38	OPR	DOM	-9999	-9999	<Null>	0.133	6/01/1997	5.6	6/01/1997	6/01/1997	9.6	9.6
662807618	272670.75	6130728.23	3	9.031965			-9999	957	3/03/1952	12.63	1/01/1952	-9999	<Null>	<Null>	-9999	-9999
662807620	275821.72	6132485.25	8	12			-9999	-9999	<Null>	1.26	28/12/1984	3.5	28/12/1984	28/12/1984	10	10
662807624	277191.62	6129938.44	15	21.02494	OPR	DOM	7.7	734	4/04/1990	1.5	27/02/1990	7.2	4/04/1990	27/02/1990	16.5	16.5
662807626	277181.7	6130988.34	-9999	12.65		DOM	6.9	1995	30/12/1994	-9999	<Null>	-9999	<Null>	30/12/1994	15	15
662807627	277671.94	6132168.19	-9999	13.02		DOM	8	1636	17/08/1996	30	17/08/1996	-9999	<Null>	17/08/1996	30	30
662807628	277011.77	6128185.28	-9999	16.3			7.4	3840	1/01/1984	-9999	<Null>	-9999	<Null>	1/01/1984	9	9
662807629	273679.32	6132989.62	-9999	5.42			-9999	1670	19/04/2007	0.7	19/04/2007	5	19/04/2007	19/04/2007	10.5	10.5
662807631	276448.71	6132091.26	-9999	9.35	OPR	IRR	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/01/1983	8	8
662807632	273891.88	6132603.27	-9999	5.64		DOM	7.1	2245	21/07/1995	1.25	21/07/1995	-9999	<Null>	21/07/1995	9.5	9.5
662807633	273949.7	6132712.26	-9999	5.93	OPR	DOM	7.9	1984	12/11/1990	-9999	<Null>	0	12/11/1990	17/10/1990	12	12
662807634	273856.73	6132302.26	5	10.29331	OPR	DOM	-9999	-9999	<Null>	0.5	3/01/1989	4	3/01/1989	3/01/1989	11	11
662807635	273385.71	6132646.22	-9999	4.97	OPR	DOM	6.9	2990	4/12/1991	0.9	4/12/1991	4.3	4/12/1991	4/12/1991	5.7	5.7
662807636	273725.77	6132426.22	-9999	5.12	OPR	DOM	7.8	2375	21/11/1991	1.2	21/11/1991	4	21/11/1991	21/11/1991	12	12
662807637	272528.51	6132300.44	-9999	8.432416	BKF		-9999	-9999	<Null>	-9999	<Null>	3.4	31/07/2014	24/09/2010	0	4
662807638	276135.7	6129215.3	10	14.44727	OPR	DOM	8.1	2063	3/04/1991	1	15/03/1991	5.2	3/04/1991	15/03/1991	10.5	10.5
662807639	276687.76	6133743.3	14	16.460006	OPR	DOM	7.4	2756	14/07/1988	1	23/12/1987	8.2	14/07/1988	23/12/1987	15	15

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807641	276551.72	6131408.26	8	12.873613	OPR	IRR	-9999	-9999	<Null>	0.01	1/01/1987	5.3	1/01/1987	1/01/1987	5.5	5.5
662807642	274741.7	6132411.27	-9999	6.75			-9999	4490	14/04/1949	-9999	<Null>	2.29	14/04/1949	<Null>	-9999	4.27
662807643	278128.03	6132132.93	-9999	15.07		DOM	-9999	888	5/12/2001	0.8	5/12/2002	10	5/12/2001	5/12/2001	19	19
662807644	272445.86	6130348.1	-9999	5.05		DOM	-9999	539	22/10/2003	1	22/10/2003	1.5	22/10/2003	22/10/2003	5.5	5.5
662807647	276581.86	6132978.39	-9999	12.03		DOM	-9999	-9999	<Null>	4	2/01/1995	-9999	<Null>	2/01/1995	17.5	17.5
662807648	276949.74	6132338.27	-9999	11.36			8.1	1625	19/11/1981	-9999	<Null>	4.5	4/04/1981	4/04/1981	6.5	6.5
662807649	277315.76	6133208.32	-9999	14.93	OPR	DOM	7.9	603	18/10/1985	-9999	<Null>	7	28/10/1985	15/10/1985	15.5	15.5
662807650	277827.77	6130472.3	18	23.560153	OPR	DOM	7.8	2047	14/07/1989	0.3	14/07/1989	5.2	14/07/1989	14/07/1989	11.2	11.2
662807651	278124.88	6132392.21	-9999	15.26		DOM	-9999	1720	14/03/2002	0.8	14/03/2002	11	14/03/2002	14/03/2002	20	20
662807652	278096.9	6132778.24	-9999	16.09		DOM	-9999	2047	28/11/1997	1.5	28/11/1997	14	28/11/1997	28/11/1997	30	30
662807653	276291.94	6129753.25	-9999	10.87		DOM	7.3	1957	29/03/1995	2	28/03/1995	-9999	<Null>	28/03/1995	18.5	18.5
662807654	276886.77	6132098.31	10	14.631604	OPR	DOM	7.8	1928	11/10/1988	0.3	1/07/1988	5	11/10/1988	1/07/1988	10	10
662807655	278416.76	6132123.36	-9999	17.19		DOM	7.7	1575	20/08/1996	0.5	22/08/1996	9	22/08/1996	22/08/1996	30	30
662807682	276630.16	6130565.34	-9999	18.602565			-9999	-9999	<Null>	-9999	<Null>	5.9	17/02/2014	17/02/2014	9	9
662807683	278221.76	6129337.3	23	28.166071			-9999	2660	7/12/1951	0.25	7/12/1951	1.52	7/12/1951	<Null>	4.88	4.88
662807684	277433.72	6130290.21	17	20.821488			-9999	700	16/11/1949	0.13	16/11/1949	6.71	16/11/1949	<Null>	9.14	9.14
662807685	272437.68	6130262.21	3	7.193827			7.7	682	5/12/2007	1.25	15/03/1985	2.5	15/03/1985	15/03/1985	6	6
662807686	276961.71	6128300.27	-9999	15.45			6.5	9170	7/05/1968	-9999	<Null>	4.57	7/05/1968	<Null>	9.14	9.14
662807687	277472.12	6133171	-9999	15.3		DOM	-9999	2443	18/04/2001	0.5	18/04/2001	11	18/04/2001	18/04/2001	15	18
662807688	277686.59	6129743.28	-9999	20.07		DOM	7.5	694	24/03/1993	-9999	<Null>	-9999	<Null>	19/03/1993	21	21
662807694	278554.1	6129876.99	-9999	25.84		DOM	-9999	528	22/06/2001	-9999	<Null>	12	22/06/2001	22/06/2001	16	16
662807695	272535.21	6132300.55	-9999	8.209296	BKF		-9999	-9999	<Null>	-9999	<Null>	3.2	31/07/2014	<Null>	0	6
662807696	277248.75	6130720.25	-9999	14.15			-9999	-9999	<Null>	1.25	20/08/1986	5.6	25/08/1986	20/08/1986	34	34
662807697	275461.77	6132178.26	-9999	8.44		DOM	7.3	2075	7/04/1994	-9999	<Null>	-9999	<Null>	2/04/1994	15	15
662807698	277229.74	6129874.21	-9999	16.35	OPR	DOM	7.4	597	13/04/1992	-9999	<Null>	9	13/04/1992	2/04/1992	18	18
662807700	278155.17	6132142.03	-9999	15.26		DOM	-9999	1602	2/03/2001	-9999	<Null>	11	2/03/2001	2/03/2001	24	24
662807701	276415.73	6132736.23	-9999	10.54			-9999	2684	26/08/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807702	277092.7	6130168.23	14	20.716578	OPR	DOM	7.2	1334	25/07/1983	0.38	1/05/1983	-9999	<Null>	1/05/1983	9.14	9.14
662807705	276958.12	6129732.01	-9999	14.73		DOM	-9999	2432	13/11/1999	0.5	13/11/1999	10	13/11/1999	13/11/1999	34	34
662807706	277776.77	6129823.18	-9999	20.62		DOM	7	699	28/11/1992	-9999	<Null>	9	7/12/1992	<Null>	-9999	18
662807710	276227.76	6133572.32	-9999	10.5			-9999	2027	2/09/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807712	276032.74	6131083.31	6	9.354249	OPR	DOM	7.8	1828	3/02/1989	0.6	2/04/1984	-9999	<Null>	2/04/1984	18	18
662807713	275990.72	6132464.31	-9999	9.25	OPR	DOM	7.1	1973	30/03/1991	-9999	<Null>	5	30/03/1991	30/03/1991	9	9
662807714	275846.82	6129818.25	-9999	6.67		DOM	7.1	1850	20/03/1995	-9999	<Null>	-9999	<Null>	20/03/1995	16.5	16.5
662807715	277746.7	6129988.27	20	24.093659	OPR	DOM	7.7	1172	9/11/1988	0.3	1/05/1988	7.5	9/11/1988	1/05/1988	12.5	12.5
662807716	278373.69	6132696.28	17	22.283749			7.7	1132	2/11/1981	0.45	2/11/1981	8.2	2/11/1981	2/11/1981	14.6	14.6
662807720	276451.73	6132046.27	8	14.077896	OPR	DOM	7.4	1826	11/10/1988	0.25	1/07/1988	3	11/10/1988	1/07/1988	8	8
662807721	274191.79	6132993.31	-9999	7.39		DOM	7.6	2108	3/04/1995	1.5	3/04/1995	-9999	<Null>	3/04/1995	18	18
662807722	276721.73	6131636.3	-9999	9.17			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807726	276298.71	6132527.25	-9999	9.63			-9999	3517	22/10/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807727	275863.11	6132986.04	-9999	10.92		DOM	-9999	2380	29/03/2000	1	29/03/2000	6.6	29/03/2000	29/03/2000	14	18
662807728	277381.73	6131035.28	-9999	12.7	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	11	21/01/1990	21/01/1990	11	11
662807729	274227.69	6132199.22	6	16.87026	OPR	DOM	7.8	2426	8/01/1986	0.5	1/01/1985	2.1	16/01/1986	8/01/1986	14	14
662807730	277321.68	6131893.26	-9999	11.49		DOM	7.8	1600	24/02/2005	-9999	<Null>	-9999	<Null>	28/11/1994	12	12
662807731	275091.75	6132804.29	10	14.045733			6.9	849	20/09/1978	0.75	1/09/1978	4.5	1/09/1978	1/09/1978	15	15
662807732	276228.69	6131542.32	-9999	7.98			-9999	2770	26/08/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807733	276950.7	6131150.3	1.74	17.501031	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	7	8/04/1991	8/04/1991	13	13
662807734	275865.72	6131672.27	-9999	7.2			-9999	2445	26/08/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807735	277123.75	6133115.28	-9999	14.07	OPR	DOM	8.1	1457	21/10/1992	1	5/08/1992	9	21/10/1992	5/08/1992	14.5	14.5
662807736	274180.77	6133165.31	-9999	8.09			-9999	2327	16/03/1936	-9999	<Null>	5.33	16/03/1936	<Null>	6.4	6.4
662807737	274386.9	6132848.28	-9999	8.13		DOM	-9999	1928	6/05/1999	-9999	<Null>	5	6/05/1999	6/05/1999	12	12
662807740	276379.71	6128175.24	-9999	11.24			-9999	871	10/11/1934	5.68	1/01/1934	-9999	<Null>	1/01/1914	37.19	37.19
662807742	273713.71	6132835.29	-9999	5.52	OPR	DOM	7.9	1010	20/09/1991	-9999	<Null>	3	<Null>	20/09/1991	-9999	9
662807743	274021.75	6133203.33	-9999	6.12		DOM	6.3	1895	27/10/1994	60	27/10/1994	-9999	<Null>	27/10/1994	18	18

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807744	276501.74	6128203.21	-9999	12.2		DOM	7.7	2375	12/02/2012	2	23/11/1995	-9999	<Null>	23/11/1995	16	16
662807745	277796.68	6132823.33	-9999	15.78		DOM	7.1	2075	29/03/1995	-9999	<Null>	-9999	<Null>	29/03/1995	18	18
662807747	274763.7	6132342.22	-9999	6.97	OPR	DOM	7.2	2432	20/01/1992	-9999	<Null>	4.5	20/01/1992	14/01/1992	15	15
662807748	276532.76	6131458.3	-9999	9.06			-9999	229	28/03/1958	-9999	<Null>	2.13	28/03/1958	<Null>	9.45	9.45
662807749	273680.7	6132673.3	-9999	5.07	OPR	DOM	7.1	1100	4/11/1991	1	4/11/1991	4	4/11/1991	4/11/1991	11	11
662807752	277366.85	6131263.24	-9999	11.57		DOM	-9999	1462	<Null>	0.5	12/04/1997	11	12/04/1997	12/04/1997	31	31
662807753	272751.85	6132558.33	-9999	5	ABD	DOM	-9999	-9999	<Null>	0.125	20/11/1997	4.2	20/11/1997	20/11/1997	0	17
662807754	278018.68	6129661.24	-9999	22.45	OPR	DOM	6.8	1362	29/10/1992	-9999	<Null>	9	29/10/1992	24/10/1992	18	18
662807755	275905.71	6130267.24	6	12			-9999	1959	1/01/1934	18.95	1/01/1934	3.66	1/01/1934	<Null>	9.14	9.14
662807765	277113.76	6129762.27	-9999	15.54			7.6	534	9/05/1988	1	7/04/1988	6	9/05/1988	7/04/1988	19	19
662807766	275203.77	6133401.22	-9999	10			-9999	1285	1/01/1950	11.37	1/01/1950	7.62	1/01/1950	<Null>	36.58	36.58
662807767	277636.71	6129795.23	-9999	19.7	OPR	DOM	7.4	945	<Null>	-9999	<Null>	-9999	<Null>	1/11/1983	13.4	13.4
662807768	278086.83	6134073.31	-9999	15.3	ABD		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	2/12/1998	0	4
662807769	272811.84	6132518.3	-9999	5		DOM	-9999	2347	2/12/1997	2	2/12/1997	4	2/12/1997	2/12/1997	11.5	11.5
662807770	275336.74	6127842.25	-9999	7.54	BKF		7.4	6176	4/05/1983	1.6	4/05/1983	1.8	4/05/1983	4/05/1983	14.6	14.6
662807772	275287.73	6133017.23	10	12			7	1830	20/02/1969	1.26	20/02/1969	3.05	20/02/1969	<Null>	13.72	13.72
662807774	278159.7	6130281.25	-9999	21.29	OPR	IRR	-9999	-9999	<Null>	-9999	<Null>	11.5	9/12/1985	9/12/1985	15	15
662807776	275677.69	6128873.27	-9999	6.5			8.5	3943	11/12/1980	0.75	11/12/1980	3.13	16/06/1986	11/12/1980	-9999	9.6
662807777	278047.82	6132956.46	-9999	16.88			7	3252	26/04/1983	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807779	275395.74	6131711.22	6	13.336754	OPR	DOM	7.4	2909	19/10/1988	0.2	10/10/1988	6	19/10/1988	10/10/1988	12	12
662807781	276646.87	6132843.23	-9999	11.64		DOM	-9999	2001	19/01/1998	-9999	<Null>	7.2	19/01/1998	19/01/1998	20	20
662807783	276295.38	6132656.05	-9999	10.14		DOM	-9999	2471	3/02/2004	1	3/02/2004	6	3/02/2004	<Null>	26	26
662807784	274925.15	6132071.01	-9999	8.24		DOM	-9999	2574	30/11/1999	1	30/11/1999	4.5	30/11/1999	30/11/1999	12	12
662807786	276515.13	6130654.99	-9999	9.83		DOM	-9999	1396	17/01/1999	0.5	17/01/1999	13	17/01/1999	17/01/1999	30	30
662807787	275928.76	6132422.27	8	13.031696			7.3	2143	10/07/1985	1.5	<Null>	3.7	10/07/1985	10/07/1985	11	11
662807789	275845.68	6130002.26	-9999	5.9			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807793	275717.71	6133530.29	-9999	10.02			-9999	2001	6/11/1961	-9999	<Null>	-9999	<Null>	<Null>	35.05	35.05

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807794	276595	6132569	-9999	12			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	10	10
662807795	277018.77	6132959.32	-9999	13.12			7.2	2284	20/05/1983	-9999	<Null>	7	4/06/1983	4/06/1983	10	10
662807796	276004.15	6131421.01	-9999	7.51		DOM	-9999	2149	13/08/2001	-9999	<Null>	4.5	1/07/2001	1/07/2001	8.84	8.84
662807797	275216.75	6132599.24	-9999	10.08			6.7	1900	8/12/1967	-9999	<Null>	4.27	8/12/1967	<Null>	7.62	7.62
662807798	277256.72	6130158.25	-9999	15.54			-9999	671	24/02/1938	5.05	24/02/1938	8.53	24/02/1938	1/01/1938	76.2	76.2
662807800	276784.69	6130228.29	-9999	12.51			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	27/02/1962	12.19	12.19
662807801	276730.71	6130361.28	-9999	12.06			-9999	843	24/04/1934	8.84	24/04/1934	2.74	24/04/1934	1/01/1934	71.02	71.02
662807802	276677.76	6130441.23	-9999	11.56			-9999	799	13/12/1933	7.58	13/12/1933	2.44	13/12/1933	1/01/1914	70.1	70.1
662807803	277166.83	6131163.35	-9999	11.64		DOM	6.7	1973	1/07/1996	-9999	<Null>	6.5	1/07/1996	1/07/1996	14	14
662807804	277223.73	6133334.27	-9999	14.25			7	1962	20/12/1984	-9999	<Null>	7.6	1/11/1984	1/11/1984	10	10
662807805	277237.72	6130326.28	-9999	15.57			-9999	-9999	<Null>	8.84	<Null>	7.01	<Null>	<Null>	-9999	66.14
662807822	274078.16	6132511.97	-9999	6.64		DOM	-9999	1832	29/11/1999	1	29/11/1999	4	29/11/1999	29/11/1999	12	12
662807823	272513.8	6130538.54	-9999	5.06			-9999	1636	30/08/2007	-9999	<Null>	3.6	30/10/2007	30/10/2007	6.1	6.1
662807824	276478.72	6133767.27	-9999	10.01			-9999	1442	10/02/1959	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662807827	278284.73	6134045.26	-9999	16.92			-9999	1370	21/10/1954	3.79	1/01/1954	-9999	<Null>	1/01/1946	36.27	36.27
662807829	272402.75	6130926.24	-9999	4.83			7.5	2030	28/02/1969	-9999	<Null>	1.52	28/02/1969	<Null>	9.14	9.14
662807839	275462.77	6129886.28	-9999	5.19			6.7	1212	26/06/1967	-9999	<Null>	0	13/12/1933	1/01/1933	90.53	90.53
662807841	275881.76	6129817.22	7	14.864527			-9999	-9999	<Null>	6.32	<Null>	-9999	<Null>	<Null>	8.53	8.53
662807842	272536.64	6132296.12	-9999	8.170336	BKF		-9999	-9999	<Null>	-9999	<Null>	3.4	31/07/2014	24/09/2010	0	4
662807851	277041.68	6130973.15	-9999	12.38		DOM	6.9	2357	3/05/1993	-9999	<Null>	-9999	<Null>	12/04/1993	21	21
662807853	274591.84	6132683.07	-9999	9.06		DOM	7	1979	11/02/1995	-9999	<Null>	-9999	<Null>	11/02/1995	12	12
662808038	278298.73	6130062.31	-9999	23.33			-9999	785	24/10/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662808039	275008.72	6129364.28	-9999	4.85			7.5	827	20/08/1976	-9999	<Null>	0	20/08/1976	<Null>	-9999	-9999
662808047	273867.68	6133019.25	7	13.764524	OPR	DOM	8.1	1608	5/09/1983	0.5	19/08/1983	4	19/08/1983	19/08/1983	9	9
662808049	275146.96	6128468.38	-9999	5.25		DOM	7.3	8402	6/11/1996	1.25	6/11/1996	-9999	<Null>	6/11/1996	11	11
662808051	275223.68	6128503.23	-9999	5.34			-9999	956	1/01/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662808054	275875.73	6128586.21	-9999	8.55			-9999	11738	6/05/1949	0.63	6/05/1949	2.74	6/05/1949	<Null>	60.96	60.96

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662808055	275662.68	6128532.25	-9999	7.29			-9999	985	4/04/1946	3.79	4/04/1946	0.61	4/04/1946	1/01/1939	60.96	60.96
662808057	275041.69	6132643.21	8	12.734416	OPR	DOM	7.2	2132	14/09/1984	1.5	14/09/1984	4	14/09/1984	14/09/1984	11	11
662808058	276076.74	6133579.28	-9999	10.5	OPR	DOM	7.8	1513	10/02/1992	1.1	2/02/1991	8	10/02/1992	2/02/1991	15	15
662808060	272634.76	6132118.29	-9999	5.01	OPR	DOM	7.5	3910	13/11/1991	1.1	13/11/1991	4	13/11/1991	13/11/1991	8	8
662808072	277733.12	6128961.96	-9999	20.18		DOM	-9999	1895	29/02/2000	0.5	3/02/2000	4.5	3/02/2000	3/02/2000	18	18
662808074	276382.76	6129679.23	-9999	11.4			-9999	-9999	<Null>	-9999	<Null>	2.77	2/10/1969	<Null>	-9999	-9999
662808076	277638.74	6130664.27	15	19.269937			-9999	1742	13/08/1934	8.84	13/08/1934	5.18	13/08/1934	<Null>	12.5	12.5
662808077	276487.69	6129093.29	-9999	11.87			-9999	913	13/12/1933	7.58	13/12/1933	5.49	13/12/1933	<Null>	81.69	81.69
662808078	276464.71	6128841.31	-9999	11.61			-9999	871	14/12/1933	2.53	14/12/1933	0.61	14/12/1933	<Null>	76.2	76.2
662808079	276472.68	6128695.21	-9999	11.71			-9999	971	6/05/1949	10.1	6/05/1949	7.62	6/05/1949	1/01/1934	60.96	60.96
662808080	276482.77	6128604.22	-9999	11.97			-9999	871	6/05/1949	3.79	1/01/1949	-9999	<Null>	<Null>	54.86	54.86
662808083	278537.73	6133034.24	-9999	19.12			-9999	2101	18/09/1914	-9999	<Null>	-9999	<Null>	<Null>	18.29	18.29
662808092	273204.7	6132013.25	-9999	5			-9999	7893	4/02/1952	-9999	<Null>	3.05	4/02/1952	<Null>	-9999	4.27
662808095	276695.72	6129349.24	-9999	13.39			-9999	829	21/08/1934	-9999	<Null>	-9999	<Null>	<Null>	84.12	84.12
662808097	276741.71	6129120.27	-9999	13.51			-9999	1070	28/08/1934	10.1	28/08/1934	3.66	28/08/1934	28/08/1934	54.86	54.86
662808098	277143.74	6133330.32	-9999	13.96	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/02/1984	11	11
662808099	276947.7	6131617.3	10	13.877486	OPR	DOM	7.8	994	24/09/1982	1.8	24/09/1982	3	24/09/1982	24/09/1982	9.1	9.1
662808119	277411.82	6131953.07	-9999	11.9		DOM	7.3	1647	26/04/1995	-9999	<Null>	-9999	<Null>	26/04/1995	16.5	16.5
662808121	275309.72	6131841.3	6	13.745845	OPR	DOM	7.7	2354	20/11/1989	1.2	14/10/1989	2.4	20/11/1989	14/10/1989	8	8
662808122	275346.79	6132218.28	-9999	9.23		DOM	-9999	1928	6/12/1996	0.2	6/12/1996	4	6/12/1996	6/12/1996	12	12
662808123	277474.69	6132820.26	-9999	14.71			7.2	2030	15/01/1982	-9999	<Null>	-9999	<Null>	1/01/1979	-9999	9.75
662808124	277142	6133540	-9999	14.04	OPR	DOM	7.8	1216	8/02/1990	-9999	<Null>	0	8/02/1990	20/12/1989	17	17
662808125	277712.76	6129153.31	-9999	19.97			-9999	2213	8/11/1945	-9999	<Null>	10.67	8/11/1945	<Null>	31.09	31.09
662808126	276836.75	6131437.21	10	13.546636			7.4	2517	24/03/1987	1	14/02/1986	3	13/03/1986	14/02/1986	11	11
662808127	273682.4	6132816.01	-9999	5.28	OPR	DOM	7.4	1428	20/09/1991	1	4/09/1991	2.4	20/09/1991	4/09/1991	9	9
662808128	277949.69	6129079.27	-9999	21.46			-9999	743	7/01/1949	-9999	<Null>	6.71	17/07/1945	1/01/1945	53.34	53.34
662808129	278065.74	6129019.27	-9999	22.51	ABD		-9999	1315	11/01/1946	-9999	<Null>	0	7/04/1994	1/01/1945	0	50.9

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662808130	277995.71	6128983.27	-9999	22.09			-9999	4633	2/08/1945	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662808131	277996.71	6128986.36	-9999	22.09			-9999	3055	27/08/1945	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662808132	277996.71	6128986.36	-9999	22.09			-9999	3374	23/10/1945	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662808133	275861.89	6127428.38	-9999	10.17		DOM	7.4	7190	13/12/1995	0.5	13/12/1995	-9999	<Null>	13/12/1995	20	20
662808134	273862.69	6132988.27	7	13.433317	OPR	DOM	7.7	2113	15/12/1983	1.6	15/12/1983	3.3	15/12/1983	15/12/1983	12.6	12.6
662808159	278498.72	6129884.24	-9999	25.54			-9999	728	6/11/1914	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662808996	273881.94	6131598.15	-9999	4.94		DOM	7.2	2664	21/02/1996	1.5	21/02/1996	-9999	<Null>	21/02/1996	18	18
662808998	277621.9	6129218.24	-9999	19.24	OPR	DOM	-9999	3827	4/04/1997	1	4/04/1997	9.5	4/04/1997	4/04/1997	24	24
662810693	277180.69	6130689.29	14	18.027799			7.4	2058	22/02/1979	1.5	22/02/1979	4.26	22/02/1979	22/02/1979	9.14	9.14
662810992	275387.74	6127185.28	-9999	9.3			7.9	3714	1/03/1985	1	1/03/1985	3	1/03/1985	1/03/1985	20	20
662810994	277323.77	6128602.26	17	24.391655			-9999	2570	3/09/1959	0.14	3/09/1959	2.13	3/09/1959	<Null>	3.96	3.96
662811197	272641.86	6132163.31	-9999	5		DOM	-9999	3804	11/11/2013	12	4/11/1996	4	4/11/1996	4/11/1996	15	15
662811509	275178.69	6132652.25	-9999	10.1			7.5	1945	8/02/1980	-9999	<Null>	-9999	<Null>	1/01/1980	-9999	-9999
662811547	276301.71	6132203.21	-9999	9.15		DOM	7.2	2227	15/02/1995	-9999	<Null>	-9999	<Null>	15/02/1995	18	18
662811550	277816.99	6130498.13	-9999	17.09		DOM	7.4	1222	21/11/1995	0.5	21/11/1995	-9999	<Null>	21/11/1995	24	24
662811586	277646.86	6133198.29	-9999	16.11		DOM	7.1	2014	6/01/1996	1	6/01/1996	-9999	<Null>	6/01/1996	18	18
662811595	273405.69	6132633.29	-9999	4.97			-9999	2270	20/04/1936	7.58	1/01/1936	-9999	<Null>	<Null>	25.91	25.91
662811596	274350.96	6132857.42	-9999	7.95		DOM	-9999	2681	23/09/2003	1.3	23/09/2003	4.5	23/09/2003	23/09/2003	11	12
662811623	277959.76	6133713.3	16.19	21.755524		OBS	7.3	1591	24/02/1988	-9999	<Null>	11.45	21/09/1991	16/06/1981	14	121
662811686	276536.68	6132198.08	-9999	9.81		DOM	-9999	-9999	<Null>	-9999	<Null>	4	<Null>	26/10/1989	13	13
662811748	273663.9	6132906.7	-9999	5.69		DOM	-9999	2245	31/01/2003	1	31/01/2003	9	31/01/2003	31/01/2003	18.2	18.2
662811772	276511.7	6128721.26	-9999	11.98	BKF		-9999	-9999	<Null>	1	26/08/1983	3.3	26/08/1983	26/08/1983	12.8	12.8
662811785	277959.76	6133713.3	16.19	21.755524	BKF	OBS	7.4	1429	24/02/1988	-9999	<Null>	11.45	21/09/1991	25/03/1981	0	121
662811861	276062.75	6128844.22	-9999	8.82			7.4	2058	1/09/1982	0.5	1/09/1982	3	1/09/1982	1/09/1982	15.24	15.24
662811872	276434.72	6133062.25	10	13.72847			7	1608	29/04/1987	0.5	1/04/1987	5.5	29/04/1987	1/04/1987	12.5	12.5
662811893	273547	6131643.13	-9999	4.97		DOM	7.3	2295	1/10/1995	1	1/10/1995	-9999	<Null>	1/10/1995	12	12
662811898	276171.65	6129128.16	-9999	10.48	OPR	DOM	7.1	3576	2/10/1992	-9999	<Null>	2.7	2/10/1992	19/09/1992	15	15

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662811899	277156.13	6133265.97	-9999	14.41		DOM	-9999	2340	20/12/2000	1.25	20/12/2000	9.2	20/12/2000	20/12/2000	17	17
662811937	277949.76	6129140.21	-9999	21.32			-9999	1959	14/09/1949	-9999	<Null>	2.44	14/09/1949	1/01/1949	-9999	5.49
662811941	272961.52	6130423.98	-9999	4.76			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	2.13	2.13
662811942	272752.68	6131490.3	-9999	5			6.7	1955	24/10/1967	-9999	<Null>	-9999	<Null>	<Null>	3.66	3.66
662812034	272861.75	6132423.19	-9999	5		DOM	7.4	2704	2/02/1996	-9999	<Null>	-9999	<Null>	2/02/1996	14	14
662812035	273136.7	6131523.27	4	10.466914			7.6	1692	30/08/1982	0.6	30/08/1982	1.9	30/08/1982	30/08/1982	6	6
662812036	278718.89	6132458.24	-9999	19.69		DOM	-9999	2517	22/10/1998	-9999	<Null>	14	22/10/1998	22/10/1998	21	21
662812037	276441.73	6131178.25	-9999	9.07			-9999	2299	30/11/1944	-9999	<Null>	-9999	<Null>	<Null>	8.53	8.53
662812046	274238.76	6132280.3	-9999	7.03			-9999	-9999	<Null>	-9999	<Null>	2	30/05/1984	30/05/1984	8	8
662812052	275606.67	6132338.11	-9999	8.73		DOM	8.2	1759	1/03/1994	-9999	<Null>	3.6	1/03/1994	1/03/1994	6	6
662812053	277778.75	6131250.3	-9999	14.56			-9999	2313	4/09/1934	-9999	<Null>	4.88	4/09/1934	<Null>	10.36	10.36
662812054	277580.15	6129546.96	-9999	19.36		DOM	-9999	1188	5/03/2001	1	5/03/2001	6.1	5/03/2001	5/03/2001	18	18
662812055	277612	6132071	-9999	12.78		DOM	-9999	1418	19/11/2001	1	19/11/2001	7	19/11/2001	19/11/2001	18	18
662812056	277921.69	6133175.23	-9999	16.93			-9999	3013	28/08/1914	-9999	<Null>	8.38	28/08/1914	<Null>	19.36	19.36
662812059	272908.75	6130376.29	3	6.738517	UKN		7.3	22408	11/11/1982	1.5	11/11/1982	3.3	11/11/1982	11/11/1982	6.6	6.6
662812062	278352.7	6129902.23	-9999	24.57			-9999	871	16/05/1983	0.6	10/05/1983	9.1	10/05/1983	10/05/1983	14.6	14.6
662812099	275983.69	6132609.32	8	13.8979			7.5	302	16/09/1975	0.3	16/09/1975	2.9	16/09/1975	16/04/1972	5	5
662812100	276433.71	6129476.24	-9999	11.82	OPR	DOM	7.4	1373	2/03/1984	0.4	2/03/1984	-9999	<Null>	2/03/1984	18	18
662812129	276372.17	6132114.98	-9999	9.2		DOM	-9999	1867	29/03/2001	0.8	29/03/2001	7.8	29/03/2001	29/03/2001	15	15
662812131	276265.74	6131045.29	-9999	8.54			-9999	2344	<Null>	-9999	<Null>	-9999	<Null>	<Null>	16.76	16.76
662812143	277246.82	6133388.33	-9999	14.42		DOM	6.7	1714	4/04/1996	-9999	<Null>	-9999	<Null>	4/04/1996	18	18
662812151	274231.77	6132093.32	-9999	6.02		DOM	-9999	-9999	<Null>	2	15/11/1995	-9999	<Null>	15/11/1995	12.5	12.5
662812154	276626.87	6129328.24	-9999	13.03		DOM	-9999	3396	8/12/1998	1	8/12/1998	6	8/12/1998	8/12/1998	18	18
662812182	276408.17	6133071.99	-9999	12.14		DOM	-9999	2681	13/04/2000	2	13/04/2000	7	13/04/2000	13/04/2000	17	17
662812277	278124.73	6132152.24	15	20.549519	OPR	DOM	8	1105	13/03/1985	1.25	13/03/1985	8	13/03/1985	13/03/1985	42	42
662812289	277576.89	6130723.26	-9999	14.62		DOM	-9999	1564	3/10/1997	-9999	<Null>	8.4	3/10/1997	3/10/1997	17	18
662812293	274601.79	6132813.18	8	12.725575			-9999	2030	17/09/1951	0.51	17/09/1951	5.18	17/09/1951	<Null>	11.58	11.58

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662812295	272592.7	6131656.25	3	9.886964	UKN		7.2	1021	7/02/1982	1.2	7/02/1982	2.1	7/02/1982	7/02/1982	6	6
662812296	278480.73	6130060.29	-9999	24.45	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	25/02/1983	20	20
662812306	276553.75	6131243.26	8	13.405418	OPR	DOM	7.7	2160	10/03/1985	2.5	10/03/1984	-9999	<Null>	10/03/1984	20	20
662812307	276490.76	6128442.25	-9999	12.05	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/03/1983	-9999	15
662812309	272945.76	6132243.24	5	9.484447	OPR	DOM	7.5	2938	11/03/1988	1	22/09/1987	2.4	11/03/1988	22/09/1987	9	9
662812312	272643.73	6131145.26	3	5.836808			7	6845	5/02/1968	1.26	5/02/1968	2.13	5/02/1968	<Null>	9.14	9.14
662812313	275993.76	6128152.23	-9999	8.95			6.8	12163	20/07/1982	-9999	<Null>	2.13	1/07/1982	1/07/1982	18.29	18.29
662812334	278251.19	6132906.35	-9999	17.21			-9999	2448	24/01/2006	2.5	24/01/2006	12	24/01/2006	24/01/2006	36	36
662812338	278027.73	6130281.26	20	26.987401	OPR	DOM	8	1177	10/07/1985	1	<Null>	7.7	27/02/1985	27/02/1985	18.5	18.5
662812339	274806.17	6133104.02	-9999	10.13		DOM	-9999	1591	21/11/2000	0.8	21/11/2000	6	21/11/2000	21/11/2000	14	16
662812345	274921.51	6128641.8	-9999	4.83	BKF		-9999	11098	18/01/2007	1.5	18/01/2007	-9999	<Null>	18/01/2007	0	10
662812346	274025.71	6132962.23	8	11.734851	OPR	DOM	7.5	2426	29/03/1985	0.5	29/03/1985	2	29/03/1985	29/03/1985	10	10
662812359	276851.95	6130023.26	-9999	13.86		DOM	-9999	827	28/01/1997	-9999	<Null>	6.8	28/01/1997	28/01/1997	14	14
662812361	275227.7	6132102.24	-9999	8.55			-9999	2084	18/08/1934	-9999	<Null>	7.32	18/08/1934	<Null>	9.45	9.45
662812363	276231.69	6128156.29	-9999	10.15	OPR	DOM	7.4	4049	12/04/1989	-9999	<Null>	8	12/04/1989	1/01/1989	11	11
662812366	276692.72	6132355.3	-9999	10.75			-9999	2159	26/09/1949	7.58	1/01/1949	-9999	<Null>	1/01/1932	39.62	39.62
662812372	278056.75	6130369.21	-9999	20.18			-9999	971	21/10/1914	-9999	<Null>	-9999	<Null>	<Null>	42.7	42.7
662812376	276616.82	6128563.44	-9999	12.9		DOM	-9999	9574	28/12/1996	-9999	<Null>	4.5	28/12/1996	28/12/1996	15	15
662812386	275936.77	6132729.27	9	12.352373			5.9	938	13/09/1983	1.6	13/09/1983	1.8	13/09/1983	13/09/1983	7.3	7.3
662812471	276596.83	6131578.31	-9999	8.98		DOM	-9999	2036	23/02/1998	-9999	<Null>	4.5	23/02/1998	23/02/1998	13.5	13.5
662812477	273716	6131658	-9999	4.94		DOM	-9999	1027	6/02/2002	1	6/02/2002	2.8	6/02/2002	6/02/2002	7	7
662812479	278206.9	6132408.3	-9999	15.88		DOM	-9999	1867	29/11/1997	0.5	29/11/1997	10	29/11/1997	29/11/1997	30	30
662812483	278161.74	6129498.23	-9999	22.77			-9999	1385	29/09/1934	-9999	<Null>	-9999	<Null>	<Null>	7.62	7.62
662812486	277286.59	6129698.34	-9999	16.85		DOM	6.8	977	24/11/1994	-9999	<Null>	-9999	<Null>	24/11/1994	15	15.5
662812488	276681.74	6130088.14	-9999	12.66		DOM	7	1172	3/05/1993	-9999	<Null>	-9999	<Null>	15/04/1993	24	24
662812531	274006.69	6127825.25	-9999	5			7.9	1027	26/03/1974	-9999	<Null>	-9999	<Null>	<Null>	2.44	2.44
662812537	276602.71	6131151.22	9	13.338366			7	2615	30/01/1968	0.3	30/01/1968	3.96	30/01/1968	<Null>	6.1	6.1

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662812562	279065.75	6130731.23	-9999	28.07			-9999	2199	6/02/1935	-9999	<Null>	-9999	<Null>	<Null>	12.8	12.8
662812664	274251.19	6132402.03	-9999	7.64		DOM	-9999	2380	31/01/2001	1.5	31/01/2001	5.2	31/01/2001	31/01/2001	12	12
662812800	275104.76	6132547.31	8	14.752134			7	408	23/12/1971	2.53	23/12/1971	6.1	23/12/1971	1/01/1968	7.62	7.62
662812804	275891.74	6132716.29	-9999	10.02			-9999	871	13/07/1934	-9999	<Null>	3.05	13/07/1934	<Null>	18.29	18.29
662812822	277569.11	6131133.04	-9999	12.71		DOM	7.4	1680	23/02/2005	1	29/09/2000	7	29/09/2000	29/09/2000	19.5	19.5
662812829	277603.77	6128440.27	-9999	19.69			7.2	4640	21/02/1979	0.13	26/02/1979	4	26/02/1979	26/02/1979	12	12
662812855	277291.85	6129838.21	-9999	16.88		DOM	7.3	523	19/12/1995	1	19/12/1995	-9999	<Null>	19/12/1995	18	18
662812930	273682.72	6131603.31	-9999	4.92	OPR	DOM	7.8	933	20/09/1991	1	20/09/1991	3.5	20/09/1991	20/09/1991	9	9
662812956	276166.74	6129883.27	-9999	10.21			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/10/1983	6	6
662812962	276490.72	6133669.22	-9999	10.52			-9999	1501	24/11/1961	-9999	<Null>	7.32	24/11/1961	<Null>	38.71	38.71
662812970	275553.7	6133299.27	-9999	10			-9999	-9999	<Null>	10.1	1/01/1950	12.19	1/01/1950	<Null>	30.48	30.48
662812974	273506.88	6131543.23	-9999	4.96		DOM	-9999	1524	21/09/1998	-9999	<Null>	2.5	21/09/1998	21/09/1998	12	12
662812978	278027.7	6132699.3	-9999	15.47			-9999	2259	15/10/1914	-9999	<Null>	-9999	<Null>	<Null>	9.14	9.14
662812982	277466.9	6129593.3	-9999	18.46		DOM	-9999	440	18/03/1998	-9999	<Null>	10.5	18/03/1998	18/03/1998	24	24
662812994	278281.92	6132628.23	-9999	16.79		DOM	7	1524	24/05/1995	-9999	<Null>	-9999	<Null>	24/05/1995	18	18
662812995	277250.74	6132819.24	-9999	13.79			-9999	1530	11/08/1934	-9999	<Null>	3.66	11/08/1934	<Null>	8.53	8.53
662812997	275894.75	6131413.25	-9999	7.19			8	1479	1/11/1983	-9999	<Null>	2	28/10/1983	28/10/1983	8	8
662813027	276815.42	6132645.15	-9999	11.72			-9999	1867	23/08/2007	1	23/08/2007	6.6	23/08/2007	23/08/2007	12	12
662813040	274881.63	6128008.29	-9999	5.67		DOM	6.7	8899	25/10/1994	-9999	<Null>	-9999	<Null>	25/10/1994	16.5	16.5
662813056	275471.74	6133245.31	11	15.207204	OPR	DOM	7.5	1973	23/02/1983	1	23/02/1983	5.1	23/02/1983	<Null>	-9999	16.7
662813064	272611.56	6132798.09	-9999	5	RHB	DOM	-9999	3443	22/01/2004	-9999	<Null>	-9999	<Null>	7/11/2003	8.5	14
662813070	274571.35	6131676.29	-9999	12.533889	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	10
662813081	275290.77	6133057.27	10	12.288624			7.5	1770	17/02/1969	1.89	17/02/1969	5.18	17/02/1969	<Null>	22.86	22.86
662813115	275866.89	6132898.27	-9999	10.43		DOM	-9999	2601	<Null>	1	3/01/1997	6.5	3/01/1997	3/01/1997	18	18
662813125	277226.78	6132898.24	-9999	13.75		DOM	7.1	2025	12/11/1994	1	12/11/1994	-9999	<Null>	12/11/1994	22.5	22.5
662813191	276926.89	6132798.24	-9999	12.16		DOM	-9999	1546	18/01/1998	-9999	<Null>	6	18/01/1998	18/01/1998	12	12
662813192	276452.69	6130988.27	-9999	9.19			-9999	2156	25/05/1937	-9999	<Null>	3.05	25/05/1937	<Null>	9.14	9.14

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662813221	274559.03	6128083.79	-9999	5.03	BKF	DOM	-9999	6389	19/10/2001	-9999	<Null>	2.4	19/10/2001	19/10/2001	0	10
662813228	275647.72	6133346.31	-9999	10.01			-9999	1430	1/01/1950	11.37	1/01/1950	10.67	1/01/1950	<Null>	36.58	36.58
662813232	276770.75	6132693.31	-9999	11.39			7.7	628	7/08/1975	-9999	<Null>	3.2	7/08/1975	<Null>	3.7	3.7
662813237	277180.77	6129619.28	16	21			7	1320	14/11/1967	3.79	14/11/1967	4.88	14/11/1967	<Null>	8.84	8.84
662813241	273111.65	6131483.13	-9999	4.99		DOM	7	1906	10/02/1995	0.75	10/02/1995	-9999	<Null>	10/02/1995	6	6
662813264	278146.95	6132163.1	-9999	15.24		DOM	7.1	1384	26/05/1995	-9999	<Null>	11.1	26/05/1995	26/05/1995	18	18
662813271	278280.71	6129852.31	-9999	24.32	OPR	DOM	7.5	517	24/01/1983	1	24/01/1983	5.7	24/01/1983	24/01/1983	-9999	13.7
662813273	274936.88	6131818.13	-9999	6.83		DOM	7.6	2510	19/10/1995	2	19/10/1995	-9999	<Null>	19/10/1995	16	16
662813274	275954.71	6132918.29	-9999	10.65			-9999	2399	30/11/1944	-9999	<Null>	-9999	<Null>	<Null>	6.1	6.1
662813275	274021.71	6127680.21	-9999	4.9	BKF		-9999	-9999	<Null>	-9999	<Null>	1.8	13/09/1983	13/09/1983	7.9	7.9
662813287	275901.88	6132903.12	-9999	10.49		DOM	7.1	2488	3/01/1995	-9999	<Null>	-9999	<Null>	3/01/1995	10.5	15
662813293	277511.61	6132933.27	-9999	15.09		DOM	7.1	2132	13/12/1994	-9999	<Null>	-9999	<Null>	13/12/1994	15	15
662813316	272911.82	6132453.41	-9999	5		DOM	7.2	2688	10/11/1992	-9999	<Null>	11	10/11/1992	7/11/1992	11.5	11.5
662813363	276659.76	6130450.46	-9999	18.014181			-9999	-9999	<Null>	-9999	<Null>	5.3	19/01/2015	19/01/2015	9	9
662813394	278226.85	6132573.28	-9999	16.34		DOM	7.1	1239	25/05/1995	-9999	<Null>	11.4	25/05/1995	25/05/1995	18	18
662813395	274177.6	6132290.15	-9999	7.18		DOM	-9999	860	24/08/2003	2	24/08/2003	4.9	24/08/2003	24/08/2003	14	14
662813397	272456.72	6131863.32	-9999	4.2		DOM	6.8	3145	4/01/1995	-9999	<Null>	-9999	<Null>	4/01/1995	7.8	7.8
662813435	278251.7	6134204.29	-9999	15.36			-9999	1170	15/02/1949	7.33	15/02/1949	12.04	15/02/1949	15/02/1949	27.61	27.61
662813438	272837.76	6131605.3	-9999	4.98			8.2	1455	5/12/1967	-9999	<Null>	-9999	<Null>	<Null>	3.05	3.05
662813452	278009	6132808	-9999	16.04		DOM	7	2025	21/01/1996	0.5	21/01/1996	-9999	<Null>	21/01/1996	24	24
662813486	276166.76	6131108.24	-9999	8.2			7	1830	27/11/1967	-9999	<Null>	2.13	27/11/1967	<Null>	4.88	4.88
662813522	275659.7	6128642.28	-9999	7.34			7.3	5181	9/05/1988	0.95	26/02/1988	3	9/05/1988	26/02/1988	11	11
662813540	277276.18	6133945.87	-9999	25.068983	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	23/10/2014	0	25
662813564	276147.77	6130822.82	-9999	8.76		DOM	-9999	2069	15/07/2004	1.5	15/07/2004	-9999	<Null>	15/07/2004	25	25
662813571	273291.73	6132447.31	-9999	4.98			-9999	4290	2/03/1961	-9999	<Null>	1.83	2/03/1961	<Null>	2.59	2.59
662813575	277956.82	6132253.16	-9999	14.26		DOM	7.5	1591	28/12/1994	-9999	<Null>	-9999	<Null>	28/12/1994	16.5	16.5
662813590	273723.76	6132566.25	-9999	5.1	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	0	<Null>	9/02/1992	10	10

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662813591	272539.74	6132134.24	-9999	5			6.7	3137	16/01/1983	-9999	<Null>	-9999	<Null>	16/01/1983	8.23	8.23
662813607	275207.29	6132580.47	-9999	10.06			-9999	2036	11/09/2007	1	11/09/2007	4	11/09/2007	11/09/2007	10	10.5
662813621	274816.89	6128328.25	-9999	4.93		DOM	7.1	7924	6/09/1996	1	6/09/1996	-9999	<Null>	6/09/1996	12	12
662813630	275647.73	6133256.29	11	8.026464			-9999	-9999	<Null>	10.1	1/01/1950	3.05	1/01/1950	<Null>	10.97	10.97
662813639	277340.77	6131264.27	-9999	11.43			8	2372	23/10/1973	-9999	<Null>	2.74	22/10/1973	<Null>	4.88	4.88
662813718	277568.74	6129629.3	-9999	18.99		DRN	7.8	1121	20/08/1986	-9999	<Null>	6.1	20/08/1986	1/07/1986	41.6	41.6
662813722	273634.17	6131680.03	-9999	4.95		DOM	-9999	1116	25/04/2001	-9999	<Null>	1.86	25/04/2001	25/04/2001	4	4
662813723	275936.9	6132448.22	-9999	9.22		IRR	-9999	-9999	<Null>	-9999	<Null>	4.5	19/12/1997	19/12/1997	8	8
662813726	276106.99	6129603.2	-9999	10.1		DOM	-9999	-9999	<Null>	-9999	<Null>	5	14/04/1996	14/04/1996	9	9
662813826	275326.83	6127903.27	-9999	7.28	OPR	DOM	-9999	6332	19/04/1997	1	26/04/1997	6	26/04/1997	26/04/1997	22	22
662813828	273185.7	6131523.27	4	10.672813			8	1861	30/09/1982	0.7	30/09/1982	1.8	30/09/1982	30/09/1982	5.1	5.1
662813846	277001.83	6133518.22	-9999	13.15		DOM	-9999	1788	18/01/1999	1	18/01/1999	10	18/01/1999	18/01/1999	18	20
662813848	278603.08	6133247.08	-9999	19.89			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	6/01/2005	20	20
662813849	277831	6133940	-9999	19.510313			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	12/08/2013	16	16
662813853	277081.75	6129393.31	-9999	15.41			-9999	-9999	<Null>	-9999	<Null>	6	1/04/1985	1/04/1985	9.5	9.5
662813863	275403.69	6132354.32	8	11.729623			7.2	2171	8/03/1983	1.5	8/03/1983	3.04	8/03/1983	8/03/1983	9.1	9.1
662813864	277761.72	6131653.36	-9999	13.24		DOM	8.2	955	31/01/1994	2.5	24/01/1994	-9999	<Null>	24/01/1994	14	14
662813868	275686.72	6129208.26	-9999	5.72			7	2030	8/11/1967	0	8/11/1967	4.62	8/11/1967	<Null>	4.72	4.72
662813899	272966.91	6131543.25	-9999	5		DOM	-9999	2352	23/05/1997	0.76	23/05/1997	2.6	23/05/1997	23/05/1997	5.7	5.7
662813909	272617.7	6131030.28	3	7.07368			9.5	994	13/05/1982	1.25	13/05/1982	1.8	13/05/1982	13/05/1982	6	6
662813912	276026.83	6131428.25	-9999	7.57		DOM	-9999	1939	3/03/1997	1	3/03/1997	7.3	3/03/1997	3/03/1997	20	20
662813913	276797.73	6130775.27	10	16.313012			7.6	2727	2/04/1987	0.3	1/02/1987	4	2/04/1987	1/02/1976	11	11
662813924	274952.76	6132260.3	-9999	8.55	OPR	DOM	7.6	1912	18/09/1990	-9999	<Null>	7	16/05/1990	18/04/1990	14	14
662813941	276684.07	6128801.81	-9999	13.41		DOM	-9999	1867	27/07/2002	0.5	27/07/2002	15	27/07/2002	27/07/2002	29	29
662813957	276222.73	6132162.31	-9999	8.87			6.5	1955	23/09/1968	-9999	<Null>	-9999	<Null>	<Null>	7.32	7.32
662813965	276306.84	6132128.41	-9999	9.05		DOM	7.2	1872	10/07/1995	-9999	<Null>	-9999	<Null>	10/07/1995	12	12
662814039	272923.75	6130412.3	2	7.9064	OPR	DOM	7.3	12163	19/10/1988	0.5	5/07/1988	3	19/10/1988	5/07/1988	12	12

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662814040	278127.47	6133988	17.59	17.66	OPR	OBS	7.6	1620	22/10/1987	0	22/10/1987	13.08	13/09/2018	22/10/1987	112.6	112.6
662814041	275990.1	6131420	-9999	7.47		DOM	-9999	1614	13/08/2001	-9999	<Null>	4.5	1/07/2001	1/07/2001	8.84	8.84
662814045	272745.75	6130939.23	-9999	5			7.9	2290	5/03/1984	-9999	<Null>	2.25	7/03/1984	7/03/1984	4.2	4.2
662814057	276886.85	6132978.07	-9999	12.85		DOM	7.1	2103	9/01/1996	-9999	<Null>	-9999	<Null>	9/01/1996	18	18
662814098	278450.71	6132291.24	-9999	17.64		STK	7.3	2019	9/05/1988	0.98	4/12/1987	8.5	9/05/1988	4/12/1987	20.1	20.1
662814099	273669.69	6132719.31	6	11.469927	OPR	DOM	7.4	1133	20/10/1989	1.2	<Null>	4.1	20/10/1989	<Null>	11.2	11.2
662814100	277876.8	6132348.33	-9999	14.02		DOM	7.1	1726	15/07/1994	-9999	<Null>	-9999	<Null>	7/06/1994	15.5	15.5
662814185	276355.71	6131995.3	8	10.327612			7.5	1984	24/03/1986	1.2	28/03/1986	3	16/04/1986	28/03/1986	9.1	9.1
662814192	274971.9	6132418.28	-9999	8.86		DOM	-9999	2301	7/02/1998	0.5	20/12/1997	4.5	20/12/1997	20/12/1997	13	22
662814242	275067.72	6128169.28	-9999	5.81	OPR	DOM	7.5	5946	9/03/1992	-9999	<Null>	3	9/03/1992	22/02/1992	12	12
662814278	278684.7	6130464.27	-9999	24.13			-9999	3446	5/11/1934	-9999	<Null>	2.13	5/11/1934	1/01/1934	13.41	13.41
662814333	277081.89	6130528.26	-9999	14.03		DOM	-9999	1474	1/01/1999	-9999	<Null>	7.5	8/01/1999	8/01/1999	15	15
662814345	277821.69	6133396.23	-9999	17	OPR	DOM	7.5	1934	10/04/1989	-9999	<Null>	10.8	10/04/1989	1/02/1989	12	12
662814350	278155.72	6132152.21	16	20.925894	OPR	DOM	-9999	-9999	<Null>	1.25	<Null>	6.1	15/03/1985	15/03/1985	12.8	12.8
662814355	276304.69	6132895.24	-9999	11.23			-9999	3117	20/07/1934	-9999	<Null>	-9999	<Null>	20/07/1934	12.19	12.19
662814356	272446.76	6130327.27	3	7.992535			7.6	371	17/11/1987	1	25/09/1987	1.8	17/11/1987	25/09/1987	5.1	5.1
662814357	276406.83	6131528.26	-9999	8.57		DOM	-9999	999	11/05/1999	1	11/05/1999	5.4	11/05/1999	11/05/1999	12	12
662814359	274856.9	6132533.32	-9999	7.67		DOM	-9999	2132	30/01/1999	1	30/01/1999	4.5	30/01/1999	30/01/1999	14	14
662814395	274811.66	6133118.39	-9999	10.1			7.1	994	24/09/1993	0.303	24/09/1993	-9999	<Null>	24/09/1993	8	8
662814396	274591.77	6132856.23	8	11.831243			-9999	2575	16/01/1952	0.61	16/01/1952	5.18	16/01/1952	<Null>	-9999	7.62
662814409	273541.87	6132498.25	-9999	5		DOM	-9999	1423	19/12/1997	-9999	<Null>	3.3	19/12/1997	19/12/1997	12	12
662814411	275861.15	6132897.98	-9999	10.43		DOM	-9999	2177	23/12/2000	1	23/12/2000	5.4	23/12/2000	<Null>	12	15
662814432	274896.84	6128158.29	-9999	5.37		DOM	-9999	6925	14/01/1999	1	15/01/1999	2	15/01/1999	15/01/1999	12	12
662814502	277138.77	6129872.21	-9999	15.58	OPR	DOM	7.5	547	25/10/1982	4	25/10/1982	6	25/10/1982	25/10/1982	18.2	18.2
662814503	276324.73	6128021.27	-9999	10.71	OPR	DOM	7.2	5298	22/11/1991	-9999	<Null>	4.5	22/11/1991	22/11/1991	20	20
662814508	273439.71	6131741.25	4	9.30954	OPR	DOM	6.9	1117	4/04/1985	1	4/04/1985	2.1	4/04/1985	4/04/1985	5.18	5.18
662814635	277382.76	6131390.28	-9999	11.91			7.6	1586	10/09/1974	-9999	<Null>	4.57	10/09/1974	<Null>	6.1	6.1

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662814769	278421.89	6133053.3	-9999	18.56		DOM	-9999	1839	9/03/1999	1	9/03/1999	14.4	9/03/1999	9/03/1999	24	24
662814965	278573.7	6134322.32	20	25.864159			7.24	2499	28/09/2016	3.79	1/01/1914	-9999	<Null>	1/01/1914	18.29	18.29
662814970	276859.69	6132705.25	11	14.596527			-9999	3031	4/10/1949	1.26	4/10/1949	3.96	4/10/1949	<Null>	7.32	7.32
662814971	274390.74	6132748.26	-9999	8.13			-9999	2845	23/10/1941	-9999	<Null>	3.66	23/10/1941	<Null>	17.37	17.37
662815112	274066.69	6132314.19	8	13.378232	OPR	DOM	7.3	1845	15/11/1982	1	15/11/1982	3.6	15/11/1982	15/11/1982	8.2	8.2
662815120	273156.37	6132463.58	-9999	4.99	BKF	IRR	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	30/09/2002	0	20
662815121	278116.91	6132278.25	-9999	15	ABD	DOM	7.1	1105	27/05/1995	-9999	<Null>	9.9	27/05/1995	27/05/1995	0	18
662815141	276239.73	6130816.22	7	13.065165	OPR	DOM	-9999	-9999	<Null>	1.5	21/11/1983	2	21/11/1983	21/11/1983	13	13
662815193	277227.7	6133040.23	13	16.857136	OPR	DOM	7.4	1832	5/09/1983	0.5	18/08/1983	6.5	18/08/1983	18/08/1983	10	10
662815198	278081.87	6132268.18	-9999	14.86		DOM	6.9	1440	26/05/1995	-9999	<Null>	11	26/05/1995	26/05/1995	18	18
662815200	273072.18	6130804.06	-9999	4.81		DOM	-9999	3597	8/06/2000	-9999	<Null>	3	8/06/2000	8/06/2000	5	5
662815204	276101.88	6129208.25	-9999	10.34		DOM	-9999	3246	25/01/1999	1	25/01/1999	4.5	25/01/1999	25/01/1999	18	18
662815235	275726.75	6129208.25	-9999	6.13			8	1928	19/03/1986	-9999	<Null>	3.24	16/06/1986	1/12/1985	-9999	8
662815262	273671.36	6133017.09	-9999	5.25			-9999	1923	22/02/2008	1	22/02/2008	5.7	22/02/2008	22/02/2008	27	27
662815384	275772.72	6129717.31	-9999	6.32			7.8	991	17/11/1987	1.2	3/10/1987	2.7	17/11/1987	3/10/1987	9	9
662815386	277106.66	6128628.37	-9999	16.11		DOM	6.6	13623	30/03/1994	-9999	<Null>	-9999	<Null>	15/03/1994	24	24
662815392	274002	6131551	4	8.664378	OPR	IRR	7.6	2216	16/01/1985	0.25	16/01/1985	3	16/01/1985	16/01/1985	9.1	9.1
662815401	276581.63	6129843.27	-9999	12.45		DOM	7.3	1429	7/01/1995	-9999	<Null>	-9999	<Null>	7/01/1995	23.5	23.5
662815402	276276.71	6129968.1	-9999	10.78		DOM	7.3	1362	17/10/1994	-9999	<Null>	-9999	<Null>	17/10/1994	16.5	16.5
662815416	278745.69	6130406.34	-9999	28.340454			-9999	-9999	<Null>	-9999	<Null>	14.6	17/02/2016	17/02/2016	19	19
662815440	273142.69	6130510.32	3	7.472436	OPR	DOM	7.3	13099	15/11/1978	0.75	15/11/1978	3	15/11/1978	15/11/1978	9.5	9.5
662815503	275731.55	6128888.13	-9999	6.54		DOM	-9999	4280	28/05/2003	1.3	28/05/2003	4	28/05/2003	28/05/2003	15	15
662815506	275786.18	6132614.98	-9999	9.77		DOM	-9999	2454	29/01/2000	0.5	29/01/2000	10	29/01/2000	29/01/2000	30	30
662815510	277521.63	6131888.26	-9999	12.43		DOM	8.3	1440	2/01/1995	-9999	<Null>	-9999	<Null>	2/01/1995	14	14
662815525	273721.85	6132783.43	-9999	5.32		DOM	7.4	1396	17/11/1996	-9999	<Null>	4.1	17/11/1996	17/11/1996	8.3	8.3
662815605	278091.72	6132333.13	-9999	14.99		DOM	7.4	1440	3/10/1995	-9999	<Null>	10.2	3/10/1995	3/10/1995	18	18
662815608	272911.72	6130936.25	-9999	4.95	OPR	DOM	7.4	4783	20/09/1991	1	7/09/1991	2.1	20/09/1991	7/09/1991	5.8	5.8

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662815609	277547.72	6133151.26	15	19.98858			-9999	2126	26/06/1983	0.25	1/06/1983	9.1	1/06/1983	1/06/1983	11.6	11.6
662815610	276932.12	6132342.01	-9999	11.33		DOM	-9999	1726	27/12/2000	1	27/12/2000	6	27/12/2000	27/12/2000	16	18
662815631	276566.84	6131373.23	-9999	9.31		DOM	-9999	2329	3/12/1998	-9999	<Null>	5	3/12/1998	3/12/1998	13.5	13.5
662815632	277801.74	6132803.36	-9999	15.69		DOM	7.4	2177	28/03/1995	-9999	<Null>	-9999	<Null>	28/03/1995	18	18
662815633	276191.8	6129383.28	-9999	10.83		DOM	7.1	1804	23/01/1996	-9999	<Null>	-9999	<Null>	23/01/1996	20	20
662815714	278115.75	6133432.24	-9999	18.17			7.2	2443	15/01/1985	-9999	<Null>	3	15/01/1985	15/01/1985	14	14
662815715	276991.83	6132153.27	-9999	11.01		DOM	-9999	1698	10/06/1997	0.8	10/06/1997	5	10/06/1997	10/06/1997	12	12
662815731	272371.96	6132278.35	-9999	5		DOM	6.6	4980	7/02/1996	1	7/02/1996	-9999	<Null>	7/02/1996	12	12
662815733	273902.74	6131563.25	4	9.475567	OPR	DOM	7.6	1697	8/05/1989	1.2	5/04/1989	2.1	8/05/1989	5/04/1989	12	12
662815734	274791.91	6127638.22	-9999	6.92		DOM	-9999	4031	20/11/1999	-9999	<Null>	3	15/09/1999	15/09/1999	12	12
662815738	278679.69	6130561.27	-9999	23.01	BKF		-9999	-9999	<Null>	-9999	<Null>	10.8	24/01/1984	24/01/1984	16.5	16.5
662815794	276054.73	6129312.21	-9999	10.23			7.8	1284	10/12/1985	1.25	10/12/1985	4.12	16/06/1986	10/12/1985	-9999	12.2
662815796	272562.76	6131665.28	3	10.74724	OPR	DOM	7.3	1149	3/09/1982	1	3/09/1982	2	3/09/1982	3/09/1982	6	6
662815803	277791.66	6132778.14	-9999	15.53		DOM	7	1984	6/02/1995	-9999	<Null>	-9999	<Null>	6/02/1995	15	15
662815826	277429.14	6131857.98	-9999	11.97		DOM	-9999	1642	15/04/1998	0.4	15/04/1998	7.5	15/04/1998	15/04/1998	18	18
662815857	272800.72	6132568.31	23.62	23.68	BKF		7.5	2482	3/07/1983	-9999	<Null>	-9999	<Null>	<Null>	0	5
662815859	277253.77	6130683.3	-9999	14.36	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	19/08/1986	0	-9999
662815862	276171.75	6133608.47	-9999	10.51		DOM	6.7	1222	29/11/1994	-9999	<Null>	-9999	<Null>	29/11/1994	20.5	20.5
662815873	278865	6130940	-9999	24.26		IRR	-9999	-9999	<Null>	0.375	17/06/2004	22.5	17/06/2004	17/06/2004	44	44
662815890	275074.7	6131678.23	5	9.862651	OPR	DOM	7.8	2426	28/11/1989	2.1	15/11/1989	2.3	28/11/1989	15/11/1989	12	12
662815901	273012.76	6131747.29	4	11.497067	OPR	DOM	-9999	6692	25/01/1990	0.2	4/12/1989	3	25/01/1990	4/12/1989	6	6
662815916	277200.7	6130109.26	16	20	OPR	DOM	7.3	1067	9/01/1985	0.5	9/01/1985	6	9/01/1985	9/01/1985	20	20
662815918	277927.73	6129099.27	-9999	21.26			-9999	3945	17/07/1945	-9999	<Null>	6.4	17/07/1945	<Null>	10.67	10.67
662815924	276750.7	6129369.23	-9999	13.67	OPR	DOM	7.5	4309	14/05/1992	1.2	7/05/1992	5	14/05/1992	7/05/1992	15.4	15.4
662815926	277806.84	6130228.16	-9999	19.26		DOM	7.2	1266	23/02/1993	-9999	<Null>	-9999	<Null>	10/02/1993	24	24
662815928	277817.72	6130438.32	18	23.338431	OPR	DOM	7.4	1832	12/08/1988	0.2	1/07/1988	5.3	12/08/1988	1/07/1988	12	12
662815941	275732.71	6131989.23	7	13			6.7	3250	5/10/1965	1.26	5/10/1965	2.44	5/10/1965	<Null>	9.14	9.14

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662815943	277395.72	6128327.31	-9999	18.61	OPR	DOM	7.2	5422	24/10/1992	0.75	24/10/1992	3.2	24/10/1992	24/10/1992	13.1	13.1
662815944	278151.86	6132168.1	-9999	15.28		DOM	7.2	1278	27/05/1995	0.3157	27/05/1995	11.1	27/05/1995	27/05/1995	18	18
662815955	278422.69	6130749.27	-9999	19.41			-9999	3003	30/10/1931	-9999	<Null>	8.53	30/10/1931	1/10/1931	-9999	20.42
662815956	274934.69	6133149.28	-9999	10.05			8	2966	17/08/1970	-9999	<Null>	-9999	<Null>	<Null>	-9999	9.14
662815994	275103.77	6132550.28	8	14.741646			7	408	23/12/1971	2.53	23/12/1971	6.1	23/12/1971	<Null>	7.62	7.62
662816008	275317.68	6132279.28	-9999	9.5			7.3	1804	7/02/1985	-9999	<Null>	-9999	<Null>	<Null>	6.1	6.1
662816017	276546.76	6129308.18	-9999	12.59		DOM	7	1945	5/04/1994	-9999	<Null>	4.6	12/04/1994	12/04/1994	20	20
662816050	273608.7	6132922.26	-9999	5.3	OPR	DOM	7.1	2493	29/10/1992	1	23/10/1992	4	29/10/1992	23/10/1992	12	12
662816051	274855.73	6127721.27	-9999	6.69	OPR	DOM	7.8	5994	6/02/1989	1.2	21/01/1988	2.2	6/02/1989	21/01/1988	9.1	9.1
662816079	276624.66	6130977.88	-9999	9.84		DOM	-9999	1423	13/12/2001	-9999	<Null>	9	13/12/2000	13/12/2000	29	29
662816080	275275.74	6132308.21	7	12			-9999	2598	13/08/1934	12.63	1/01/1934	-9999	<Null>	<Null>	10.67	10.67
662816149	274751.32	6127354.32	-9999	6.44			-9999	-9999	<Null>	0.3	24/02/2008	5.6	24/02/2008	24/02/2008	10	12
662816169	277786.71	6129580.23	-9999	20.6	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	9	1/06/1991	1/06/1991	11	11
662816170	273771.91	6132903.33	-9999	6.05		DOM	7.2	2075	28/06/1995	2.5	28/06/1995	-9999	<Null>	28/06/1995	14	14
662816176	277260.77	6132063.27	11	15.62219			7.9	1889	1/11/1983	0.1	1/08/1983	4.6	1/08/1983	1/08/1983	12.5	12.5
662816177	277163.74	6132293.22	-9999	12.13			-9999	2330	7/10/1914	-9999	<Null>	-9999	<Null>	<Null>	9.14	9.14
662816178	274322.76	6132817.28	-9999	7.78	OPR	DOM	7.3	2008	10/12/1991	1.2	10/12/1991	4	10/12/1991	10/12/1991	12	12
662816180	273190.77	6131584.22	4	8.86087	OPR	DOM	7.2	1687	24/09/1982	0.8	24/09/1982	1.9	24/09/1982	24/09/1982	6	6
662816187	275968.98	6131467.09	-9999	7.32			-9999	1895	24/02/1997	-9999	<Null>	-9999	<Null>	<Null>	8	8
662816239	277036.85	6128258.27	-9999	16.21		DOM	-9999	5880	15/11/1997	0.5	15/11/1997	9	15/11/1997	15/11/1997	30	30
662816330	272769.14	6132476.95	-9999	5		DOM	-9999	3098	12/09/2000	-9999	<Null>	2.7	12/09/2000	12/09/2000	12	12
662816331	274835.72	6131809.31	6	10.984117			-9999	1601	26/10/1959	2.53	26/10/1959	3.05	26/10/1959	<Null>	12.8	12.8
662816332	279005	6130791	-9999	26.61	ABD	IRR	-9999	1939	17/06/2004	-9999	<Null>	-9999	<Null>	15/06/2004	0	50
662816335	273798.76	6133122.22	-9999	5.27			7	770	2/11/1967	-9999	<Null>	3.35	8/11/1967	<Null>	7.62	7.62
662816336	273694.23	6132656.99	-9999	5.09		DOM	-9999	1519	8/04/2002	1	8/04/2002	4	8/04/2002	8/04/2002	13.5	13.5
662816337	276081.72	6131523.17	-9999	7.55		DOM	7.3	927	3/08/1994	4	3/08/1994	-9999	<Null>	3/08/1994	12	12
662816338	277178	6131028	-9999	12.79		DOM	7.3	807	30/04/2012	-9999	<Null>	-9999	<Null>	21/12/1992	15	15

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662816339	277551.9	6133013.28	-9999	15.41		DOM	-9999	1962	22/04/1997	-9999	<Null>	10.5	22/04/1997	22/04/1997	15	18
662816340	275659.74	6131867.23	-9999	7.17			-9999	4012	22/10/1946	-9999	<Null>	3.05	22/10/1946	<Null>	15.24	15.24
662816341	275208.16	6132732.97	-9999	10.14		DOM	-9999	1995	27/02/2000	1	27/02/2000	7.8	27/02/2000	27/02/2000	15	15
662816342	272617.73	6131719.26	-9999	4.05	OPR	DOM	7.9	1484	24/03/1992	-9999	<Null>	1.8	24/03/1992	6/03/1992	6.8	6.8
662816344	278359.58	6133570.3	-9999	18.87		IND	-9999	1535	14/04/2002	2.5	14/04/2002	14	14/04/2002	14/04/2002	28.5	30
662816345	273746.92	6132273.45	-9999	5.2		DOM	-9999	2613	<Null>	2	2/01/1997	4.9	2/01/1997	2/01/1997	18	18
662816383	277188.18	6130341.01	-9999	15.19		DOM	-9999	1883	1/11/2000	-9999	<Null>	9	1/11/2000	1/11/2000	20	20
662816451	275728.74	6132139.31	-9999	8.17			7.4	2301	5/03/1985	-9999	<Null>	3.5	4/03/1985	4/03/1985	5.6	5.6
662816477	276429.7	6133222.3	-9999	12.33			-9999	-9999	<Null>	-9999	<Null>	5.33	29/11/1955	<Null>	10.06	10.06
662816509	273591.91	6131498.16	-9999	4.93		DOM	7.2	2132	17/01/1996	2	17/01/1996	-9999	<Null>	17/01/1996	12	12
662816524	276619.72	6131259.3	8	14.999713			-9999	-9999	<Null>	0.63	20/01/1987	0	20/01/1987	1/01/1987	10	10
662816540	275486.62	6132108.28	-9999	8.17		DOM	7.1	2267	30/03/1994	-9999	<Null>	-9999	<Null>	11/03/1994	15	15
662816554	274624.76	6132360.32	-9999	6.68			-9999	2387	7/06/1949	-9999	<Null>	3.05	7/06/1949	<Null>	-9999	12.19
662816598	274041.72	6133113.25	8	12.616527			-9999	2199	16/03/1936	6.32	16/03/1936	4.57	16/03/1936	<Null>	8.23	8.23
662816599	273362.43	6132533.55	-9999	4.98			-9999	1878	18/01/2007	1.5	18/01/2007	4.1	18/01/2007	18/01/2007	10	10
662816600	277348.97	6129955.74	-9999	16.92		IRR	-9999	816	7/02/2002	0.8	7/02/2002	7	7/02/2002	7/02/2002	21	24
662816616	272774.73	6130645.24	3	8.398243			7.3	2273	31/07/1985	1	<Null>	1.8	31/07/1985	31/07/1985	5	5
662816620	276502.72	6133111.31	-9999	12.52			-9999	1656	1/08/1940	8.84	1/01/1940	-9999	<Null>	1/09/1934	39.32	39.32
662816634	272547.76	6131636.26	3	11	UKN		7.5	1105	3/09/1982	0.5	1/09/1982	2	1/09/1982	1/09/1982	6	6
662816675	273645.76	6131608.28	-9999	4.93			-9999	747	1/01/1979	-9999	<Null>	1.5	1/01/1979	1/01/1979	3.5	3.5
662816676	277726.68	6128548.27	-9999	20.55		DOM	7.3	3770	9/06/1994	0.75	24/10/1992	-9999	<Null>	24/10/1992	13.1	13.1
662816686	274440.74	6128269.99	-9999	4.8			-9999	5081	14/02/2007	-9999	<Null>	3	14/02/2007	14/02/2007	5	5
662816701	275887.74	6129730.24	-9999	7.44			7.4	1362	5/02/1987	0.1	8/12/1986	4	5/02/1987	8/12/1986	8	8
662816722	272682.74	6132199.29	-9999	5	BKF		7.3	4530	13/03/1983	-9999	<Null>	3.2	27/02/1983	27/02/1983	40	40
662816723	277041.89	6132248.28	-9999	11.52		DOM	-9999	1826	10/04/1997	1	10/04/1997	9.5	10/04/1997	10/04/1997	20	20
662816729	273206.69	6132124.3	5	10.199482	OPR	DOM	7.6	849	25/07/1982	1	25/07/1982	2	25/07/1982	25/07/1982	20	20
662816748	275199.75	6132090.23	-9999	8.51			-9999	2144	18/08/1934	-9999	<Null>	7.32	18/08/1934	<Null>	9.45	9.45

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662816778	276631.75	6133648.36	-9999	10.71		DOM	7.3	1782	18/09/1995	1.5	18/09/1995	-9999	<Null>	18/09/1995	24	24
662816783	275547.7	6133186.24	11	9.489946	OPR	DOM	7.4	1906	21/09/1984	1.51	27/07/1984	5.48	27/07/1984	27/07/1984	10.97	10.97
662816808	274694.76	6132498.24	-9999	7.83			-9999	3603	16/03/1951	-9999	<Null>	3.05	16/03/1951	<Null>	-9999	3.66
662816811	277772.02	6131658.16	-9999	13.3		DOM	7.2	1541	25/09/1995	0.5	25/09/1995	-9999	<Null>	25/09/1995	30	30
662816815	274189.57	6132065.57	-9999	5.86		DOM	-9999	2889	11/12/2003	1.875	11/12/2003	5	11/12/2003	11/12/2003	13.5	13.5
662816828	277511.84	6129133.31	-9999	19.12	ABD	DOM	-9999	5954	18/04/1997	-9999	<Null>	-9999	26/06/2018	18/04/1997	0	24
662816830	276571.75	6129388.27	-9999	12.75		DOM	6.7	2284	8/06/1994	-9999	<Null>	-9999	<Null>	29/05/1994	24	24
662816880	277693.15	6129226.05	-9999	19.55		DOM	-9999	3706	24/05/2001	0.25	24/05/2001	8	24/05/2001	24/05/2001	16	16
662816881	276320.75	6129439.28	-9999	11.47			-9999	-9999	<Null>	0.75	24/07/1986	4	25/08/1986	24/07/1986	20	20
662816882	276171.75	6129910.25	8	15.118951			-9999	2387	23/11/1953	3.79	23/11/1953	2.44	23/11/1953	1/01/1935	10.67	10.67
662816883	277830.73	6129202.24	-9999	20.35	OPR	DOM	7.8	1720	1/01/1985	0.4	1/01/1985	7	1/01/1985	1/01/1985	20	20
662816885	276826.68	6130133.31	-9999	13.22			6.89	814	25/01/2016	-9999	<Null>	-9999	<Null>	<Null>	7.62	7.62
662816896	276613.69	6132667.27	-9999	10.58			-9999	2830	24/10/1961	-9999	<Null>	2.74	24/10/1961	<Null>	4.57	4.57
662816903	277548.75	6132024.23	-9999	12.5			-9999	2627	11/09/1934	-9999	<Null>	5.49	11/09/1934	<Null>	7.62	7.62
662816904	276540.7	6131384.24	8	13.590852			6.9	2194	22/01/1987	1.25	19/01/1987	2.1	22/01/1987	19/01/1987	11	11
662816906	276231.83	6129998.19	-9999	10.5		DOM	7	1116	8/11/1994	0.5	8/11/1994	-9999	<Null>	8/11/1994	16.5	16.5
662816907	273751.68	6132428.31	-9999	5.2		DOM	7.2	2397	28/02/1995	-9999	<Null>	-9999	<Null>	28/02/1995	16	16
662816921	278023.74	6129423.28	-9999	21.71			-9999	5469	3/12/1945	0.63	3/12/1945	24.38	3/12/1945	<Null>	27.43	27.43
662816922	278110.72	6129950.29	-9999	22.51			-9999	842	21/10/1914	-9999	<Null>	-9999	<Null>	<Null>	26.2	26.2
662816924	276262.13	6129693	-9999	10.7			-9999	2375	9/10/2001	0.25	3/09/2001	4.9	3/09/2001	3/09/2001	12	12
662816934	277086.96	6128933.13	-9999	15.79		DOM	7.1	6504	15/06/1995	1	15/06/1995	-9999	<Null>	15/06/1995	18.5	18.5
662816937	277636.81	6132308.19	-9999	13.23		DOM	7.5	1614	17/03/1995	1.1	17/03/1995	-9999	<Null>	17/03/1995	15.5	15.5
662816956	273341.74	6131604.29	-9999	5	OPR	DOM	7.2	1177	3/02/1986	1	3/02/1986	1.5	13/03/1986	3/02/1986	4	4
662816958	272615.74	6131065.3	-9999	4.99	OPR	DOM	7.7	600	27/09/1991	1	27/09/1991	1.8	27/09/1991	27/09/1991	5.7	5.7
662816962	278233.15	6131547	-9999	15.76		IND	7.5	2103	21/02/2005	1.2	11/05/2001	10.5	11/05/2001	11/05/2001	16	20.5
662816966	275355.72	6127576.32	-9999	8.1	BKF		7.6	5951	14/05/1992	2	14/04/1992	6	14/05/1992	14/04/1992	15	15
662816967	278687	6133106.9	-9999	20.22			-9999	1541	20/12/2005	0.5	21/12/2005	15.7	21/12/2005	21/12/2005	20	20

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662816977	276031.71	6130086.3	8	14.485374			-9999	2101	14/03/1934	5.05	24/02/1934	4.57	24/02/1934	1/01/1934	9.14	9.14
662817079	273846.86	6131708.28	-9999	4.97		DOM	-9999	1877	<Null>	1.5	17/04/1997	4.8	17/04/1997	17/04/1997	17	17
662817080	276893.85	6129527.28	-9999	13.86		DOM	7	4053	17/05/1995	2	17/05/1995	-9999	<Null>	17/05/1995	16	16
662817088	276140.7	6131921.21	-9999	8.36	OPR	DOM	7.2	1799	1/11/1991	2.5	1/11/1991	4	1/11/1991	1/11/1991	12	12
662817089	275965.69	6131979.3	8	12.595957			-9999	742	1/01/1951	22.73	1/01/1945	-9999	<Null>	1/01/1914	9.14	9.14
662817102	276198.17	6132317.95	-9999	8.87		DOM	-9999	1861	30/01/2001	1	30/01/2001	4.5	30/01/2001	30/01/2001	7.5	7.5
662817106	274821.85	6132008.32	-9999	7.25		DOM	-9999	2448	9/12/1997	1.5	9/12/1997	5	9/12/1997	9/12/1997	13.5	14
662817107	277136.91	6131153.29	-9999	11.63		DOM	-9999	1995	3/01/1998	0.5	3/01/1998	7	3/01/1998	3/01/1998	30	30
662817109	276082.73	6129533.21	-9999	10.23	BKF		8.2	1144	24/03/1992	0.2	9/03/1992	9	24/03/1992	9/03/1992	12	12
662817142	275656.81	6132693.31	-9999	9.97		DOM	7.4	2323	23/10/1996	1.5	23/10/1996	-9999	<Null>	23/10/1996	12	12
662817160	272538.49	6132267.32	-9999	8.163816	BKF		-9999	-9999	<Null>	-9999	<Null>	3	31/07/2014	<Null>	0	5.2
662817174	275864.75	6127754.23	-9999	9.13	ABD		7.7	9941	14/02/1992	-9999	<Null>	15	14/02/1992	9/02/1992	15	15
662817185	274653.7	6132443.29	-9999	7.45			-9999	5777	14/04/1949	-9999	<Null>	3.05	14/04/1949	<Null>	-9999	3.35
662817186	277011.7	6129623.25	-9999	15.05		DOM	7.3	1306	4/04/1995	1	4/04/1995	-9999	<Null>	4/04/1995	22	22
662817187	274366.99	6132860.13	-9999	8.04			-9999	2482	17/01/2007	1	17/01/2007	5.1	17/01/2007	17/01/2007	15.1	15.1
662817188	273717.56	6132098.48	-9999	5.04		DOM	-9999	3161	7/07/2004	1	7/07/2004	4.3	7/07/2004	7/07/2004	10.5	10.5
662817238	278020	6132801	-9999	15.82		DOM	6.9	2295	21/01/1996	0.5	21/01/1996	-9999	<Null>	21/01/1996	24	24
662817239	274336.72	6133103.23	9	13.472131			-9999	1713	3/01/1946	6.32	3/01/1946	5.18	3/01/1946	<Null>	9.14	9.14
662817264	276197.74	6132074.23	-9999	8.71	OPR	IRR	7.6	1923	3/01/1985	1	28/12/1984	6	28/12/1984	28/12/1984	30	30
662817273	274927	6133198	-9999	10.01		DOM	-9999	2058	29/10/2001	0.44	29/10/2001	6	29/10/2001	29/10/2001	30	30
662817274	276900.72	6131688.3	-9999	9.69			-9999	3860	2/01/1958	-9999	<Null>	4.88	2/01/1958	<Null>	-9999	4.88
662817317	275838.77	6129138.3	-9999	7.94			8.2	1687	29/11/1982	1	29/11/1982	2.1	29/11/1982	29/11/1982	10.9	10.9
662817321	272958.46	6132535.58	-9999	5			-9999	1328	5/11/2007	1	5/11/2007	5.4	5/11/2007	5/11/2007	13	13
662817322	276911.81	6132278.18	-9999	11.06		DOM	7.3	1810	9/11/1995	1.5	9/11/1995	-9999	<Null>	9/11/1995	17	17
662817324	276630.76	6132986.24	11	14.848449			-9999	3412	18/09/1934	0.16	18/09/1934	4.57	18/09/1934	<Null>	8.23	8.23
662817325	273497.73	6132516.25	5	11.368794			7	2155	8/11/1967	0.44	8/11/1967	2.74	8/11/1967	<Null>	4.27	4.27
662817326	276284.71	6130808.22	-9999	9.04			6.5	2485	6/01/1969	-9999	<Null>	2.13	6/01/1969	<Null>	6.1	6.1

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662817327	276321.83	6128538.23	-9999	11.2		DOM	-9999	3846	2/03/1998	0.25	26/02/1998	3	26/02/1998	26/02/1998	12	12
662817328	274687.7	6132362.32	-9999	6.36			-9999	4215	14/04/1949	-9999	<Null>	2.29	14/04/1949	<Null>	-9999	4.27
662817329	272315.13	6132693.97	-9999	4.99		DOM	-9999	2432	31/03/2000	-9999	<Null>	5	31/03/2000	31/03/2000	12	12
662817331	276559	6133390	-9999	17.956471	BKF		-9999	-9999	<Null>	-9999	<Null>	8.5	3/03/2016	<Null>	0	-9999
662817332	274038.03	6132299.73	6	15.126875			7.9	1620	12/09/1985	5	<Null>	4.5	12/09/1985	12/09/1985	13	13
662817333	278536.76	6130538.15	-9999	21.75		DOM	7.3	661	25/07/1995	0.5	25/07/1995	-9999	<Null>	25/07/1995	30	30
662817334	272866.71	6130317.3	3	8.123617			-9999	2974	3/12/1959	1.01	3/12/1959	1.22	3/12/1959	<Null>	4.88	4.88
662817335	278403.76	6132286.21	-9999	17.28			7.5	1714	16/06/1993	-9999	<Null>	0	18/12/1986	4/11/1986	20	20
662817363	276316.73	6133217.31	11	14.072164	OPR	DOM	-9999	-9999	<Null>	1.5	22/11/1983	4.2	22/11/1983	22/11/1983	12.8	12.8
662817392	276606.84	6129478.26	-9999	12.7		DOM	7.2	1698	21/12/1993	-9999	<Null>	-9999	<Null>	21/12/1993	21	21
662817410	275933.72	6131516.32	-9999	7.08	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	4	20/04/1991	20/04/1991	10.3	10.3
662817411	277164.03	6131412.94	-9999	17.078276			-9999	1850	2/01/2009	0.33	2/01/2009	7	2/01/2009	2/01/2009	20	20
662817412	276731.73	6130058.17	-9999	13.04		DOM	7	1110	4/03/1996	1	4/03/1996	-9999	<Null>	4/03/1996	12	12
662817413	273523.71	6131723.24	3	9.968552			6.8	4085	15/10/1984	0.25	15/10/1984	2	15/10/1984	15/10/1984	5	5
662817469	278191.67	6132395.85	-9999	15.76		DOM	-9999	1306	12/03/2002	0.8	12/03/2002	11	12/03/2002	12/03/2002	19	19
662817472	277059.76	6130147.22	-9999	14.3			-9999	799	27/11/1940	-9999	<Null>	7.01	27/11/1940	<Null>	9.75	9.75
662817477	275729.73	6129068.24	8	12.805848	ABD	DOM	8	1664	19/04/1991	1.5	4/04/1991	4.3	4/04/1991	4/04/1991	0	10.2
662817478	275174.74	6132690.22	10	14.893037			7.1	2227	24/09/1978	0.82	20/09/1978	6	20/09/1978	20/09/1978	15	15
662817479	272701.99	6131667.87	-9999	4.7		DOM	-9999	702	17/11/2004	0.5	17/11/2004	3	17/11/2004	17/11/2004	6	6
662817504	273079.85	6132440.2	-9999	4.99		DOM	-9999	3563	17/01/2004	1.33	17/01/2004	4.2	17/01/2004	17/01/2004	10.5	10.5
662817533	273848.74	6133053.31	7	13			7.3	1754	13/03/1987	1.25	4/02/1987	3	13/03/1987	4/02/1987	11	11
662817546	277027.76	6131079.26	-9999	11.85	OPR	DOM	7.4	1979	19/07/1989	-9999	<Null>	0	19/07/1989	22/05/1989	12	12
662817549	277406.78	6132808.28	-9999	14.41		DOM	8.2	1714	29/12/1994	-9999	<Null>	-9999	<Null>	29/12/1994	15	15
662817555	273968.72	6131811.31	8	14.903238			7.5	2284	23/01/1979	1.5	23/01/1979	5.48	23/01/1979	23/01/1979	14.32	14.32
662817618	276011.67	6129123.23	-9999	9.71		DOM	6.9	3747	9/02/1995	-9999	<Null>	-9999	<Null>	9/02/1995	20	20
662817620	275381.94	6132688.44	-9999	10.05		DOM	7.2	1979	29/02/1996	1.25	29/02/1996	-9999	<Null>	29/02/1996	10	10
662817621	276150.78	6132113.32	-9999	14.905839			-9999	1901	12/05/2009	3	12/05/2009	6.5	12/05/2009	12/05/2009	15	15

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662817622	275804.72	6133282.23	11	16.104554			-9999	1328	26/08/1914	10.1	1/01/1914	-9999	<Null>	<Null>	12.19	12.19
662817623	273346.77	6132108.35	-9999	5		DOM	7	3937	31/01/1995	1.8	31/01/1995	-9999	<Null>	31/01/1995	10	10
662817644	276129.71	6129798.22	-9999	10.03	OPR	DOM	8	1901	8/05/1989	-9999	<Null>	4	8/05/1989	1/05/1989	10.5	10.5
662817653	274256.76	6133098.14	-9999	8.34		DOM	6.2	2064	1/01/1995	0.8	14/10/1994	-9999	<Null>	14/10/1994	14	14
662817654	273711.76	6133128.17	-9999	4.99		DOM	7.1	2256	20/02/1995	1.5	20/02/1995	-9999	<Null>	20/02/1995	12.5	12.5
662817777	277811.83	6132088.35	-9999	13.67		DOM	7.5	1524	1/06/1995	3	1/06/1995	-9999	<Null>	1/06/1995	24.5	24.5
662817795	277566.81	6131928.21	-9999	12.66		DOM	7.1	512	28/07/1995	0.5	28/07/1995	-9999	<Null>	28/07/1995	30	30
662817796	277595.73	6129474.23	-9999	19.42	OPR	DOM	7.6	1270	10/11/1991	-9999	<Null>	11	10/11/1991	10/11/1991	20	20
662817799	275765.73	6129492.25	-9999	6.13			-9999	-9999	<Null>	0.75	16/05/1979	3	16/06/1986	16/05/1979	14	14
662817810	273726.73	6132664.23	-9999	5.17	OPR	DOM	7.9	1878	23/09/1991	1.5	21/08/1991	3.6	23/09/1991	21/08/1991	10.5	10.5
662817818	275427.01	6127208.34	-9999	9.29	ABD	DOM	-9999	-9999	<Null>	0.35	4/04/1996	-9999	<Null>	4/04/1996	0	19
662817830	277315.74	6130874.28	13.19	17.179439	OPR	DOM	7.4	1973	16/11/1978	1.01	12/11/1978	-9999	12/09/2014	12/11/1978	15	15
662817831	276648.72	6133070.26	11	17.989255			7.3	2295	6/05/1986	0.76	6/05/1986	4	6/05/1986	1/01/1986	11	11
662817833	272866.89	6131713.25	-9999	4.78		DOM	-9999	5234	22/12/1998	1	22/12/1998	3	22/12/1998	22/12/1998	12	12
662817834	275996.76	6131521.31	-9999	7.27			-9999	2541	11/12/1945	-9999	<Null>	4.27	11/12/1945	<Null>	9.75	9.75
662817835	275632.75	6132065.25	-9999	7.84			-9999	2560	14/11/1934	-9999	<Null>	4.88	4/09/1934	1/01/1934	30.48	30.48
662817852	276549.77	6133718.28	-9999	10.18			-9999	1784	13/12/1933	10.1	13/12/1933	3.05	13/12/1933	<Null>	31.39	31.39
662817880	277718.71	6129884.25	-9999	20.09			7.1	783	4/02/1982	-9999	<Null>	7	4/02/1982	4/02/1982	13	13
662817947	276041.73	6132777.24	9	14.974508			7.5	2482	18/09/1981	1.5	18/09/1981	3	18/09/1981	18/09/1981	9	9
662817948	276416.73	6129054.25	-9999	11.42			6.7	2143	1/01/1983	0.5	12/02/1983	4	12/02/1983	12/02/1983	11.5	11.5
662817949	278001.86	6132318.29	-9999	14.52		DOM	-9999	1457	23/01/1999	0.5	23/01/1999	10	23/01/1999	23/01/1999	30	30
662817969	274930.76	6131936.31	7	11.917237	OPR	DOM	-9999	2199	31/01/1984	1.5	31/01/1984	4	31/01/1984	31/01/1984	11	11
662818003	277411.88	6131358.35	-9999	12.04		DOM	7.1	2092	19/07/1996	1.5	19/07/1996	10	19/07/1996	19/07/1996	24	24
662818041	277411.88	6129623.26	-9999	17.87		DOM	-9999	650	27/03/1997	-9999	<Null>	8.2	27/03/1997	27/03/1997	18	18
662818079	278111.71	6130443.25	-9999	20.05			-9999	929	11/08/1934	22.1	15/06/1934	10.06	15/06/1934	4/08/1934	65.23	65.23
662818081	278041.89	6132743.27	-9999	15.76		DOM	7	2216	21/01/1996	0.5	21/01/1996	-9999	<Null>	21/01/1996	24	24
662818093	276203.73	6128800.28	10	14.091143	OPR	DOM	7.8	3023	12/11/1990	1.5	15/09/1990	2.1	12/11/1990	15/09/1990	12	12

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662818106	278023.75	6130238.21	20	26.504994			7.5	2103	1/01/1983	1	1/02/1983	6	1/02/1983	1/02/1983	18.28	18.28
662818107	277216.66	6133178.26	-9999	14.63		DOM	7.2	2443	14/03/1995	1.2	14/03/1995	-9999	<Null>	14/03/1995	15	15
662818108	273126.69	6132268.28	5	11.12298			7.3	3367	17/11/1987	1	22/09/1987	2.4	17/11/1987	22/09/1987	9	9
662818109	278456.74	6130363.28	-9999	22.78		DOM	-9999	-9999	<Null>	0.25	10/12/1992	15	<Null>	10/12/1992	21	21
662818141	278131.81	6129778.21	-9999	23.21		DOM	6.8	1289	16/08/1994	-9999	<Null>	-9999	<Null>	16/08/1994	21	21
662818155	272699.74	6131043.31	-9999	5	OPR	DOM	7.9	750	3/07/1992	-9999	<Null>	3	3/07/1992	27/02/1992	5	5
662818157	276178.76	6129650.25	-9999	10.26	OPR	DOM	7.5	821	10/12/1991	-9999	<Null>	7.5	10/12/1991	10/12/1991	14	14
662818225	275788.77	6132751.27	-9999	10.02			-9999	1999	4/07/1930	-9999	<Null>	-9999	<Null>	<Null>	8.53	8.53
662818233	275516.72	6132981.24	-9999	10.08	OPR	DOM	7.1	2306	24/06/1992	2	24/06/1992	7	24/06/1992	24/06/1992	14.2	14.2
662818236	277375.08	6130984.4	-9999	12.97		DOM	-9999	1810	9/12/2002	2	9/12/2002	6.1	9/12/2002	9/12/2002	18	18
662818284	276726.71	6130151.29	12	18.027526	OPR	DOM	7.7	902	10/04/1985	1	10/04/1985	3	10/04/1985	10/04/1985	22	22
662818364	276346.76	6130913.3	-9999	8.89		DOM	-9999	-9999	<Null>	0.3	14/02/1990	9.14	14/02/1990	14/02/1990	10.66	10.66
662818393	277441.89	6129453.27	-9999	18.05		DOM	-9999	3230	23/05/1996	0.5	23/05/1996	11	23/05/1996	23/05/1996	30	30
662818434	275714.67	6131313.14	-9999	6.68		DOM	7.1	2204	3/05/1993	-9999	<Null>	-9999	<Null>	21/04/1993	15	18
662818447	277941.9	6131878.29	-9999	14.47		DOM	-9999	1856	16/12/1997	-9999	<Null>	9	16/12/1997	16/12/1997	18	18
662818448	273018.69	6132196.22	-9999	5			8	2848	20/03/1972	-9999	<Null>	3.35	20/03/1972	<Null>	6.71	6.71
662818463	273917.72	6131973.32	-9999	5.82			-9999	2909	2/06/1983	1	2/06/1983	1.5	2/06/1983	<Null>	7.3	7.3
662818467	275908.76	6132738.24	9	13.135025	OPR	DOM	-9999	-9999	<Null>	1.25	29/11/1984	2	29/11/1984	29/11/1984	11	11
662818478	277851.29	6132369.74	-9999	13.94			-9999	1692	24/10/2007	1	24/10/2007	9.4	24/10/2007	24/10/2007	17	18
662818479	277251.78	6131053.2	-9999	12.37		DOM	7.4	2194	24/11/1992	1	7/11/1992	-9999	<Null>	7/11/1992	13.5	13.5
662818491	273735.69	6131668.23	4	9.902577	OPR	DOM	7.3	929	14/09/1984	1	14/09/1984	1.8	14/09/1984	14/09/1984	4.3	4.3
662818494	273784.74	6133031.3	7	13.118002	OPR	DOM	7.8	1826	24/10/1985	1.25	24/10/1985	3.7	5/12/1985	24/10/1985	11	11
662818509	276788.73	6130631.31	11	16.19283			-9999	2584	18/09/1934	0.63	18/09/1934	7.62	18/09/1934	<Null>	11.28	11.28
662818553	275801.71	6128233.31	-9999	8.03			6.9	13701	23/03/1983	0.9	23/03/1983	6	23/03/1983	23/03/1983	18.5	18.5
662818598	276507.16	6130652.02	-9999	9.83		DOM	-9999	1474	17/11/1999	0.5	17/11/1999	7	17/11/1999	17/11/1999	25	25
662818651	276063.71	6129233.29	-9999	10.22			7.4	1340	7/04/1983	0.5	17/06/1983	5	17/06/1983	<Null>	-9999	7
662818699	275106.73	6132764.25	10	14			-9999	2230	19/03/1952	1.26	19/03/1952	8.23	19/03/1952	1/01/1951	10.97	10.97

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662818746	274596.88	6132808.4	-9999	9.13		DOM	6.9	2154	15/12/1993	1.2	20/10/1993	-9999	<Null>	20/10/1993	12	12
662818748	276216.12	6132358.02	-9999	8.98		DOM	-9999	1670	30/01/2001	1	30/01/2001	4.5	30/01/2001	30/01/2001	7.5	7.5
662818749	278046.85	6134123.29	-9999	14.99	ABD		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	11.5
662818753	274244.34	6132042.23	-9999	5.61			-9999	1378	4/07/2007	1	3/07/2007	3.3	3/07/2007	3/07/2007	6	7
662818754	276082.73	6129533.21	-9999	10.23	BKF		7.3	1144	24/03/1992	0.4	6/02/1992	6	24/03/1992	6/02/1992	18	18
662818755	276756.87	6130958.31	-9999	10.67		DOM	-9999	1815	2/07/1997	0.25	2/07/1997	4.5	2/07/1997	2/07/1997	13	13
662818757	276766.87	6132463.34	-9999	11.29		DOM	-9999	1094	9/08/1995	0.5	9/08/1995	-9999	<Null>	9/08/1995	30	30
662818773	276170.74	6129236.25	-9999	10.7	OPR	DOM	7	3885	6/02/1989	1.2	21/01/1989	3.5	6/02/1989	21/01/1989	10.6	10.6
662818790	276007.77	6133353.26	11	14.652657			7.5	1664	1/12/1972	12.63	1/12/1972	7.62	1/12/1972	<Null>	12.19	12.19
662818791	272454.05	6130335.81	-9999	5.04			-9999	868	10/11/2007	-9999	<Null>	3	10/11/2007	10/11/2007	5.5	5.5
662818792	275656.68	6127235.3	10	13.956917			-9999	-9999	<Null>	0.4	1/02/1988	5	1/02/1988	1/02/1988	10.5	10.5
662818793	274640.71	6128347.21	-9999	4.98			7.2	816	5/02/1975	-9999	<Null>	0.61	5/02/1975	<Null>	2.44	2.44
662818825	277802.74	6129751.22	-9999	20.73			7.7	882	9/11/1987	1.25	7/11/1987	6.2	9/11/1987	7/11/1987	16.5	16.5
662818854	277492.76	6129582.27	18	20.848563			-9999	428	3/12/1945	1.26	3/12/1945	7.01	3/12/1945	<Null>	11.58	11.58
662818867	277131.74	6129838.3	-9999	15.63	OPR	DOM	7.5	1021	29/10/1992	1	22/10/1992	5.5	29/10/1992	22/10/1992	20	20
662818869	276835.75	6133621.27	-9999	12.26			7.3	2380	1/12/1983	-9999	<Null>	6	1/12/1983	1/12/1983	10.6	10.6
662818927	273069.69	6131564.23	-9999	5			-9999	1670	16/03/1936	-9999	<Null>	-9999	<Null>	<Null>	4.88	4.88
662819173	276516.71	6131647.27	8	15.090697			-9999	1716	22/01/1951	0.44	22/01/1951	3.05	22/01/1951	1/01/1949	5.49	5.49
662819206	272720.7	6131097.22	3	8.652444			7.1	1038	24/04/1986	0.88	19/04/1986	2.7	4/05/1986	19/04/1986	4.8	4.8
662819212	277576.73	6130936.26	-9999	13.38	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	5	18/05/1989	<Null>	8	8
662819217	278121.72	6130125.27	-9999	21.58			-9999	842	20/10/1914	-9999	<Null>	-9999	<Null>	<Null>	36.4	36.4
662819316	273700.76	6131672.25	4	8.520851			8.1	1216	19/10/1988	40	3/03/1988	2	19/10/1988	3/03/1988	8.5	8.5
662819318	273828.69	6131578.29	4	9.971781	OPR	DOM	7.6	1479	8/05/1989	1.2	5/04/1989	2.1	8/05/1989	5/04/1989	11.1	11.1
662819320	276412.73	6132665.4	-9999	10.2		DOM	-9999	1541	13/02/2002	0.8	13/02/2002	5.4	13/02/2002	13/02/2002	16	16
662819321	276316.93	6132638.25	-9999	10.04		DOM	7.1	2369	25/03/1995	3	25/03/1995	-9999	<Null>	25/03/1995	24	24
662819334	277578.7	6133230.26	15	19.284838	OPR	DOM	7.6	1788	17/03/1983	0.6	21/02/1983	10	21/02/1983	21/02/1983	13	13
662819336	276319.74	6131102.22	7	12.27019	OPR	DOM	7.4	1867	1/03/1984	0.5	1/03/1984	-9999	<Null>	1/03/1984	14	14

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662819337	274378.7	6132466.24	8	12.753917	OPR	DOM	7.5	1463	14/12/1982	1.5	14/12/1982	2.1	14/12/1982	14/12/1982	7.3	7.3
662819427	274101.04	6132300.78	-9999	7.08		DOM	6.4	1681	25/02/1993	2.5	24/01/1993	4	25/02/1993	<Null>	-9999	12
662819429	272751.85	6132558.33	-9999	5		DOM	-9999	1519	6/01/1998	1.75	6/01/1998	4.5	6/01/1998	6/01/1998	14.5	14.5
662819430	277091.93	6130218.38	-9999	14.55		DOM	7.6	1110	5/03/1996	1	5/03/1996	-9999	<Null>	5/03/1996	13	13
662819487	278061.78	6133106.27	17	20.992331			-9999	-9999	<Null>	0.3	1/01/1983	10.7	1/01/1983	1/01/1983	13.7	13.7
662819488	275730.74	6133018.24	-9999	10.45			-9999	-9999	<Null>	10.1	1/01/1950	4.57	1/01/1950	<Null>	42.67	42.67
662819491	277161.9	6130253.28	-9999	15.01		DOM	-9999	1328	21/01/1999	0.5	25/04/1999	13	25/04/1999	25/04/1999	30	30
662819526	276209.74	6130004.31	-9999	10.36			-9999	842	1/07/1939	-9999	<Null>	-9999	<Null>	1/07/1939	68.58	68.58
662819527	276211.64	6129383.22	-9999	10.93		DOM	7.1	2323	27/02/1995	-9999	<Null>	-9999	<Null>	27/02/1995	20.5	20.5
662819575	273112.68	6132312.25	-9999	5	BKF	IRR	-9999	2761	2/09/2002	0.66	2/09/2002	4.14	2/09/2002	<Null>	0	9.5
662819590	277426.86	6133068.39	-9999	14.88		DOM	7.3	2121	13/08/1996	1	13/08/1996	-9999	<Null>	13/08/1996	15	15
662819659	275180.71	6127848.28	-9999	7.03			9.2	2312	10/02/1980	0.3	16/02/1980	4	16/02/1980	16/02/1980	10.05	10.05
662819699	276267.7	6129925.26	-9999	10.67	OPR	DOM	7.4	1519	29/11/1992	1	29/11/1991	4	21/01/1992	29/11/1991	15	15
662819710	274092.7	6132582.27	-9999	6.63			7.38	4590	25/02/2019	-9999	<Null>	3.66	23/08/1934	1/08/1934	20.12	20.12
662819715	273821.75	6128363.12	-9999	4.53	ABD	DOM	-9999	-9999	<Null>	-9999	<Null>	3.3	9/01/1995	9/01/1995	0	6.5
662819976	275201.74	6131879.27	-9999	7.18	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	2.2	1/01/1984	1/01/1984	4.7	4.7
662820101	273735.75	6131669.23	4	9.894606			7.3	761	19/03/1982	1	4/01/1979	3.66	4/01/1979	4/01/1979	7.32	7.32
662820116	278421.73	6132423.17	-9999	17.48		DOM	6.9	1866	15/03/1993	-9999	<Null>	11	26/02/1993	26/02/1993	18	18
662820117	276111.23	6133698.47	-9999	10.24			-9999	1826	1/09/2008	1	1/09/2008	7	1/09/2008	1/09/2008	20	20
662820122	277065.72	6131826.3	10	16.00728	BKF		-9999	2845	1/04/1940	0.57	1/04/1940	4.57	1/04/1940	1/01/1940	0	12.19
662820123	277558.77	6129442.25	-9999	19.06	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	5	8/01/1992	8/01/1992	9	9
662820124	276198.71	6131930.29	-9999	8.5	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	4	19/12/1990	19/12/1990	9	9
662820125	277420.77	6132474.3	12	16.592005			7.6	1653	5/05/1988	0.3	1/11/1987	11	3/05/1988	1/11/1987	15	15
662820134	276817.7	6131431.31	-9999	9.77	BKF		7.4	2199	1/04/1983	-9999	<Null>	-9999	<Null>	1/06/1983	9.14	9.14
662820135	273396.76	6131560.25	3	9.843057			7.3	1384	27/02/1979	0.75	27/02/1979	3.65	27/02/1979	27/02/1979	12.8	12.8
662820144	276338.69	6131955.26	39.82	11.297371	BKF		7.5	1951	6/01/1982	-9999	<Null>	-9999	<Null>	<Null>	-9999	4
662820150	275031.89	6132343.28	-9999	9.56		DOM	-9999	2194	12/03/1999	1.2	12/03/1999	6	12/03/1999	12/03/1999	12	12

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662820191	277439.72	6133216.22	-9999	15.32	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	10.7
662820200	275865.15	6127556.99	-9999	9.82	ABD		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	3/03/2000	0	20
662820201	273697.76	6132715.24	-9999	5.14	OPR	DOM	7.9	1351	12/11/1990	-9999	<Null>	4	12/11/1990	17/10/1990	11	11
662820238	275731.76	6133401.32	-9999	10			-9999	1370	1/01/1950	15.16	1/01/1950	10.97	1/01/1950	<Null>	36.58	36.58
662820266	277055.76	6133200.31	-9999	14.2	OPR	DOM	7.2	2199	9/04/1992	0.8	20/03/1992	8	9/04/1992	20/03/1992	9	9
662820336	275186.95	6132428.35	-9999	10.05		DOM	7.3	2835	27/10/1995	0.5	27/10/1995	-9999	<Null>	27/10/1995	18	18
662820344	277141.77	6133186.31	14	17.1505	OPR	DOM	-9999	-9999	<Null>	0.38	1/04/1984	7.5	1/04/1984	1/04/1984	10	10
662820400	274265.13	6132515.03	-9999	7.69		REC	-9999	2477	27/10/2000	2.5	27/10/2000	3.5	27/10/2000	27/10/2000	12	12.5
662820406	277266.85	6133163.17	-9999	14.71		DOM	6.8	1748	5/02/1996	1	5/02/1996	-9999	<Null>	5/02/1996	20	20
662820407	277516.9	6131853.29	-9999	12.38		DOM	7.3	1541	22/02/1996	0.5	22/02/1996	-9999	<Null>	22/02/1996	24	30
662820422	274891.86	6133188.3	-9999	10.01		DOM	7.19	2290	16/02/2018	0.5	26/09/1998	9	26/09/1998	26/09/1998	30	30
662820450	272834.75	6130808.24	-9999	4.97	ABD		-9999	-9999	<Null>	-9999	<Null>	2	15/05/1983	15/05/1983	6	6
662820451	276138.73	6130205.25	8	16			-9999	1570	6/04/1934	5.05	6/04/1934	4.12	6/04/1934	<Null>	9.75	9.75
662820452	276129.16	6130468.05	507.9	507.68		REC	-9999	2143	12/12/2000	1	12/12/2000	2.79	12/12/2000	12/12/2000	18	18
662820453	275613.7	6127433.27	-9999	9.33			7.6	2909	16/12/1981	0.75	16/12/1981	2.4	16/12/1981	16/12/1981	20.1	20.1
662820454	274318.75	6132994.23	-9999	8			-9999	1230	26/10/1949	2.27	26/10/1949	9.75	26/10/1949	<Null>	31.09	31.09
662820503	277280.09	6130687.01	-9999	14.38		DOM	-9999	2517	13/11/1999	0.5	13/11/1999	10	13/11/1999	13/11/1999	39	39
662820504	275697.1	6131711.68	-9999	6.76		DOM	-9999	1687	11/01/2006	0.5	10/04/2004	11	12/02/2004	12/02/2004	11	30
662820505	276438.69	6130854.28	-9999	9.21	OPR	DOM	-9999	-9999	<Null>	-9999	<Null>	4	26/08/1991	26/08/1991	9.8	9.8
662820506	272951.75	6132153.15	-9999	5		DOM	7.6	1496	11/11/1995	1	11/11/1995	-9999	<Null>	11/11/1995	14	14
662820507	277706.71	6128644.24	-9999	20.31	BKF		-9999	-9999	<Null>	-9999	<Null>	2.5	1/09/1983	1/09/1983	16.4	16.4
662820557	276062.77	6132758.22	-9999	10.14			-9999	2585	30/01/1962	-9999	<Null>	-9999	<Null>	1/01/1962	7.01	7.01
662820578	275751.85	6132568.33	-9999	9.62		DOM	6.9	1546	23/12/1994	1	23/12/1994	-9999	<Null>	23/12/1994	18	18
662820584	274448.76	6132557.22	-9999	8.46			-9999	3146	22/03/1951	-9999	<Null>	3.66	22/03/1951	<Null>	-9999	12.19
662820590	275028.15	6132354.04	-9999	9.5		DOM	-9999	2307	8/06/2000	1.5	8/06/2000	5.5	8/06/2000	8/06/2000	19.5	19.5
662820605	276071.68	6129098.18	-9999	10.03	OPR	DOM	-9999	-9999	<Null>	1	<Null>	2.1	28/03/1985	28/03/1985	8.5	8.5
662820645	275747.12	6132400.02	-9999	9.05		DOM	-9999	1720	22/10/1994	-9999	<Null>	3.9	22/10/1994	22/10/1994	16.5	16.5

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662820646	275843.71	6129450.22	-9999	7.17	BKF		8.7	938	23/12/1980	0.25	22/12/1980	3	22/12/1980	22/12/1980	-9999	14.4
662820651	276296.99	6129733.4	-9999	10.9		DOM	7.4	1968	29/03/1995	2	29/03/1995	-9999	<Null>	29/03/1995	18.5	18.5
662820652	276331.71	6130968.1	7	14.052671			7.2	1995	8/04/1988	0.5	8/04/1988	4	29/04/1988	29/04/1988	14	14
662820682	278476.86	6132943.19	-9999	18.53	ABD	DOM	-9999	1996	<Null>	0.5	31/10/1996	11	2/11/1996	2/11/1996	30	30
662820687	276225.72	6128980.31	10	14.023332			7	2285	7/12/1967	0.24	7/12/1967	2.44	7/12/1967	<Null>	6.71	6.71
662820766	274615.7	6127429.29	6	14			7.4	3236	10/12/1975	1.3	10/12/1975	3.66	10/12/1975	<Null>	14.02	14.02
662820775	276513.73	6132456.26	9	16.276766			-9999	871	11/02/1945	0.25	11/02/1945	1.52	11/02/1945	<Null>	4.57	4.57
662820846	276116.66	6129693.12	-9999	9.88		DOM	7.7	2364	4/11/1994	-9999	<Null>	6	4/11/1994	4/11/1994	12	12
662820963	277391.69	6132396.23	12	20.522706			7.6	1479	25/03/1987	0.4	1/03/1987	8	25/03/1987	1/03/1987	10	10
662820969	277701.76	6132550.3	14	17.931786			7.6	1602	12/11/1980	0.45	3/10/1981	5.48	3/10/1981	3/10/1980	12.49	12.49
662820997	278658.91	6132945.39	-9999	19.77		DOM	-9999	2143	1/02/1997	-9999	<Null>	15	1/02/1997	1/02/1997	22	28
662821013	277634.76	6130775.28	-9999	14.33			-9999	1200	2/01/1958	-9999	<Null>	3.66	2/01/1958	<Null>	-9999	6.4
662821014	275781.74	6131470.3	-9999	6.67	OPR	DOM	7.6	1968	6/02/1990	-9999	<Null>	6	6/02/1990	28/01/1990	10	10
662821036	275973	6129798	-9999	13.250293			-9999	1776	20/09/2010	0.25	20/09/2010	6	20/09/2010	20/09/2010	15	15
662821043	276688.25	6128753.28	-9999	13.43		DOM	-9999	1485	9/08/2002	0.5	9/08/2002	11	9/08/2002	9/08/2002	36	36
662821044	277161.96	6130988.19	-9999	12.6		DOM	7.1	1636	4/10/1996	1	4/10/1996	-9999	<Null>	4/10/1996	15	15
662821120	275441.84	6133208.16	-9999	10.02		DOM	6.8	2121	10/03/1995	-9999	<Null>	-9999	<Null>	10/03/1995	12	12
662821122	275305.71	6127696.29	-9999	7.74			-9999	7839	9/02/1937	-9999	<Null>	-9999	<Null>	<Null>	4.27	4.27
662821127	273558.71	6131738.32	3	9.970506	OPR	IRR	7.9	3539	4/12/1990	1.25	4/12/1990	2.4	4/12/1990	4/12/1990	9.6	9.6
662821132	273438.72	6131641.22	3	8			8.5	1552	13/05/1980	0.75	13/05/1980	2.43	13/05/1980	13/05/1980	10.97	10.97
662821136	275933.73	6127479.21	-9999	10.3			-9999	5140	16/10/1934	-9999	<Null>	2.13	16/10/1934	<Null>	17.98	17.98
662821138	276191.97	6133208.37	-9999	11.87		DOM	6.9	1984	8/09/1995	-9999	<Null>	-9999	<Null>	8/09/1995	15	15
662821140	276801.83	6129498.13	-9999	13.82		DOM	7.6	495	27/09/1995	0.5	27/09/1995	-9999	<Null>	27/09/1995	24	24
662821177	274596.93	6132928.39	-9999	9.17		DOM	7	2262	9/05/1995	5	9/05/1995	-9999	<Null>	9/05/1995	18	18
662821335	275977.7	6132715.29	9	13.368327	OPR	DOM	7.3	2088	3/01/1986	1	3/01/1986	2.4	24/01/1986	3/01/1986	7.9	7.9
662821471	277657.78	6131376.22	13	17			6.7	2685	24/01/1966	0.88	24/01/1966	3.35	24/01/1966	<Null>	7.32	7.32
662821505	276872.76	6129800.22	-9999	14.18			-9999	766	12/05/1987	0.84	12/05/1987	0	12/05/1987	13/04/1987	19	19

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662821536	273075.23	6131736.98	-9999	4.98			-9999	1754	19/04/2007	-9999	<Null>	2.6	19/04/2007	19/04/2007	6.5	6.5
662821539	275250.7	6127507.24	8	10.1205			-9999	4990	6/05/1949	0.25	1/01/1949	-9999	<Null>	<Null>	12.19	12.19
662821541	273503.68	6131506.3	-9999	4.95	OPR	DOM	7.8	1322	17/09/1984	-9999	<Null>	3	10/09/1983	10/09/1983	8	8
662821558	277258.77	6128809.24	-9999	17.25	OPR	DOM	7.3	3241	23/01/1990	-9999	<Null>	7	23/01/1990	3/01/1990	15	15
662821574	276989.75	6131067.23	-9999	11.82	OPR	DOM	7.7	2054	24/03/1992	0.6	19/02/1992	6	24/03/1992	19/02/1992	13.5	13.5
662821612	275961.39	6130325.7	-9999	7.57	BKF		-9999	-9999	<Null>	1	30/07/2006	-9999	<Null>	30/07/2006	0	12.5
662821645	276258.69	6130576.26	-9999	9.34			7.4	2047	28/07/1977	-9999	<Null>	3	1/03/1977	1/03/1977	9	9
662821746	278361.73	6132944.28	-9999	17.82			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/12/1914	13.41	13.41
662821772	273884.75	6131732.31	-9999	5	OPR	DOM	7.8	1256	2/03/1992	0.8	4/02/1992	2	2/03/1992	4/02/1992	7	7
662821836	273867.77	6132960.32	7	13.853992			7.3	1804	3/02/1983	1.5	3/02/1983	3.6	3/02/1983	3/02/1983	10.9	10.9
662821846	277022.76	6132290.22	11	16	OPR	DOM	-9999	-9999	<Null>	0.5	8/01/1985	3	8/01/1985	8/01/1985	9.1	9.1
662821872	274181.84	6132848.32	-9999	7.1		DOM	-9999	2216	14/01/1999	1	14/01/1999	4	14/01/1999	14/01/1999	12	12
662821873	273548.73	6131761.27	-9999	4.98			7.5	827	30/04/1970	-9999	<Null>	1.83	30/04/1970	<Null>	2.74	2.74
662821951	278225.71	6134156.27	-9999	15.77			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	18/02/1958	11.58	11.58
662821952	276608.92	6130563.98	-9999	17.945773			-9999	-9999	<Null>	-9999	<Null>	5.8	13/02/2014	13/02/2014	9	9
662821960	277401.15	6129865.5	-9999	17.68	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	8
662821961	277382.89	6129857.04	-9999	17.55	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	8
662822052	275172.95	6128669.59	-9999	4.91			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	10/11/2004	4.5	4.5
662822053	275155.29	6128661.8	-9999	4.9			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	9/11/2004	4.2	4.2
662822054	275152.97	6128688.12	-9999	4.88			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	9/11/2004	4.5	4.5
662822055	275133.86	6128661.68	-9999	4.88			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	9/11/2004	4.8	4.8
662822056	275107.43	6128648.05	-9999	4.88			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	9/11/2004	4.2	4.2
662822057	275113.21	6128628.56	-9999	4.9			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	9/11/2004	4	4
662822058	275073.76	6128687.77	-9999	4.84			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	9/11/2004	4	4
662822059	275097.36	6128711.78	-9999	4.84			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	8/11/2004	4	4
662822060	274942.85	6128684.28	-9999	4.83			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	8/11/2004	3.8	3.8
662822159	277076.63	6130893.2	-9999	12.81		DOM	7.4	1922	24/03/1993	-9999	<Null>	-9999	<Null>	13/03/1993	18	18

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662822279	276008.72	6131935.29	-9999	8.05			-9999	1000	14/08/1945	7.58	26/07/1945	9.14	26/07/1945	1/01/1945	72.24	72.24
662822313	277501.95	6132988.2	-9999	15.16		DOM	7	1856	11/10/1995	0.4	18/07/1995	-9999	<Null>	18/07/1995	30	30
662822339	277218.76	6128180.24	-9999	17.9			7.7	2125	6/03/1979	0.51	1/03/1979	3.5	1/03/1979	1/03/1979	15	15
662822395	278083.95	6133539.77	-9999	17.89			-9999	-9999	<Null>	0.5	8/09/2007	10	8/09/2007	8/09/2007	24	24
662822610	276794.71	6131485.25	10	11.824526	BKF		7.4	1917	25/03/1987	0.3	1/03/1987	3	25/03/1987	1/03/1987	0	9
662822748	275971.66	6129543.16	-9999	9.22		DOM	7.4	1703	27/11/1994	1	27/11/1994	-9999	<Null>	27/11/1994	20	20
662822749	273608.34	6131566.13	-9999	4.94	BKF	DOM	-9999	1440	15/09/2003	1	15/09/2003	2	15/09/2003	15/09/2003	0	6
662822780	273981.8	6132261.69	5	13.749789	OPR	DOM	7.7	2086	19/04/1979	2.5	18/04/1979	3.65	18/04/1979	18/04/1979	7.31	7.31
662822802	276711.82	6130203.31	-9999	12.33		DOM	-9999	938	14/03/1997	-9999	<Null>	6.6	14/03/1997	14/03/1997	15	15
662822802	275961.39	6130325.7	-9999	7.57	BKF		-9999	-9999	<Null>	1	30/07/2006	-9999	<Null>	30/07/2006	0	12.5
662822922	278263.69	6129340.71	-9999	23.37	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	3
662822990	274987.7	6131870.22	-9999	7.15			-9999	3055	27/07/1945	-9999	<Null>	3.66	27/07/1945	<Null>	9.14	9.14
662823068	277866.16	6129905	-9999	20.76		DOM	-9999	666	4/03/2000	-9999	<Null>	11	4/03/2000	4/03/2000	21	21
662823153	277687	6133585	-9999	16.35	EQP	RCL	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	-9999	-9999
662823176	278097.76	6134090.23	-9999	15.32			-9999	-9999	<Null>	-9999	<Null>	13.72	8/09/1954	<Null>	18.29	18.29
662823258	278275.73	6133892.31	18	23.26335			6.8	326	23/09/1981	1.26	1/01/1954	10.67	17/10/1955	1/01/1952	14.7	14.7
662823306	275789.34	6128806.54	-9999	7.46			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	29/10/2007	6	6
662823307	275770.74	6128763.09	-9999	7.81			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	29/10/2007	5.8	5.8
662823334	277553.77	6128703.22	-9999	19.29			-9999	8937	6/10/1960	-9999	<Null>	2.13	6/10/1960	<Null>	3.05	3.05
662823369	272732.72	6132193.32	-9999	5	OPR	DOM	7.5	3201	3/03/1992	1.1	4/02/1992	3.5	3/03/1992	4/02/1992	11	11
662823398	275861.99	6129863.24	-9999	6.66		DOM	7.2	2103	24/01/1996	0.5	24/01/1996	-9999	<Null>	24/01/1996	12	12
662823451	276567.73	6129586.3	-9999	12.55			6.6	2008	13/03/1987	1	23/02/1987	4.5	13/03/1987	23/02/1987	12	12
662823474	276597.2	6131749.14	-9999	8.93		DOM	-9999	1815	12/05/2003	1	12/05/2003	3.5	12/05/2003	12/05/2003	12	12
662823652	278201.16	6133200.04	-9999	17.97		DOM	-9999	2493	25/11/1999	0.5	25/11/1999	6	25/11/1999	25/11/1999	35	35
662823653	273816.73	6132378.08	-9999	5.55		DOM	7.8	2165	17/03/1993	0.77	14/02/1993	-9999	<Null>	14/02/1993	7.6	7.6
662823658	277647.29	6131163.73	-9999	13.45			-9999	1150	19/03/2007	0.6	20/03/2007	8	20/03/2007	20/03/2007	25	25
662823671	278531.9	6132285.5	-9999	18.29			-9999	1524	16/10/2005	1	16/10/2005	10	16/10/2005	16/10/2005	18	18

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662823751	276220.15	6133089.03	-9999	11.67		DOM	-9999	2561	6/02/2001	0.9	6/02/2001	7.5	6/02/2001	6/02/2001	18	18
662823765	278516.97	6129723.41	-9999	25.7			-9999	-9999	<Null>	-9999	<Null>	5.5	17/02/1997	<Null>	7.8	7.8
662823771	277066.69	6128667.24	-9999	15.86			7.6	4900	28/11/1986	0.13	19/11/1986	6.1	28/11/1986	19/11/1986	12.2	12.2
662824546	276031.67	6130355.1	-9999	7.95			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	6/09/2007	13.5	13.5
662824686	278015.74	6128757.21	-9999	22.74			-9999	1685	11/08/1934	-9999	<Null>	3.05	11/08/1934	<Null>	5.33	5.33
662824689	277861.99	6133303.09	-9999	17.06		DOM	6.8	2064	7/12/1995	-9999	<Null>	-9999	<Null>	7/12/1995	18	18
662824907	276236.96	6129049.4	-9999	15.88689	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	6.2
662824947	276221.87	6131358.23	-9999	8.2		DOM	-9999	1289	11/09/1999	1	11/09/1999	4.5	11/09/1999	11/09/1999	11	12
662825154	277187.76	6133834.32	-9999	14.87			-9999	943	28/03/1946	-9999	<Null>	-9999	<Null>	<Null>	21.34	21.34
662825183	273901.67	6132998.12	-9999	6.92	OPR	DOM	7.7	2421	17/01/1992	0.2	16/11/1991	3.6	17/01/1992	16/11/1991	13	13
662825204	277786.76	6132303.29	-9999	13.6		DOM	7.5	1839	9/10/1995	1	9/10/1995	-9999	<Null>	9/10/1995	22	22
662825367	278907.19	6130996.56	-9999	25.930417			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	13/01/2010	17	17
662825566	276610	6130449	-9999	16.674564	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	18
662825647	278922.18	6131029.11	-9999	30.479038	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662825720	276731.31	6130435.94	-9999	17.454702			-9999	-9999	<Null>	-9999	<Null>	5.3	16/01/2015	16/01/2015	9	9
662825816	278061.86	6129618.22	-9999	22.7		DOM	-9999	1043	4/03/1998	-9999	<Null>	11	4/03/1998	4/03/1998	23	23
662825817	275821.67	6129633.15	-9999	6.95		DOM	7.1	1061	31/01/1994	-9999	<Null>	-9999	<Null>	28/01/1994	10	10
662825845	278130.41	6129835.37	-9999	23.04		DOM	-9999	921	29/11/2002	0.8	29/11/2002	10.5	29/11/2002	29/11/2002	19	19
662826092	278986.1	6131044.28	-9999	32.362995	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	14/09/2011	0	5
662826093	279004.36	6131013.11	-9999	34.462619	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	14/09/2011	0	5
662826408	278353.74	6133861.24	-9999	17.92			-9999	-9999	<Null>	-9999	<Null>	10.67	14/09/1954	<Null>	11.28	11.28
662826409	276569	6132587	-9999	12.829693			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	7.38	7.38
662826410	273610.59	6131679.23	-9999	4.95			-9999	-9999	<Null>	-9999	<Null>	4	20/02/2001	20/02/2001	4	4
662826437	278083.7	6130219.24	-9999	20.78			-9999	-9999	<Null>	-9999	<Null>	5.18	1/01/1931	1/01/1931	12.19	12.19
662826796	277381.37	6128357.41	-9999	23			-9999	1328	10/03/2012	3.157	15/03/2012	3	15/03/2012	15/03/2012	42	42
662826904	278604.28	6133230.45	-9999	19.91			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	6/01/2005	20	20
662826959	278213.77	6130647.87	-9999	25.518196	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	10/05/2013	0	11.5

UNIT_NO	EASTING	NORTHING	REF ELEV	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662827093	278486.67	6130949.14	-9999	22.999163			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	26/08/2013	13.5	13.5
662827249	278212.35	6130645.97	-9999	25.569445			-9999	-9999	<Null>	-9999	<Null>	9.8	28/01/2016	28/01/2016	12	12
662827250	276560	6132582	-9999	12.98894			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	7.27	7.27
662827454	273343.76	6132049.23	-9999	5			-9999	1100	1/06/1959	-9999	<Null>	-9999	<Null>	<Null>	27.43	27.43
662827455	273751.72	6133113.17	-9999	5.27		DOM	7.5	1066	16/01/1995	-9999	<Null>	-9999	<Null>	16/01/1995	16.5	16.5
662827596	276581.88	6129788.22	-9999	12.46		DOM	-9999	1143	25/03/1997	-9999	<Null>	5.8	25/03/1997	25/03/1997	15	15
662828116	278481.98	6130924.69	-9999	24.065182			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	23/07/2014	14	14
662828168	277304	6130226	-9999	20.889015			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	11/02/2016	12	12
662828177	272409.81	6130392.87	-9999	5.05			-9999	464	11/02/2008	-9999	<Null>	4	11/02/2008	11/02/2008	6	6
662828206	278752.67	6132388.35	-9999	20			-9999	-9999	<Null>	-9999	<Null>	13.3	16/12/1993	16/12/1993	17.5	18
662828209	277195.75	6133904.22	-9999	14.89			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/01/1979	-9999	-9999
662828298	276448.05	6131253.88	-9999	13.123428			-9999	-9999	<Null>	-9999	<Null>	3.5	5/01/2011	5/01/2011	6.5	6.5
662828309	275755.2	6128761.53	-9999	12.016392			-9999	-9999	<Null>	-9999	<Null>	3.4	3/08/2012	3/08/2012	5.5	5.5
662828429	277081.81	6128938.33	-9999	15.75		DOM	7.2	1132	10/02/1995	-9999	<Null>	-9999	<Null>	10/02/1995	20	20
662828897	276744.75	6128051.63	-9999	20.77504			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	18/07/2017	8	8
662829717	278839	6132252	-9999	28.462476	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662829718	278835	6132260	-9999	28.833626	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	26/07/1996	0	-9999
662829719	278826	6132255	-9999	27.8569	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662829720	278828	6132251	-9999	27.836	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662829721	278829	6132244	-9999	27.477021	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662829722	278851	6132258	-9999	28.384359	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662829723	278837	6132260	-9999	28.780763	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	-9999
662829731	277072	6130318	-9999	19.075333			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	10	10
662829916	278262.16	6134083.67	-9999	22.309662			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	17/11/2015	18	18
662830069	273608	6131556	-9999	10			-9999	1586	15/03/2019	0.6	15/03/2019	1.5	15/03/2019	15/03/2019	4	4

T1 Aquifer Wells

UNIT NO	EASTING	NORTHING	REF ELEV (m AHD)	GRND ELEV (m)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662800719	278620.69	6131117.26	19.45	19.23	OPR	IND	-9999	2684	5/02/1962	12.63	8/02/1962	10.21	14/09/2018	8/02/1962	156.97	156.97
662801435	278644.74	6133628.22	-9999	20.6	BKF		10.6	921	2/08/1977	3.92	2/08/1977	21.2	2/08/1977	15/07/1977	0	184
662804576	278605.72	6133363.21	18.63	18.81			8.2	445	28/11/1988	-9999	<Null>	14.54	21/09/1991	2/11/1977	125	125
662807538	275976.74	6133753.31	14.45	13.45	RHB	OBS	8.3	860	23/04/2013	7.5	4/10/1949	16.76	11/12/2018	3/11/1945	149	149.35
662807541	275966.7	6133648.28	-9999	9.99			7	846	1/12/1972	12.63	1/12/1972	18.29	1/12/1972	<Null>	182.88	182.88
662807546	275900	6133659	-9999	9.98			7.8	888	20/11/1986	6.8	9/01/1974	19.46	9/01/1974	1/01/1974	144	144
662807549	276546.72	6133682.25	-9999	10.43			-9999	671	29/02/1952	5.68	22/02/1934	8.23	22/02/1934	1/01/1934	141.73	141.73
662807552	277132.72	6133969.28	15.9	15.8		OBS	7.4	1054	3/11/1984	11.25	21/09/1949	17.05	4/03/1985	15/11/1945	143.26	143.26
662807553	277168.77	6133893.24	-9999	14.25			-9999	829	9/08/1955	8.84	1/01/1955	13.72	6/12/1951	6/12/1951	176.17	176.17
662807555	277636.76	6134041.28	-9999	15.01			7.8	1027	11/02/1997	-9999	<Null>	-9999	<Null>	<Null>	140.82	140.82
662807558	278093.72	6134117.21	-9999	15.19			-9999	1085	22/10/1954	-9999	<Null>	18.29	14/09/1954	1/01/1946	167.64	167.64
662807561	278458.7	6134253.27	-9999	16.09	BKF		7.3	1759	15/03/1986	8.84	4/05/1946	0	15/03/1986	2/05/1946	0	169.16
662807570	278053.76	6133707.22	-9999	17.13	BKF		7.4	991	24/09/1981	15.16	7/07/1965	22.25	28/02/1969	7/07/1965	-9999	122.22
662807576	272970.73	6131893.33	-9999	5.03			7.7	849	26/11/1986	2.65	23/02/1970	13.72	23/02/1970	23/02/1970	131.67	131.67
662807579	273062.7	6132095.3	-9999	5			-9999	-9999	<Null>	6.32	14/04/1934	3.05	14/04/1934	14/04/1934	122.53	122.53
662807580	273172.68	6132275.3	-9999	5			7	827	2/02/1970	10.1	2/02/1970	11.28	2/02/1970	1/01/1929	135.64	135.64
662807583	273286.72	6131692.28	-9999	5			-9999	786	29/06/1932	10.1	11/06/1932	0.46	11/06/1932	11/06/1932	140.82	140.82
662807584	273297.7	6132067.28	-9999	5			-9999	800	26/02/1952	-9999	<Null>	-9999	<Null>	<Null>	143.26	143.26
662807586	272923.72	6132497.22	-9999	5			-9999	856	11/02/1946	3.79	11/02/1946	8.23	11/02/1946	11/02/1946	134.11	134.11
662807588	273141.69	6132426.27	-9999	4.99			-9999	857	15/04/1952	3.79	1/01/1952	-9999	<Null>	<Null>	158.5	158.5
662807591	273386.76	6132508.28	-9999	4.98			-9999	771	26/02/1952	8.84	1/01/1948	12.19	6/11/1945	1/01/1945	128.02	128.02
662807592	273415.69	6132396.22	-9999	4.99			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	128.02	128.02
662807593	273557.71	6132361.23	8.47	8.5	ABD	OBS	7.2	732	13/11/1984	10	18/10/1949	10.51	29/06/1995	29/10/1945	0	145.69
662807596	274019.73	6132871.28	-9999	6.38			-9999	729	26/02/1952	12.63	1/01/1946	6.1	1/01/1931	1/01/1931	198.12	198.12
662807608	274111.74	6131879.23	4	20.221973	BKF	IRR	7.2	972	28/05/1996	7.58	1/01/1972	33.53	18/03/1970	24/10/1952	0	152.4
662807614	273274.7	6130299.26	-9999	4.39	ABD		-9999	914	21/04/1955	12	13/09/1949	12.65	13/09/1949	21/11/1945	140.21	140.21

UNIT NO	EASTING	NORTHING	REF ELEV (m AHD)	GRND ELEV (m)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807617	272430.72	6130534.22	-9999	5.04			-9999	857	2/05/1956	15.16	2/05/1956	5.49	2/05/1956	1/01/1956	143.26	143.26
662807619	272595.71	6130816.27	-9999	5.02			-9999	800	26/02/1952	15.79	26/02/1952	18.59	26/02/1952	5/02/1946	137.16	137.16
662807625	272515.75	6131088.25	3.78	3.8		OBS	7.7	981	16/02/2006	-9999	<Null>	3.98	11/12/2018	28/06/1968	128	128.02
662807640	274853.73	6133214.22	10	14.18012	ABD		-9999	871	21/04/1955	10.1	25/09/1949	10.66	25/09/1949	16/11/1945	146.3	146.3
662807656	274789.77	6131656.22	-9999	5.89			7.5	931	29/09/1987	12.88	1/01/1972	12.19	17/03/1966	1/01/1948	213.36	213.36
662807657	274364.35	6131907.75	-9999	4.95	BKF		7.8	966	29/09/1987	12.63	16/03/1962	0	18/09/1987	8/03/1962	0	217.02
662807658	274455.8	6132221.49	6	16.960762	BKF	IRR	6.7	2818	23/05/1996	12.63	7/10/1965	6.1	7/10/1965	10/09/1965	0	216.71
662807659	274302	6132021	6	8.565457			-9999	1145	16/06/1953	13.89	26/08/1952	6.4	26/08/1952	9/02/1928	174.35	174.35
662807660	275639.7	6131429.29	6.8	6.04		OBS	8	708	27/07/1983	12.63	5/12/1949	2.61	19/09/2018	5/12/1949	256.5	258
662807661	275267.71	6131190.26	3.92	3.9	RHB	OBS	7	744	1/02/1972	12	12/07/1979	6.55	10/09/1982	29/10/1962	206	213.36
662807662	274908.74	6130961.31	-9999	4.84			-9999	800	19/03/1958	17.68	19/04/1949	5.49	19/04/1949	19/04/1949	147.83	147.83
662807663	274945.76	6130882.28	3.18	4.25	BKF	OBS	7.4	761	21/01/1983	-9999	<Null>	2.06	27/09/2003	17/09/1962	0	213.97
662807664	274672.73	6130617.27	-9999	4.65			-9999	813	1/01/1962	-9999	<Null>	-9999	<Null>	1/10/1962	213.36	213.36
662807665	274928.74	6130328.22	-9999	4.86			-9999	813	13/07/1948	5.05	13/07/1948	0	13/07/1948	1/01/1934	140.21	140.21
662807667	274781.7	6131357.21	-9999	4.98			-9999	742	11/09/1934	3.54	11/09/1934	0	11/09/1934	11/09/1934	161.54	161.54
662807691	276008	6133306	11.66	12.08	BKF	OBS	7.8	810	20/11/1986	9.0909	11/12/1973	13.78	11/09/2005	11/12/1973	204	204
662807692	276001.68	6133381.3	-9999	11.11			6.7	733	20/12/2002	10.1	6/12/1967	48.77	6/12/1967	<Null>	153.62	153.62
662807693	275756.76	6133176.28	-9999	10.38	BKF		7.6	757	12/08/2014	7.58	14/12/1967	11.58	12/08/2014	14/12/1967	0	152.4
662807699	275551.76	6132582.29	-9999	9.54			7	1064	24/11/1967	10.61	26/10/1967	18.29	26/10/1967	1/01/1967	147.83	147.83
662807703	276169.69	6132894.26	-9999	10.85			-9999	700	27/02/1952	12.63	23/10/1934	6.4	23/10/1934	23/10/1934	149.05	149.05
662807704	276305.77	6132959.31	-9999	11.39	BKF		-9999	643	21/12/1951	15.16	17/09/1949	8.84	17/09/1949	16/01/1946	144.02	144.02
662807707	276178.72	6133417.28	-9999	11.17			-9999	729	27/02/1952	-9999	<Null>	-9999	<Null>	1/01/1934	147.83	147.83
662807708	276074.69	6133435.26	-9999	11			-9999	700	27/02/1952	-9999	<Null>	7.62	28/07/1934	28/07/1934	146.3	146.3
662807709	276258.73	6133476.29	-9999	10.86			-9999	771	13/12/1937	7.58	13/12/1937	22.86	13/12/1937	1/01/1937	144.78	144.78
662807711	276630.71	6133369.29	-9999	12.28			-9999	671	27/02/1952	6.32	22/02/1934	8.23	22/02/1934	1/02/1934	138.99	138.99
662807717	277317.71	6133518.26	-9999	14.97	OPR	DRN	6.7	855	18/03/1966	6.32	18/03/1966	20.12	18/03/1966	18/03/1966	143.26	143.26
662807718	277606.76	6133418.31	-9999	16.16			7.7	1049	25/03/1974	16.42	1/01/1967	12.19	1/01/1940	1/07/1934	124.36	124.36

UNIT NO	EASTING	NORTHING	REF ELEV (m AHD)	GRND ELEV (m)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807719	277655.76	6133580.22	15.19	15.2	BKF	OBS	8.2	921	17/02/1975	11.37	15/10/1934	19.26	7/09/1983	15/10/1934	0	131.37
662807723	278005.76	6132838.29	-9999	16.22			-9999	643	2/11/1934	15.16	13/10/1934	12.8	13/10/1934	23/10/1934	160.02	160.02
662807724	278578.79	6133452.75	17.95	23.143966		OBS	7.2	1272	24/11/1986	15.16	21/11/1969	20.17	29/03/1982	21/11/1969	154	155.45
662807725	278538.36	6133623.31	18.19	22.930189		OBS	7.6	1100	2/10/2003	10.05	31/08/1973	24.45	13/09/2018	31/08/1973	127	127
662807738	276455.7	6131966.23	-9999	9.09			-9999	657	23/03/1955	17.05	12/03/1951	19.81	12/03/1951	12/03/1951	137.16	137.16
662807739	276450.7	6131987.3	7.78	7.78	ABD	OBS	7.9	761	17/02/1975	18.95	15/12/1948	8.41	15/09/1998	13/11/1934	0	204.22
662807746	277080.7	6131793.26	-9999	10.31	UKN		7.6	910	24/02/2005	10.1	14/07/1971	9.14	14/07/1971	1/01/1971	118.87	118.87
662807756	278141.74	6131236.28	16	16	ABD	OBS	7.8	1356	13/11/1984	15.16	5/12/1949	10.23	5/03/2004	27/07/1934	0	104.85
662807764	276063.74	6131086.29	-9999	7.89			-9999	757	27/02/1952	3.79	20/09/1935	0	20/09/1935	1/01/1932	117.35	117.35
662807773	276396.71	6130598.29	-9999	9.85			-9999	729	27/06/1935	15.16	27/06/1935	0	27/06/1935	1/01/1935	112.78	112.78
662807775	277305.74	6130632.3	13.73	13.73		OBS	7.7	772	28/04/1981	22.73	16/12/1948	5.2	14/09/2018	13/11/1934	111.56	113.39
662807778	278107.76	6130816.21	-9999	17.23			-9999	-9999	<Null>	7.58	<Null>	7.01	<Null>	<Null>	41.45	41.45
662807782	275761.7	6130463.28	-9999	7.47			-9999	813	24/10/1949	10.74	24/10/1949	11.58	23/10/1946	23/11/1945	144.78	144.78
662807785	275897.7	6130206.22	6	8.294674	UKN		-9999	800	28/02/1952	11.37	1/01/1952	0	24/08/1935	1/01/1934	174.35	174.35
662807790	275892.75	6129939.26	-9999	6.74			-9999	-9999	<Null>	5.05	<Null>	0	<Null>	<Null>	95.4	95.4
662807791	276024.76	6130466.3	-9999	7.69			7.3	832	25/11/1986	15.16	1/01/1967	-9999	<Null>	<Null>	141.73	141.73
662807799	276937.74	6130495.21	-9999	12.84			-9999	828	1/01/1934	-9999	<Null>	-9999	<Null>	1/01/1914	73.15	73.15
662807843	272731.73	6128112.24	-9999	4.85			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	8/12/1950	124.05	124.05
662807844	272731.71	6128113.24	-9999	4.86			-9999	743	29/02/1960	11.37	12/03/1951	16.76	12/03/1951	12/03/1951	141.73	141.73
662807846	274105.7	6128103.31	-9999	5.07			-9999	743	29/02/1960	6.32	3/04/1951	15.85	3/04/1951	3/04/1951	103.63	103.63
662807847	274148.71	6128499.32	-9999	3.97	PLG		-9999	1070	7/06/1957	5.68	14/02/1927	0	14/02/1927	14/02/1927	92.96	115.82
662807849	274409	6128473	-9999	7.03			-9999	1100	29/02/1960	22.73	7/12/1956	0	7/12/1956	7/12/1956	79	114.6
662807850	274339.76	6127422.24	-9999	6.13			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/09/1909	88.7	88.7
662807852	273981.7	6128542.24	3.38	2.61	BKF		8.3	1077	17/12/1986	-9999	<Null>	0.01	21/09/1991	15/01/1968	0	153.31
662808044	274796.76	6128803.28	-9999	4.76			-9999	1145	29/02/1960	6.06	30/04/1951	14.33	30/04/1951	30/04/1951	91.44	91.44
662808046	274675.71	6127378.27	-9999	4.62			-9999	2130	19/11/1914	-9999	<Null>	2.74	19/11/1914	<Null>	86.26	86.26
662808048	275812.7	6129682.22	-9999	6.8			-9999	843	5/03/1952	8.21	6/06/1947	7.92	6/06/1947	30/03/1946	140.51	140.51

UNIT NO	EASTING	NORTHING	REF ELEV (m AHD)	GRND ELEV (m)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662808050	275246.72	6128651.32	6	11.05236			-9999	1013	6/05/1949	1.89	6/05/1949	-9999	<Null>	<Null>	90	90
662808052	275109.74	6128431.3	-9999	5.77	RHB	OBS	8.7	865	25/08/1986	8.84	15/12/1948	0.01	19/09/2018	18/01/1946	94	103.63
662808073	276554.77	6129645.26	-9999	12.44			-9999	885	13/12/1933	-9999	<Null>	3.96	13/12/1933	<Null>	69.19	69.19
662808081	276701.74	6128592.27	13.13	13.18		OBS	7.3	1485	10/11/2005	5	31/10/1985	2.67	19/09/2018	8/09/1914	57	70.7
662808082	275939	6128153	-9999	8.71	BKF		-9999	-9999	<Null>	0.51	<Null>	-9999	<Null>	<Null>	0	76.81
662808084	276150.72	6128216.24	3	13.837881	BKF		7.7	1183	2/06/2015	-9999	<Null>	4.73	2/06/2015	8/08/1968	0	81.38
662808093	277237	6129129	-9999	16.41			7.7	1832	29/08/2006	10.74	1/01/1967	7.32	25/02/1946	1/01/1945	64.01	64.01
662808094	276665	6129471	12.26	12.45	RHB	OBS	7.6	1670	11/11/1985	2	6/11/1985	12.76	13/03/2014	<Null>	69	79.25
662808096	276738.69	6129251.28	-9999	13.45			-9999	786	15/09/1914	-9999	<Null>	-9999	<Null>	1/08/1914	83.82	83.82
662808120	277744.75	6129663.23	20.37	20.09	ABD	OBS	7.9	617	13/10/1977	20.21	11/08/1950	6.93	13/03/1991	11/08/1950	0	60.96
662811161	272370.68	6128691.32	7.39	7.53		OBS	7.8	960	13/12/1984	-9999	<Null>	12.42	27/03/1998	15/11/1979	226	267
662811199	277183.71	6133914.25	-9999	14.91			7.6	832	3/11/1979	-9999	<Null>	15	23/11/1979	23/11/1979	170	170
662811505	275183.75	6127962.24	-9999	6.75			-9999	-9999	<Null>	8.84	1/01/1964	-9999	<Null>	<Null>	103.63	103.63
662811786	277959.76	6133713.3	16.16	21.755524		OBS	7.6	655	24/02/1988	-9999	<Null>	26.39	5/02/1998	16/06/1981	121	121
662811875	277971.8	6133718.37	-9999	16.9		OBS	-9999	-9999	<Null>	-9999	<Null>	24	16/06/1981	16/06/1981	121	121
662811876	277971.8	6133718.37	-9999	16.9		OBS	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	16/06/1981	121	121
662812446	278524.71	6133684.24	21.86	21.49	OPR	IND	7.9	1005	19/12/2006	12	31/07/1989	31.41	4/09/2007	7/02/1983	200	257.8
662812516	278545.74	6133586.14	-9999	19.91	BKF	IND	7.7	1300	23/11/2004	18.75	29/09/1983	21.2	29/09/1983	29/09/1983	0	210
662813389	277664.76	6134040.3	-9999	15.09			-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	1/12/1949	138.7	138.7
662813504	278447	6134312	-9999	14.99	OPR	IND	7.9	906	19/11/1985	6.25	26/08/1985	20.5	19/11/1985	26/08/1985	191.3	191.3
662813505	278327.75	6134254.31	-9999	14.99	OPR	IND	7.5	927	19/11/1985	8.75	12/07/1985	19.3	19/11/1985	12/07/1985	196	196
662813732	278462.75	6134320.3	-9999	14.98		IND	7.6	972	8/10/1986	5	25/07/1986	19.1	8/10/1986	25/07/1986	186.5	186.5
662813939	278570.71	6134336.23	-9999	14.96	BKF	IND	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	30/03/1987	0	177.5
662813940	278358.76	6133997.22	-9999	17.69		IND	7.8	1010	18/02/2005	0.14	13/04/1987	29	13/04/1987	13/04/1987	203.6	203.6
662814013	277838.76	6133852.28	-9999	16.13			7.6	714	29/09/1987	25	9/09/1987	24.4	29/09/1987	9/09/1987	215	215
662814214	272255.7	6129076.29	-9999	5.48			8.4	1034	26/02/2009	6	20/05/1988	8.7	21/09/2018	20/05/1988	228	228
662814229	276005.71	6130430.31	-9999	7.45	BKF	IND	-9999	849	6/07/1988	20	5/06/1988	3.6	6/07/1988	5/06/1988	0	138

UNIT NO	EASTING	NORTHING	REF ELEV (m AHD)	GRND ELEV (m)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662814373	277829.7	6131087.27	-9999	14.15	OPR	IND	7.5	1765	26/11/1988	12	26/11/1988	11.2	26/11/1988	26/11/1988	64	64
662814393	278432.72	6133854.28	-9999	18.54		IND	7.7	725	22/05/1989	12.5	13/12/1988	34	22/05/1989	13/12/1988	207.5	207.5
662815323	272198.72	6129349.26	-9999	5.85	OPR	IND	-9999	983	17/07/1990	7	2/07/1990	5.8	2/07/1990	2/07/1990	228	228
662815498	277707.74	6134119.26	-9999	15	OPR	IND	7.9	719	3/04/1991	25	5/02/1991	24	3/04/1991	5/02/1991	216	216
662815556	274046	6128556	-9999	4.59	OPR	OBS	7.9	1050	25/02/2005	10	24/01/1991	6.7	24/01/1991	24/01/1991	211	215
662815991	277806.73	6131092.26	-9999	14.04	OPR	IND	7.2	1440	23/02/2005	12	2/04/1992	11.2	2/04/1992	2/04/1992	65	65
662816261	277971.79	6133728.21	-9999	16.85		OBS	6.9	3471	25/08/1993	5	25/09/1992	-9999	<Null>	25/09/1992	120	121
662818780	274348	6132130	-9999	6.04		IRR	7.7	771	23/02/2005	8.4	6/12/1996	10	6/12/1996	6/12/1996	216	221
662819428	275921.85	6130328.24	-9999	7.18	OPR	IND	8.1	845	2/03/2005	31	20/11/1998	3	20/11/1998	20/11/1998	140	140
662820552	274357.48	6131546.76	-9999	4.74		IRR	-9999	755	17/11/2000	10	17/11/2000	11.3	17/11/2000	17/11/2000	221	221
662820663	278361.17	6133575.98	-9999	18.86		IRR	-9999	1105	3/09/2001	5	7/08/2001	-9999	<Null>	7/08/2001	114	121
662820854	274702	6131817	-9999	5.95		IND	-9999	688	11/01/2002	20	11/01/2002	15	11/01/2002	11/01/2002	224	224
662820911	273694	6129636.65	-9999	3.99	BKF	GTH	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	28/03/2002	0	104
662820912	273684.71	6129626.21	-9999	3.99	BKF	GTH	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	104
662820913	273674.7	6129616.2	-9999	3.98	BKF	GTH	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	104
662820914	273665.81	6129606.2	-9999	3.98	BKF	GTH	-9999	1328	9/11/2018	-9999	<Null>	-9999	<Null>	<Null>	0	104
662820915	273656.92	6129597.31	-9999	3.98	BKF	GTH	-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	<Null>	0	104
662821320	277553	6130518	-9999	16.19		DRN	-9999	722	12/06/2003	1.2	12/06/2003	12.5	12/06/2003	12/06/2003	84	84
662821949	278199	6131438	17	17	OPR	OBS	-9999	2334	4/06/2015	12	24/02/2005	7.76	14/09/2018	24/02/2005	49.09	49.09
662822322	274246	6128574	-9999	5.91	OPR	MAR	-9999	1039	19/10/2005	10	12/10/2005	7	12/10/2005	12/10/2005	188	196.7
662822597	276537.63	6133389	-9999	11.85	RHB		-9999	831	14/03/2014	5	12/02/2011	18	12/02/2011	4/03/2005	122.5	144
662823335	274441	6128460	-9999	4.88	OPR	MAR	-9999	1083	7/08/2007	15	29/05/2007	0.85	7/08/2007	29/05/2007	119	124
662823525	278530	6133192	-9999	19.55			-9999	1078	31/08/2007	10	3/08/2007	27.3	3/08/2007	3/08/2007	206	206
662823539	272889	6128948	-9999	4.56	NIU	INV	-9999	998	24/07/2007	8	6/06/2007	-9999	<Null>	6/06/2007	215	215
662824910	274670.4	6131664.22	-9999	9.392029			-9999	-9999	<Null>	2.2731	20/11/2008	12	22/11/2008	22/11/2008	220	220
662825428	275410	6129193	-9999	6.23		INV	7.51	1104	23/09/2014	5	28/06/2010	-0.46	20/09/2018	28/06/2010	117	117
662826395	274880.64	6127397.26	-9999	10.655516	OPR	IRR	7.33	1279	11/12/2018	10.1024	27/09/2008	-9999	<Null>	27/09/2008	110	124

UNIT NO	EASTING	NORTHING	REF ELEV (m AHD)	GRND ELEV (m)	STATUS	PURPOSE	PH	TDS (mg/L)	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662827005	274778	6129092	-9999	7	BKF		-9999	-9999	<Null>	-9999	<Null>	-9999	<Null>	29/04/2013	0	180
662827006	274768	6129083	-9999	6.850467	BKF		-9999	1156	13/06/2013	-9999	<Null>	-9999	<Null>	<Null>	0	186
662827008	274834.05	6127412.68	-9999	14.288677	OPR	IRR	-9999	1317	15/08/2013	20	15/08/2013	4	15/08/2013	<Null>	124	124
662827263	277706	6133437	-9999	21.61946			-9999	-9999	<Null>	10	24/05/2014	22	24/05/2014	24/05/2014	124	124
662827792	275719	6133208	-9999	18.158036		IRR	7.67	730	12/08/2018	10	7/05/2015	9.74	29/08/2017	7/05/2015	151	151
662827794	276137	6128201	-9999	10.736216	OPR	IRR	7.35	1158	18/10/2018	10	15/05/2015	2.13	24/10/2017	15/05/2015	70	70
662829437	274772	6126935	-9999	15.673587		TWS	-9999	-9999	<Null>	20	9/04/2018	10	9/04/2018	9/04/2018	107.5	107.5

UNIT_NO	EASTING	NORTHING	REF ELEV (mAHD)	GRND ELEV (m AHD)	STATUS	PURPOSE	PH	TDS	TDS DATE	YIELD (L/s)	YIELD DATE	SWL (m bgl)	SWL DATE	DRILL DATE	LAT DEPTH (m)	MAX DEPTH (m)
662807607	274016	6131583	8	11.621665	UKN		-9999	2115	7/01/1952	5.68	5/02/1951	9.14	5/02/1951	14/05/1928	147.83	147.83
662807630	274468.71	6133189.29	10	15.198174			-9999	3098	31/01/1946	6.32	18/01/1946	15.24	18/01/1946	1/01/1932	264.57	264.57
662807751	277278.74	6131424.26	10.82	10.82	ABD	OBS	8.5	468	13/11/1984	25	29/09/1950	5.9	29/06/1995	22/09/1950	0	132.59
662807759	278634.69	6131316.28	-9999	18.68	OPR	IND	7.2	2942	21/11/1986		<Null>	-9999	<Null>	<Null>	103.02	103.02
662807848	274350.73	6128485.23	-9999	10.41			-9999	1000	29/02/1960	1.26	14/01/1930	0	14/01/1930	14/01/1930	170.69	170.69
662808059	275798.68	6127494.32	-9999	9.78	BKF		-9999	1730	21/04/1955	15.16	1/01/1949	1.68	3/08/1955	1/01/1914	0	111.86
662811501	274771.74	6126916.22	-9999	8.17	ABD	RCL	7.78	1222	31/08/1990	25.2561	22/10/1990	-9999	26/05/2018	25/08/1990	0	109.73
662812452	275638.74	6131431.27	6.45	6.04		OBS	8.1	813	19/03/1986		<Null>	-0.52	19/09/2018	25/08/1983	256.5	258
662813648	277716.7	6133961.31	-9999	15.51			-9999		<Null>		<Null>	-9999	<Null>	24/06/1970	213.4	213.4
662814266	278126.75	6133992.28	17.49	17.52	OPR	OBS	7.99	1093	9/01/2014	2	19/08/1988	13.69	13/09/2018	19/08/1988	246	246
662814292	277381	6130687	-9999	14.49	OPR	IND	7.4	661	15/01/1992		<Null>	6.7	6/03/1987	8/12/1986	91	91
662822321	274426	6128496	-9999	4.97	OPR	MAR	-9999	1197	11/10/2005	12	4/10/2005	-9999	<Null>	4/10/2005	210	221
662825427	275385	6129186	-9999	12.89		INV	7.59	1020	23/09/2014	10	24/06/2010	-4.07	20/09/2018	24/06/2010	191	227
662825717	273921	6128612	-9999	10.722895	NIU	INV	-9999	5580	3/11/2010	15	3/11/2010	3	3/11/2010	3/11/2010	340	340
662825718	274657	6128969	-9999	7.191138	OPR	MAR	-9999	2709	17/10/2010	15	19/10/2010	0	17/10/2010	17/10/2010	280	280
662825719	274990	6129202	-9999	10.54434	OPR	MAR	-9999	1035	20/10/2010	10	8/07/2010	0.81	8/07/2010	8/07/2010	224	240
662827002	275158	6129229	-9999	9.819146	OPR	MAR	-9999	925	26/05/2013	30	22/05/2013	3.5	26/05/2013	26/05/2013	220	220
662827007	274849	6129133	-9999	6.544001	OPR	MAR	-9999	2721	13/06/2013	30	11/06/2013	2.5	13/06/2013	13/06/2013	234	234

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Appendix D

Existing Scenario 2, 3 and 4 Drain Standard Mapping





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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Drain Standard]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

Drainage Standard Map
Scenario 2 - Future Development, Existing Infrastructure



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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Drain Standard]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

Drainage Standard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5



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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Drain Standard]
NearMap [Aerial Photograph]

West Torrens
Stormwater Management Plan

Drainage Standard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Appendix E

Existing Scenario Flood Plain Mapping



Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

Disclaimer

This map is provided on the basis that those responsible for its preparation and publication do not accept any responsibility for any loss or damaged 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.

The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents. The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Floodplain Map
Scenario 1 - Existing Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Floodplain Map
Scenario 1 - Existing Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Floodplain Map
Scenario 1 - Existing Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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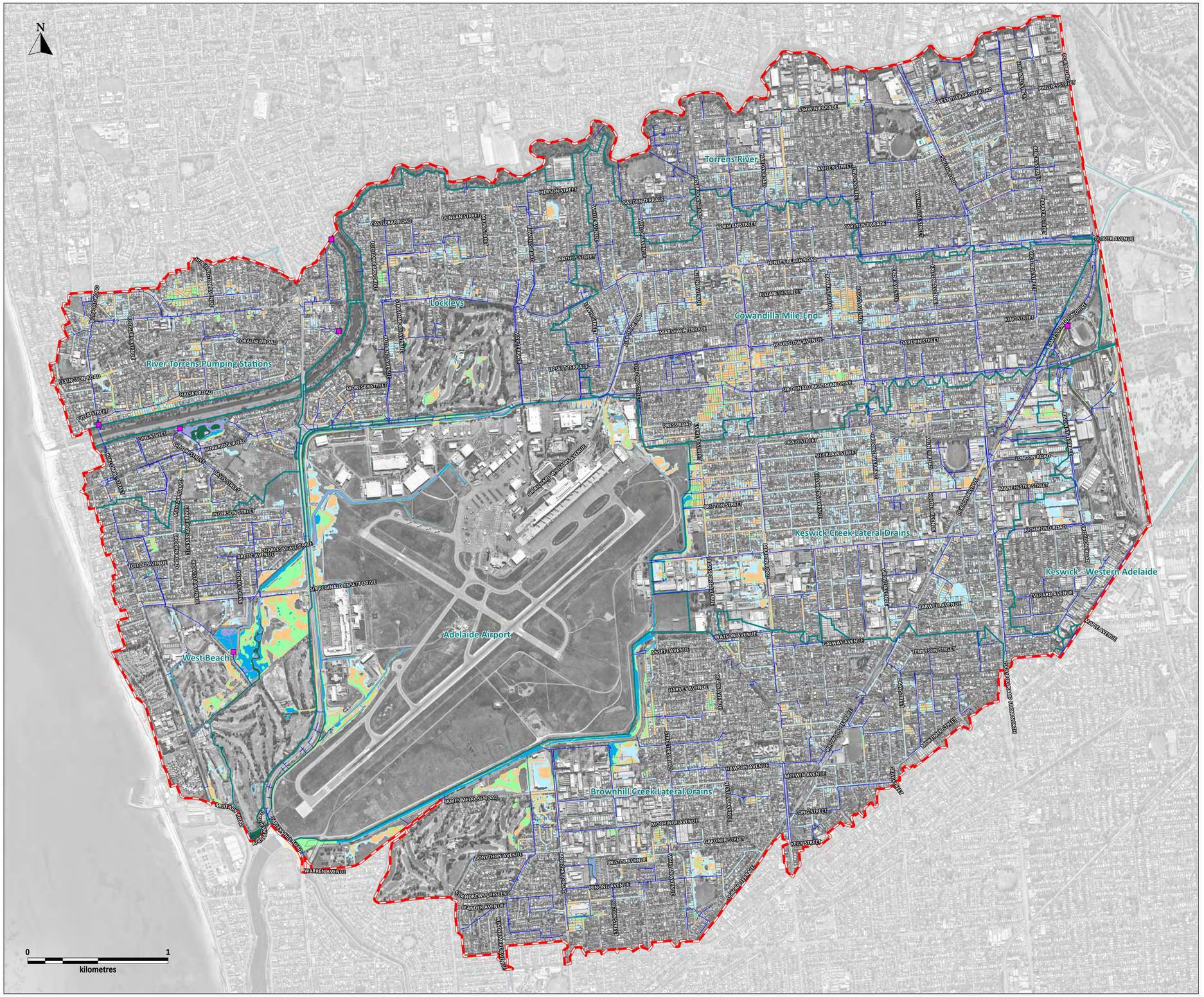
West Torrens
Stormwater Management Plan

5% AEP Floodplain Map
Scenario 1 - Existing Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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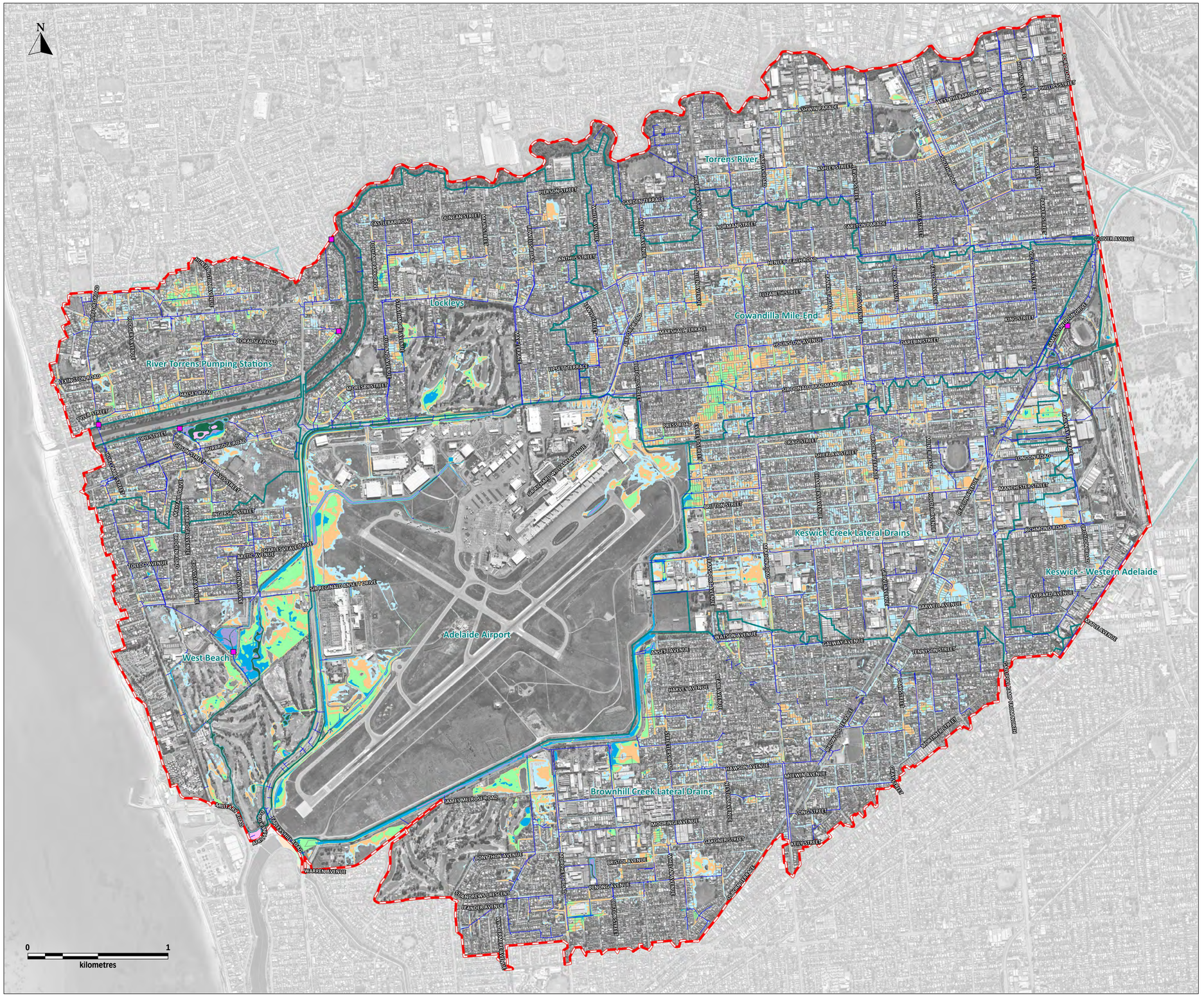
West Torrens
Stormwater Management Plan

2% AEP Floodplain Map
Scenario 1 - Existing Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

Disclaimer

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The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents. The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Floodplain Map
Scenario 1 - Existing Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Floodplain Map
Scenario 2 - Future Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Floodplain Map
Scenario 2 - Future Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Floodplain Map
Scenario 2 - Future Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents. The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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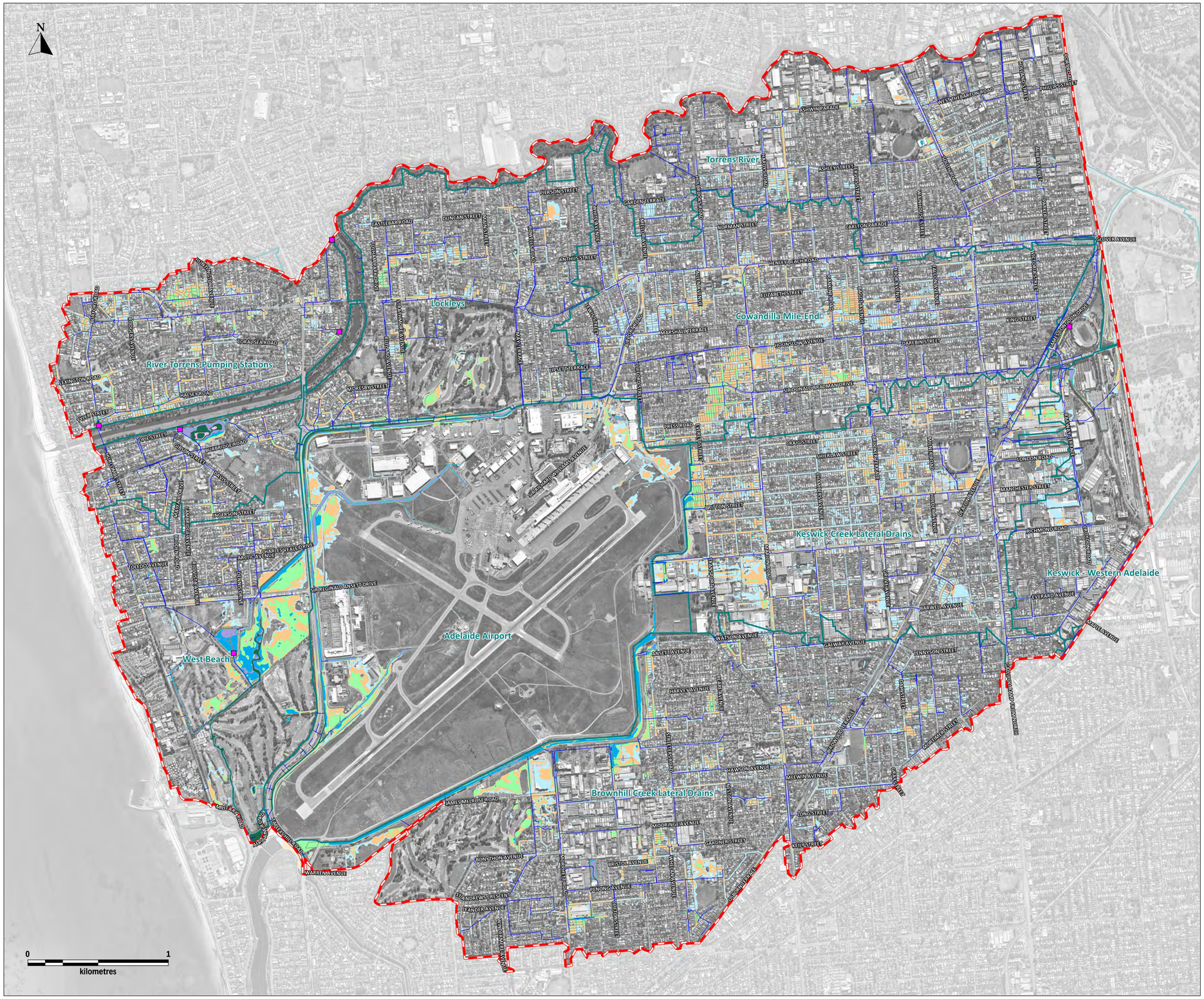
West Torrens
Stormwater Management Plan

5% AEP Floodplain Map
Scenario 2 - Future Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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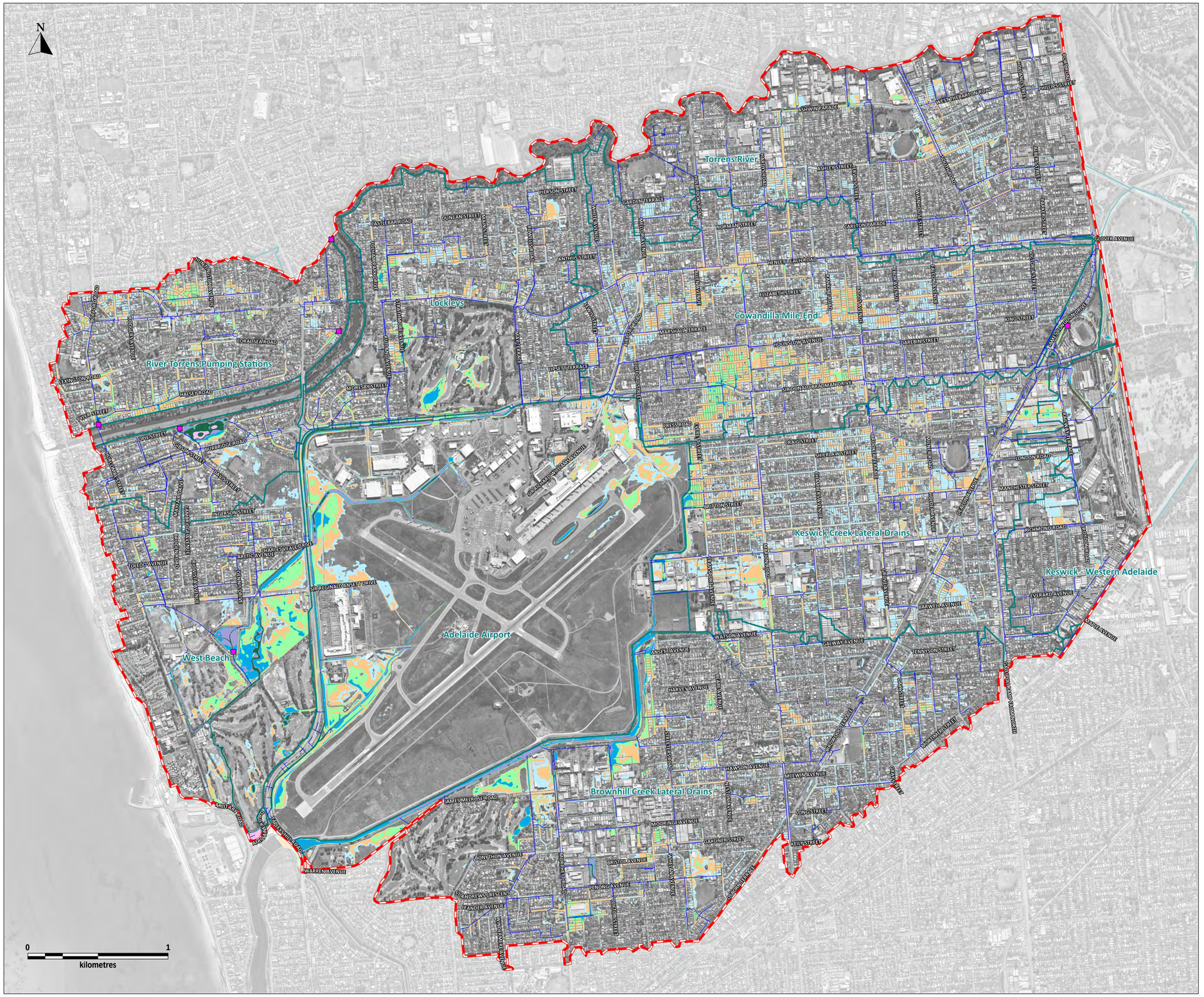
West Torrens
Stormwater Management Plan

2% AEP Floodplain Map
Scenario 2 - Future Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Floodplain Map
Scenario 2 - Future Development, Existing Infrastructure

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Floodplain Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents. The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.



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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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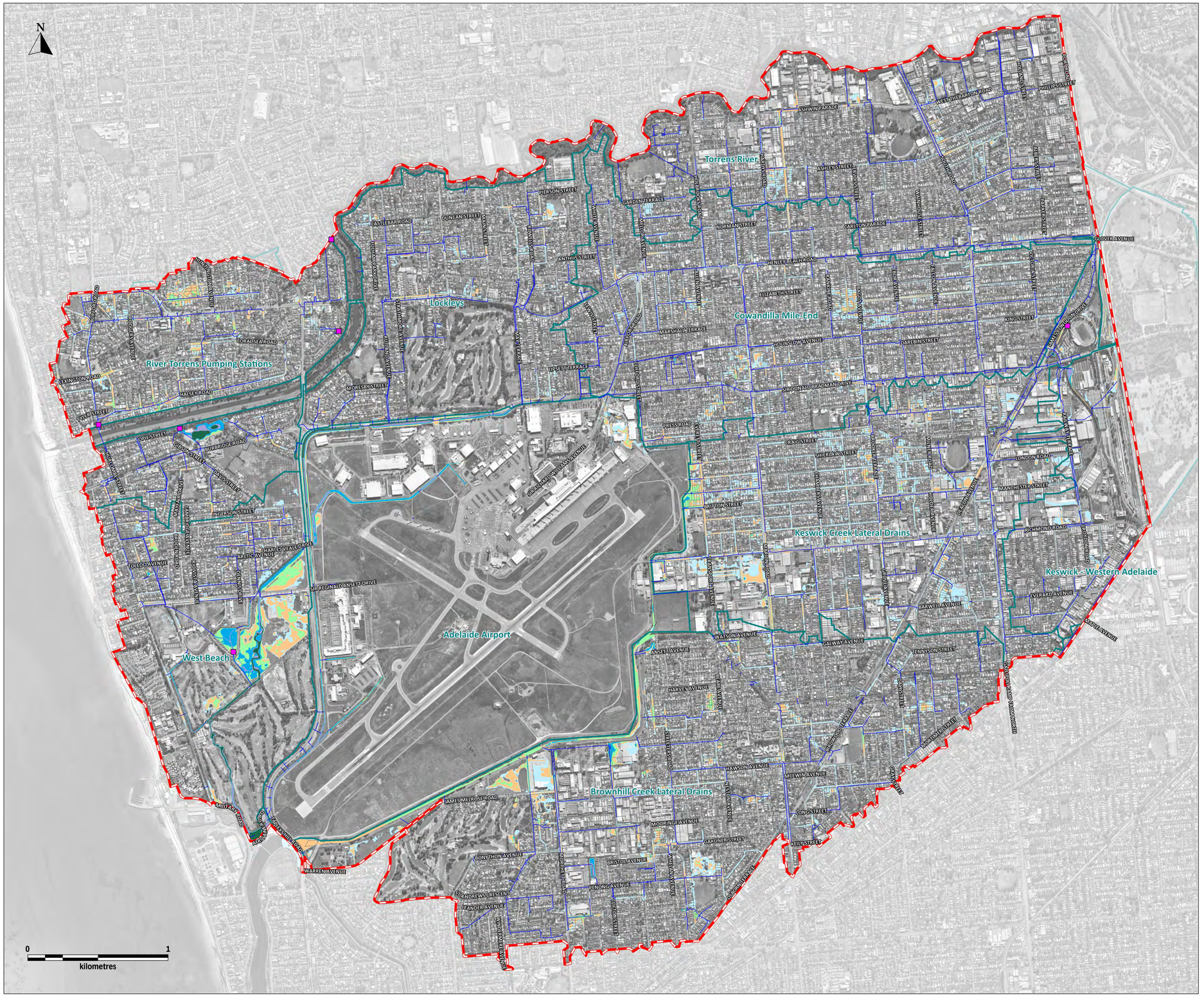
West Torrens
Stormwater Management Plan

0.2 EY Floodplain Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Floodplain Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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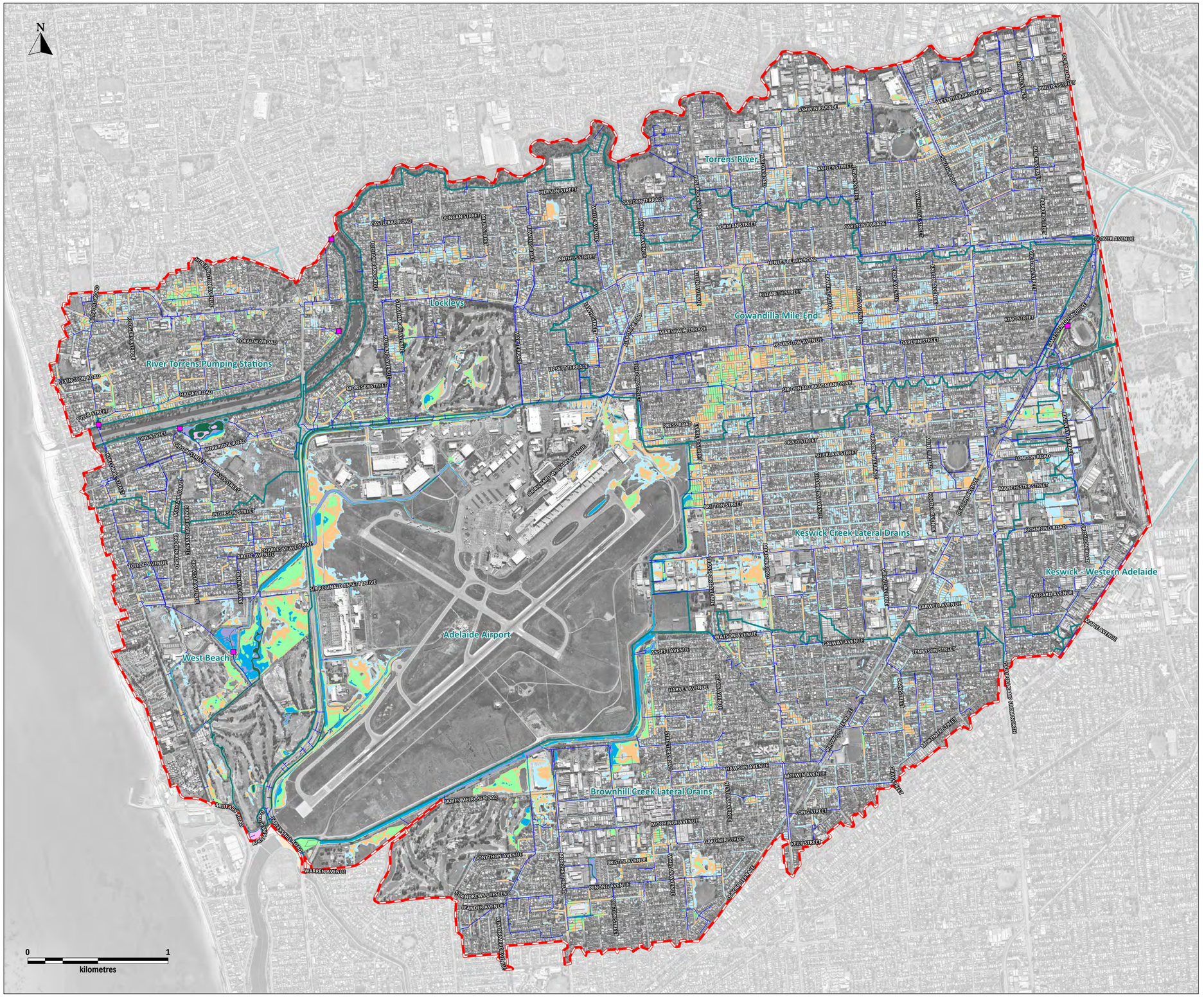
West Torrens
Stormwater Management Plan

5% AEP Floodplain Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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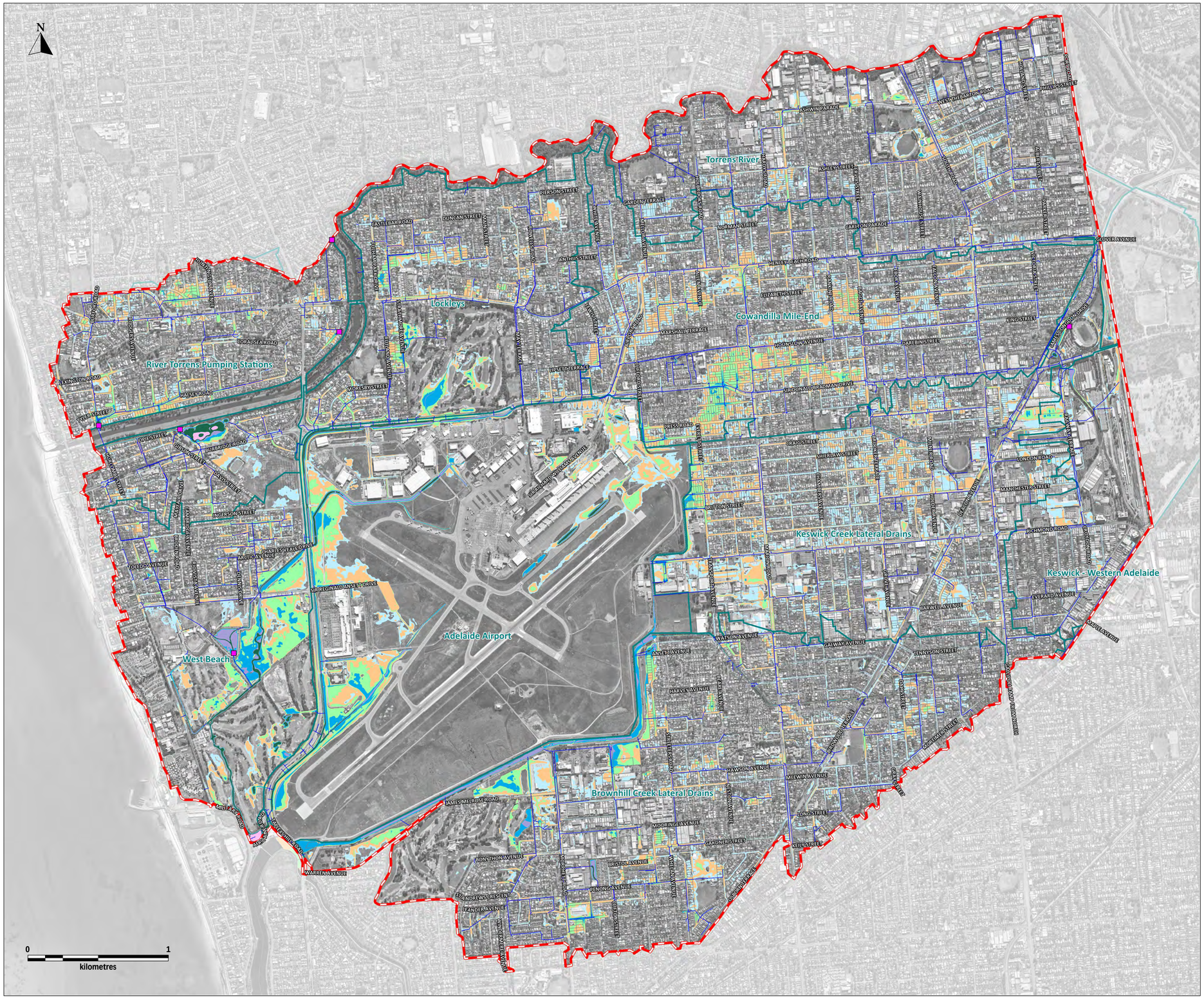
West Torrens
Stormwater Management Plan

2% AEP Floodplain Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Floodplain Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Floodplain Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.



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Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Floodplain Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

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Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

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Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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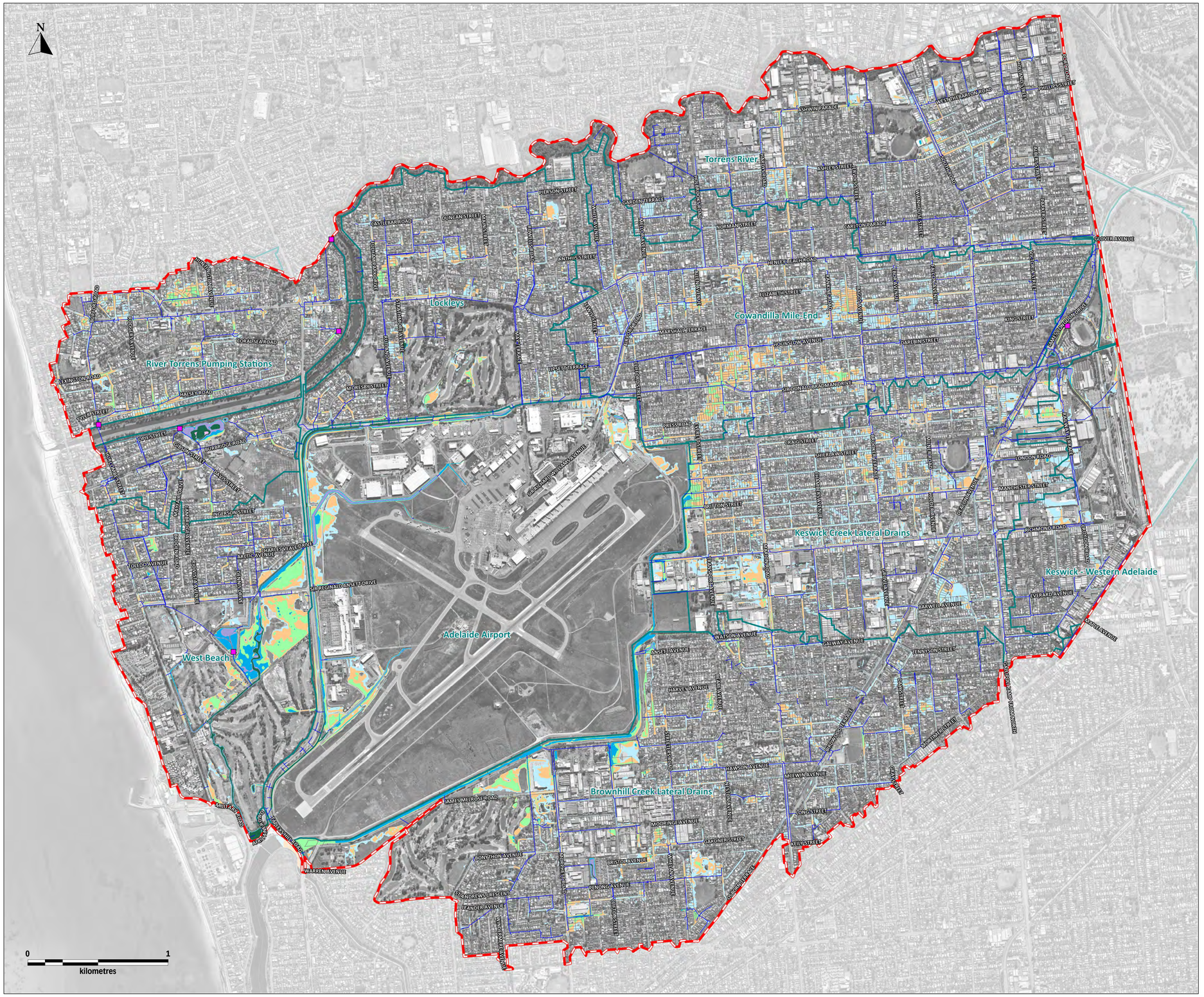
West Torrens
Stormwater Management Plan

10% AEP Floodplain Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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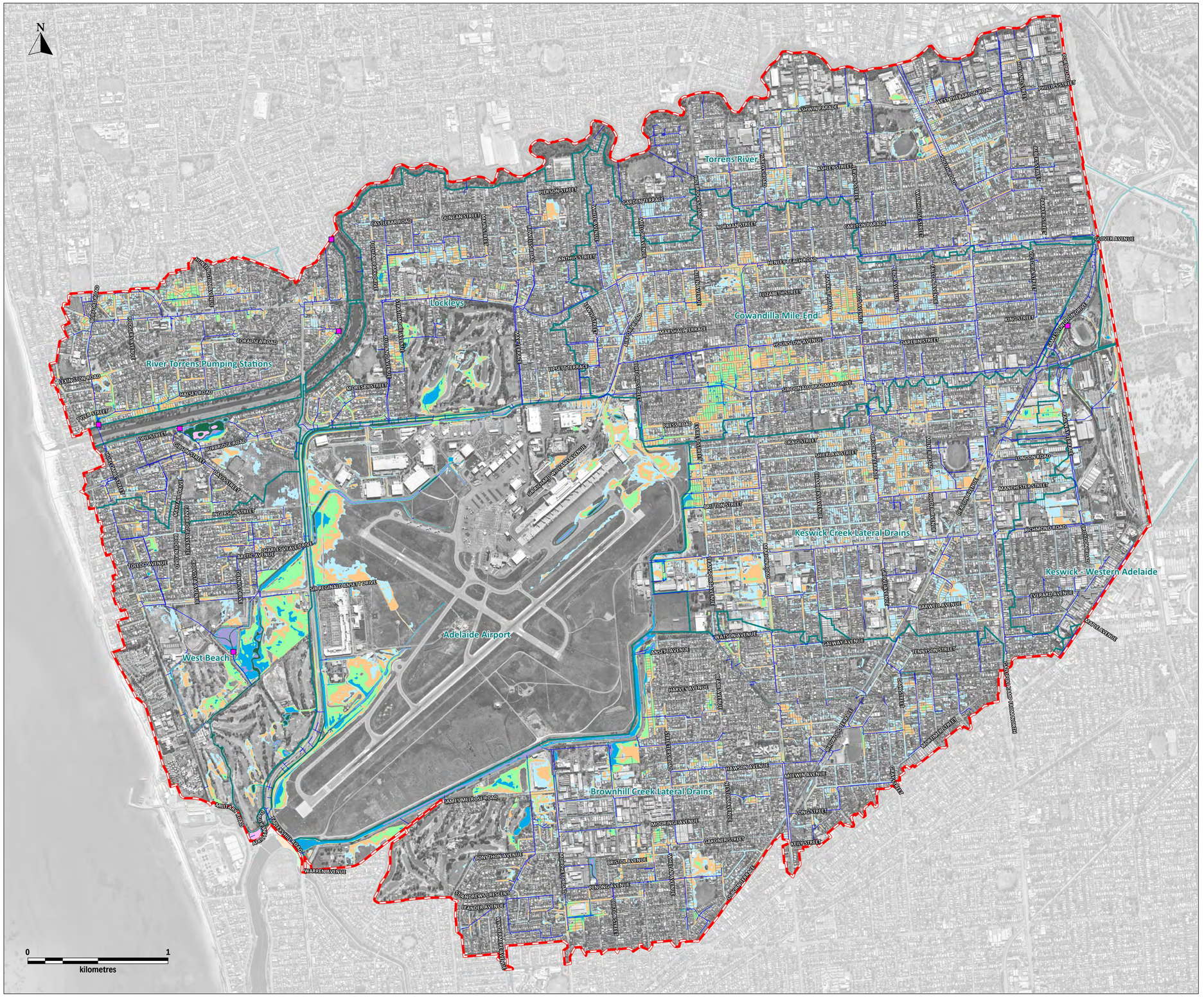
West Torrens
Stormwater Management Plan

5% AEP Floodplain Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

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- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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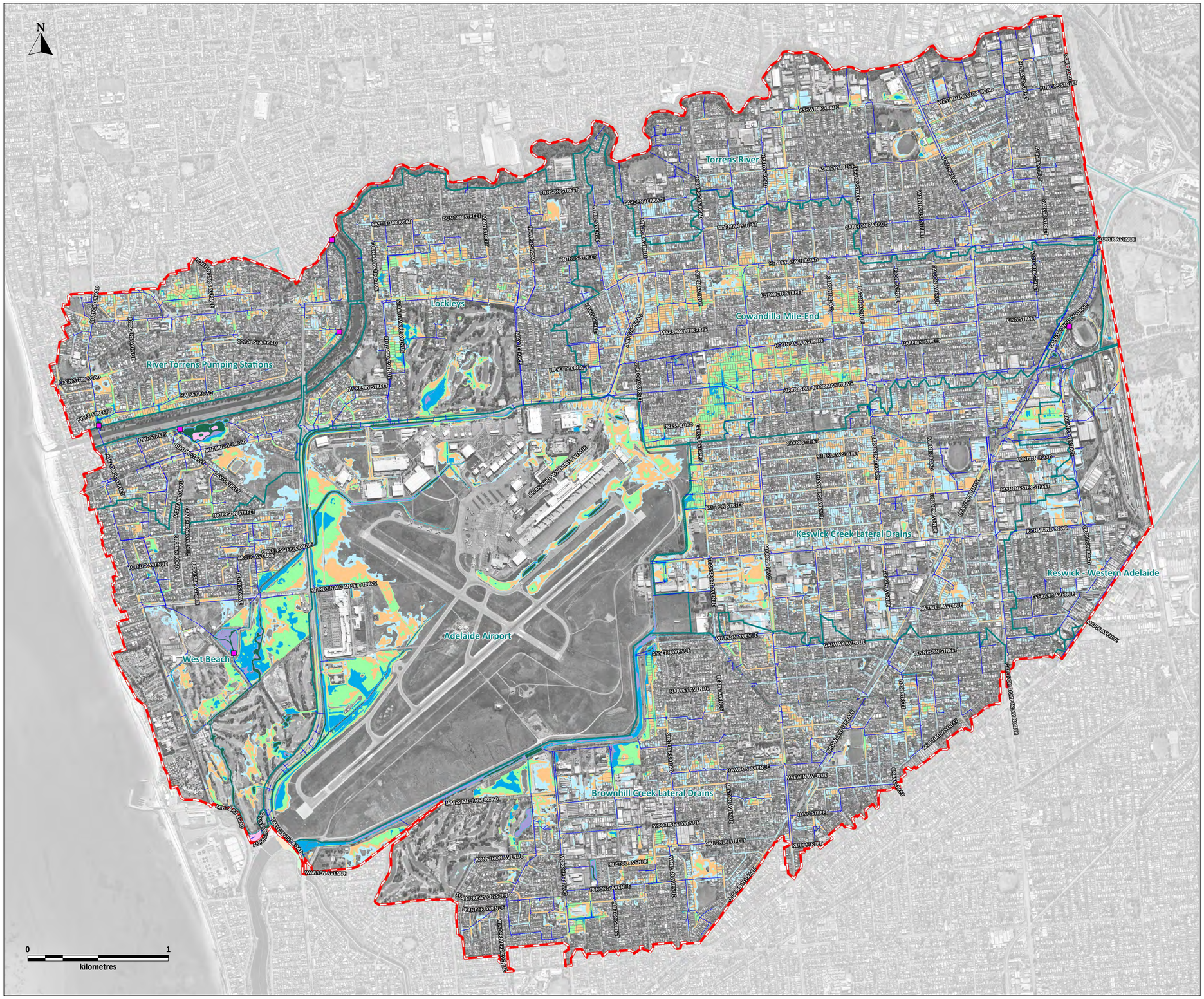
West Torrens
Stormwater Management Plan

2% AEP Floodplain Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

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- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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The flood extents are not based on actual historical floods.

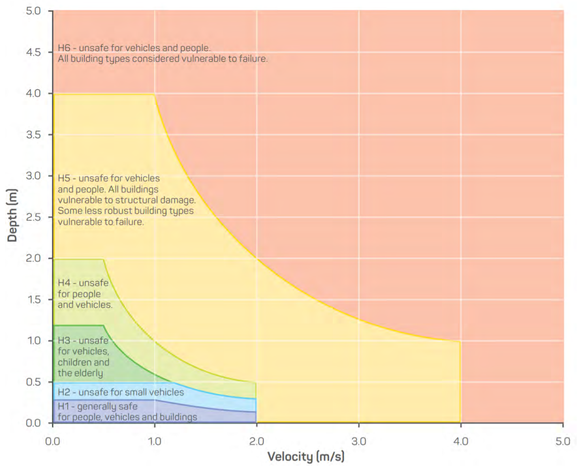
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Floodplain Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

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Areas of very shallow flooding

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Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

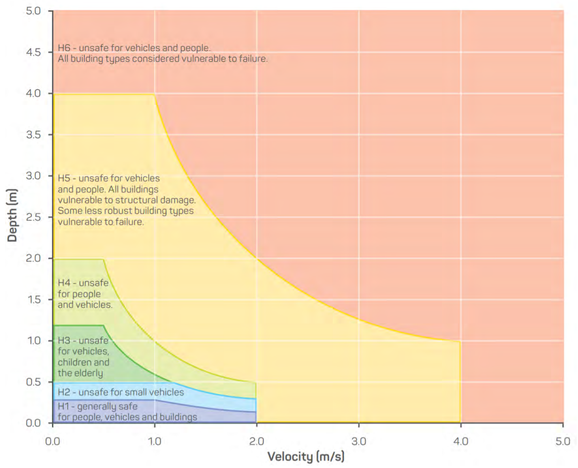
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Hazard Map
Scenario 1 - Existing Development, Existing Infrastructure



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

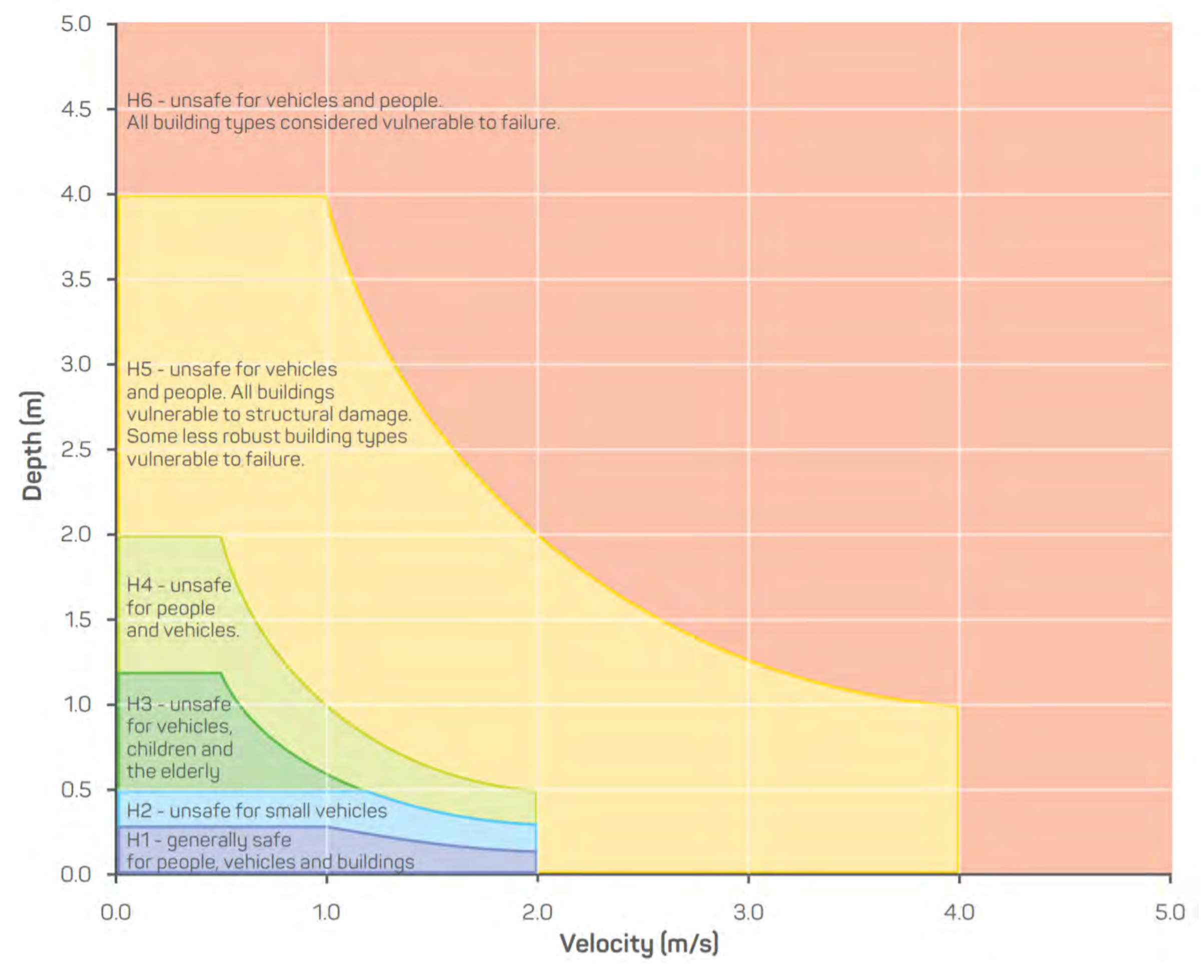
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Hazard Map
Scenario 1 - Existing Development, Existing Infrastructure

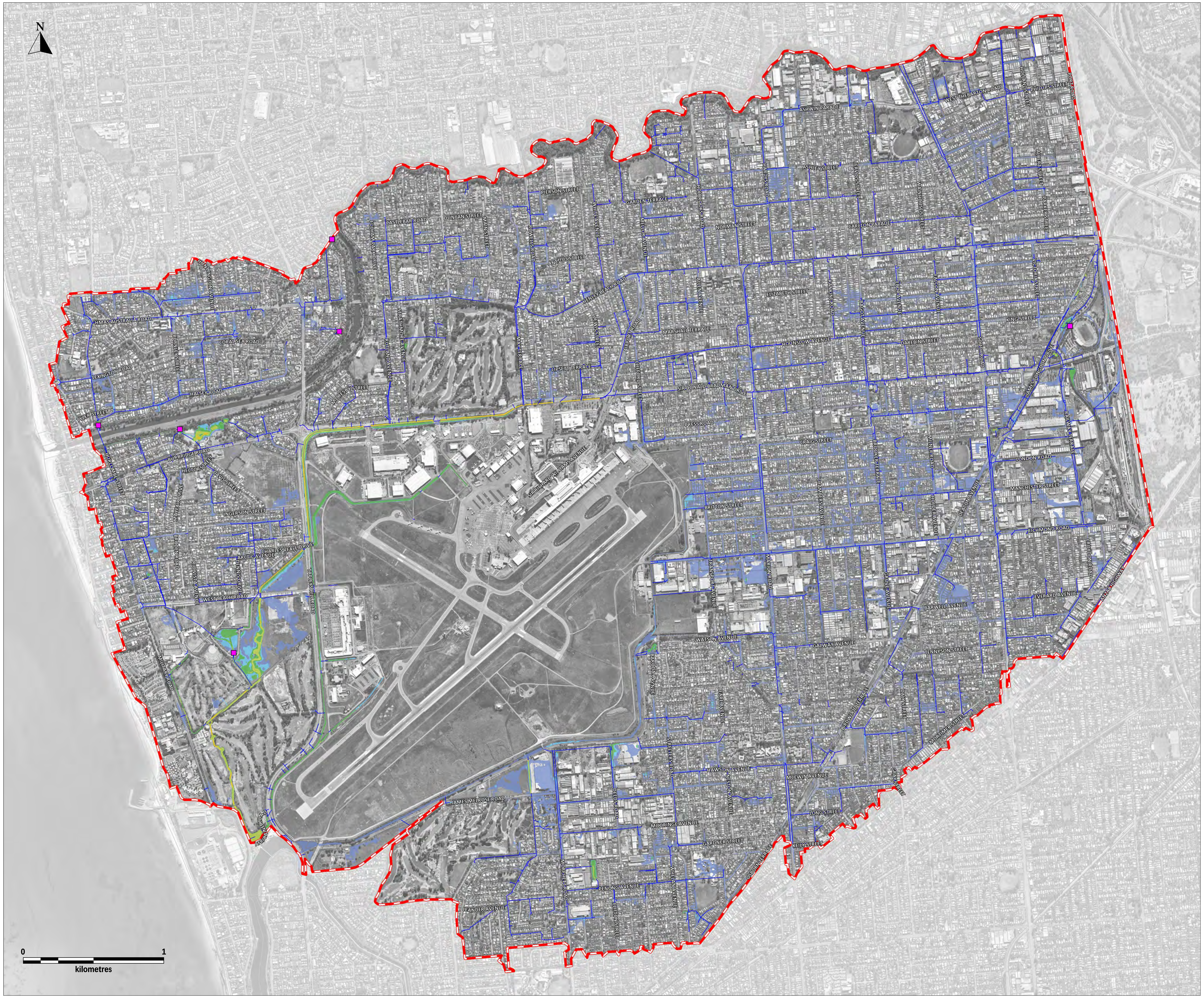


Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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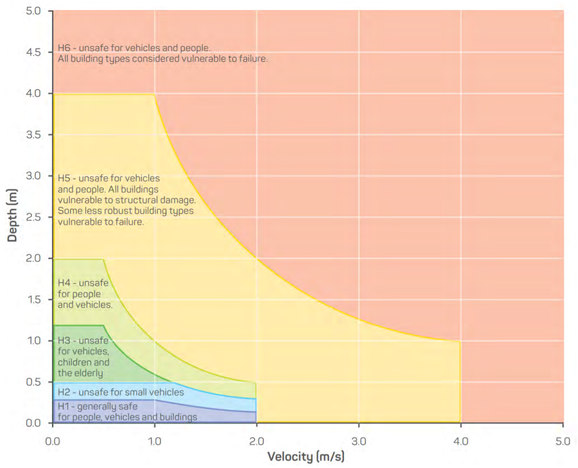
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West Torrens

Stormwater Management Plan

10% AEP Hazard Map

Scenario 1 - Existing Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

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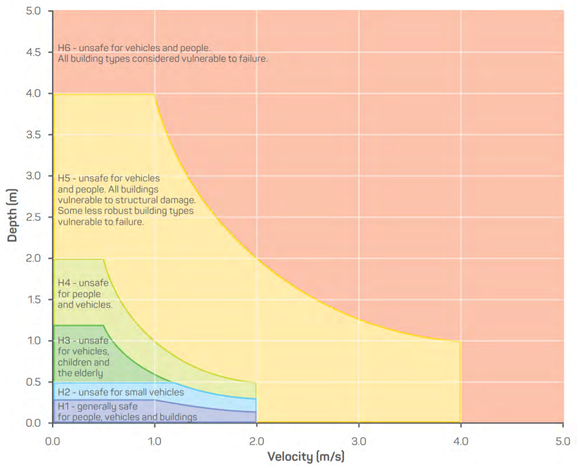
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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

5% AEP Hazard Map
Scenario 1 - Existing Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

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The data contained on this map is based on survey, hydraulic and hydrological modelling to accuracy sufficient for broad scale flood risk management and planning. Further development, earthworks and other changes to the catchment may affect the actual flood extents. The modelling reflects current practice but it may be realised that there are uncertainties and assumptions associated with the data and the processes on which the models are based, and therefore the flood extents shown on this map cannot be regarded as exact predictions.

The flood extents are not based on actual historical floods.

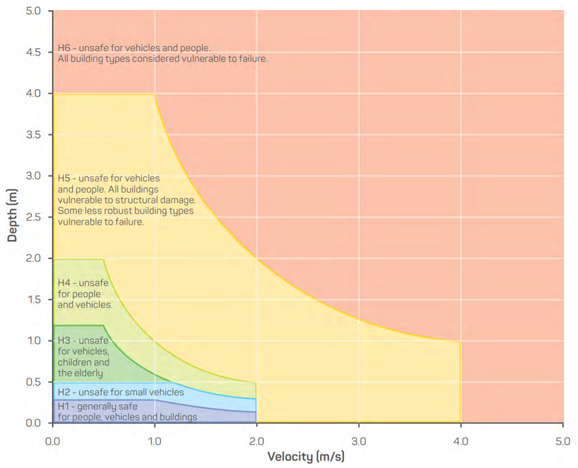
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

2% AEP Hazard Map
Scenario 1 - Existing Development, Existing Infrastructure

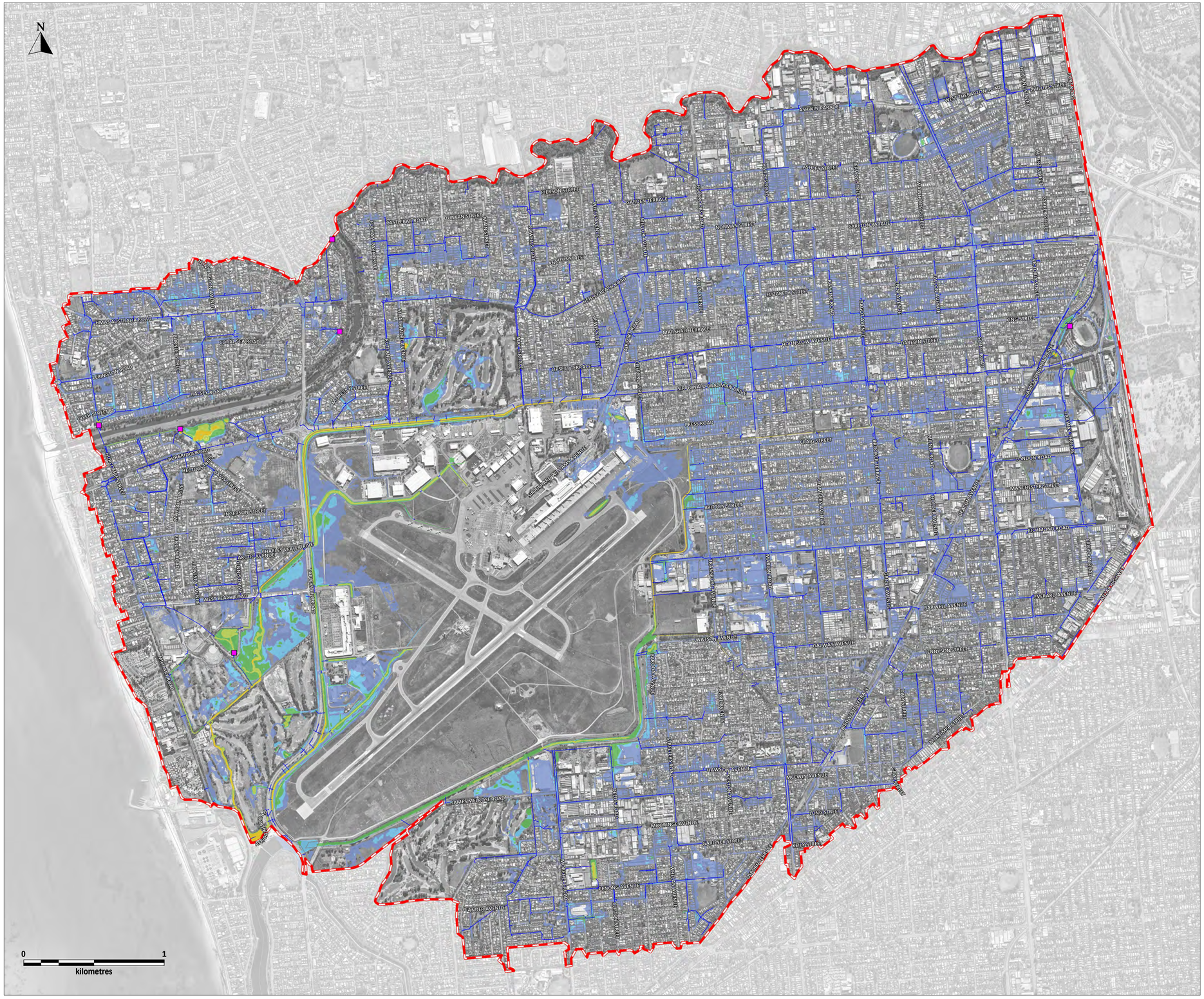


Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

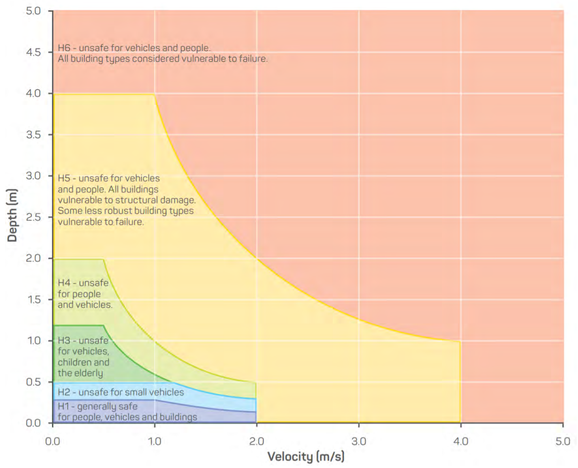
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Data Sources:
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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Hazard Map
Scenario 1 - Existing Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

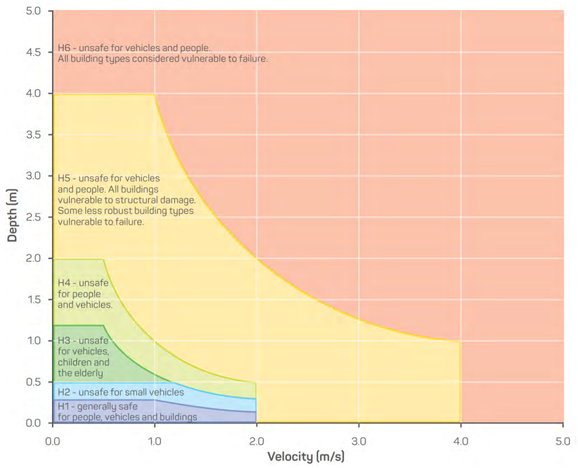
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Data Sources:
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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Hazard Map
Scenario 2 - Future Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

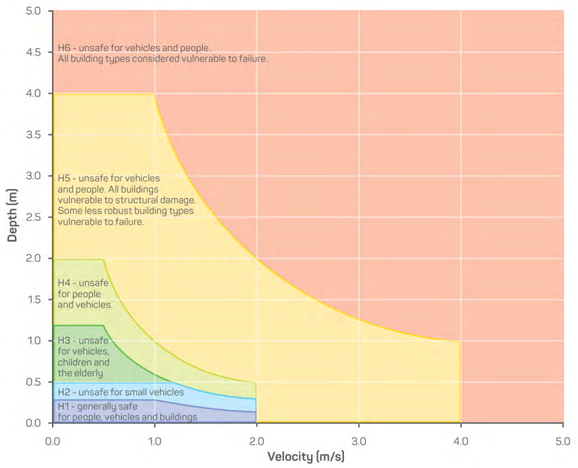
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Hazard Map
Scenario 2 - Future Development, Existing Infrastructure

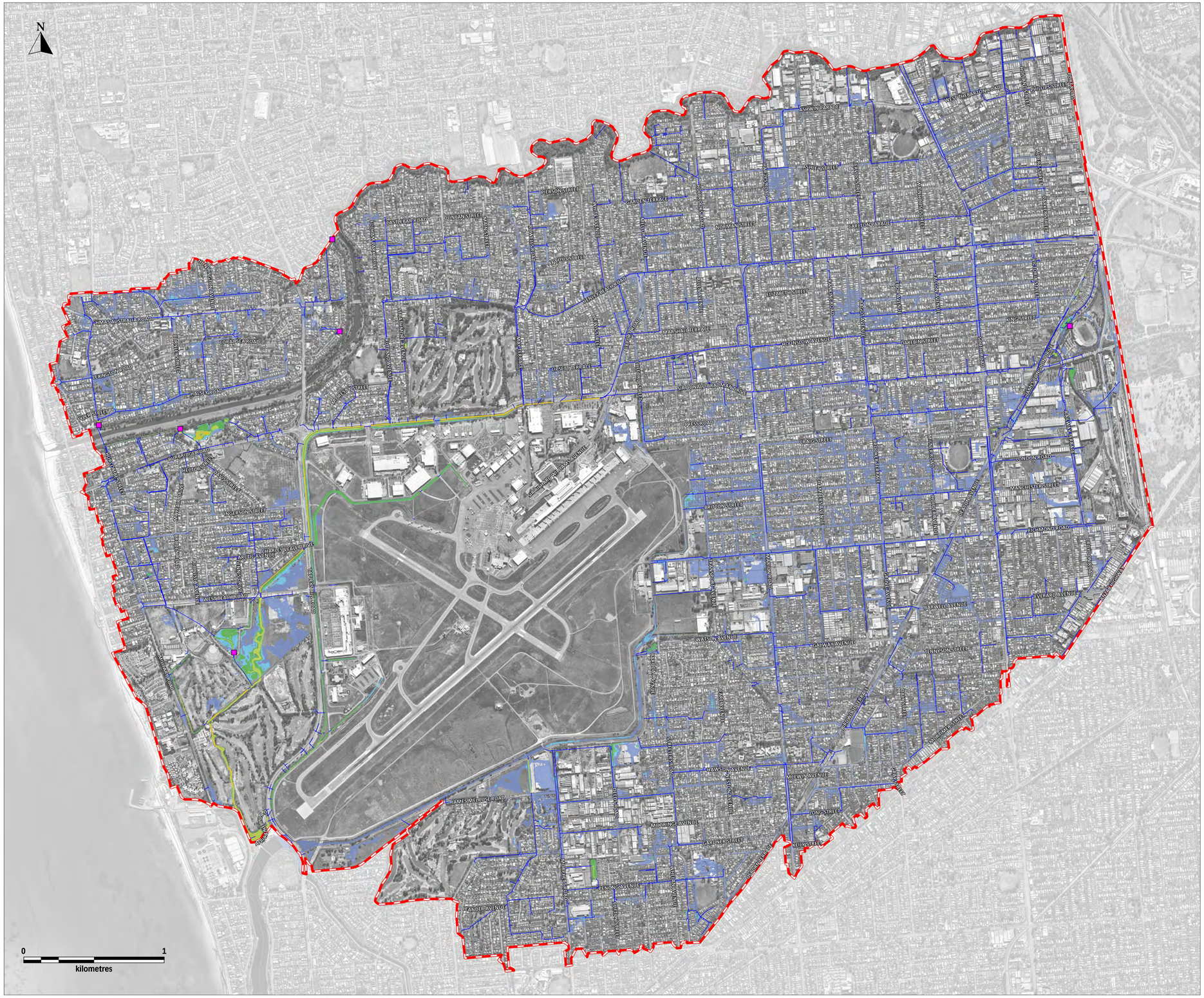


Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

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Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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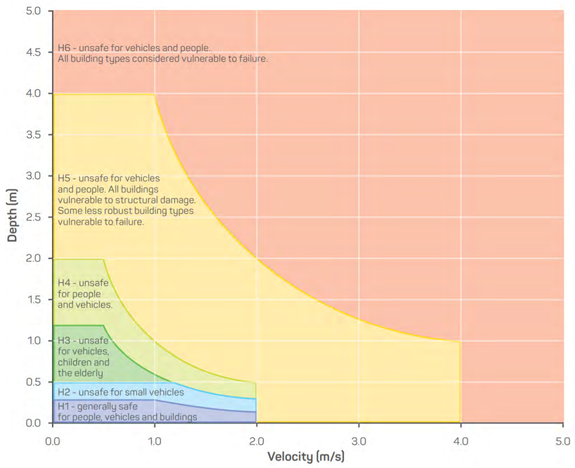
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Hazard Map
Scenario 2 - Future Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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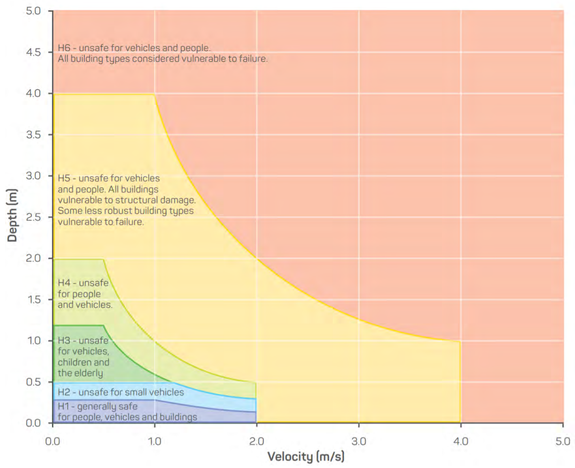
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

5% AEP Hazard Map
Scenario 2 - Future Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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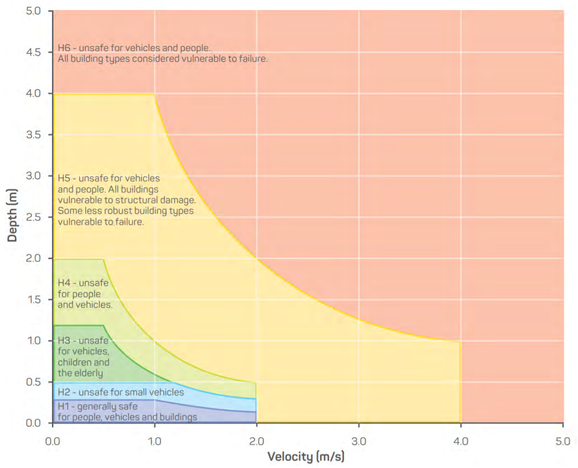
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

2% AEP Hazard Map
Scenario 2 - Future Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

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Storm Durations

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Scope of Mapping

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Land outside the flood extent shown on this map could be affected by:

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Areas of very shallow flooding

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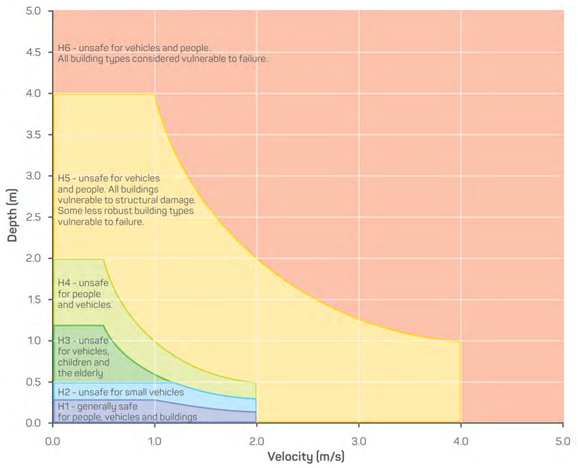
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Hazard Map
Scenario 2 - Future Development, Existing Infrastructure



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

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Scope of Mapping

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• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

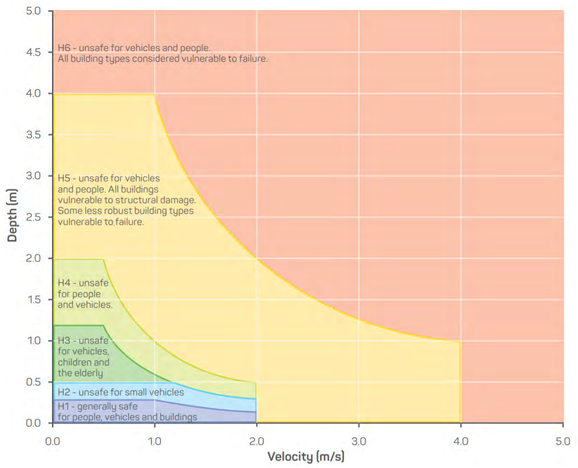
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Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Hazard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

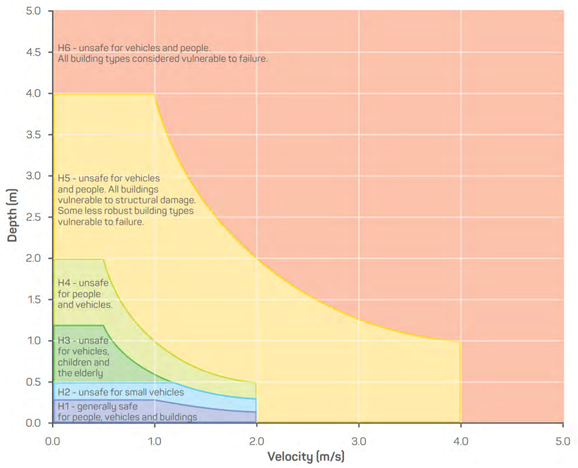
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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Hazard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

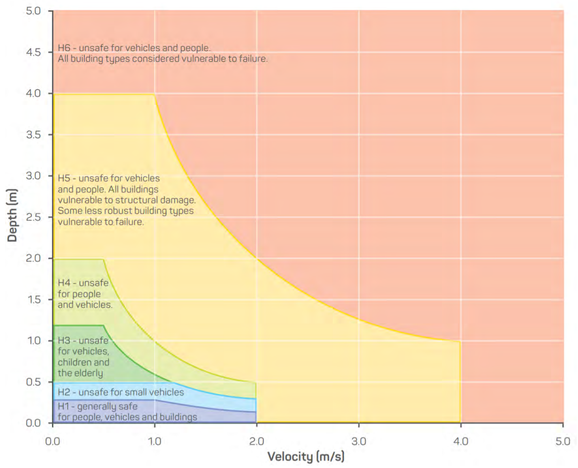
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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Hazard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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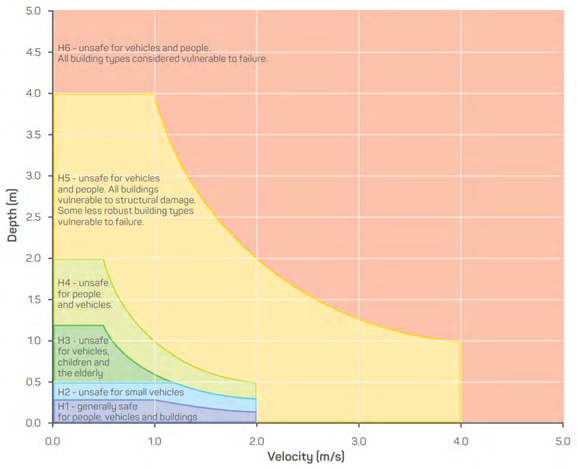
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

5% AEP Hazard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

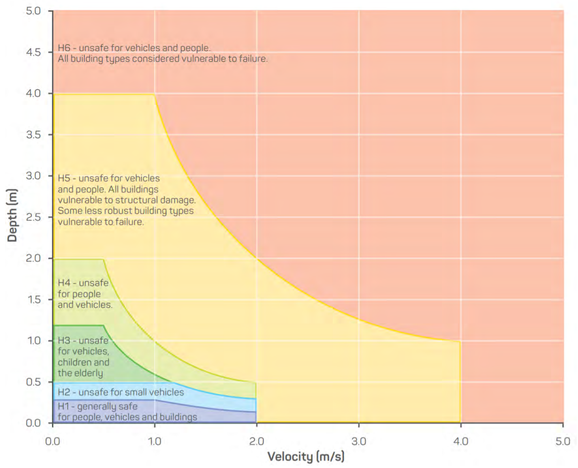
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

2% AEP Hazard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

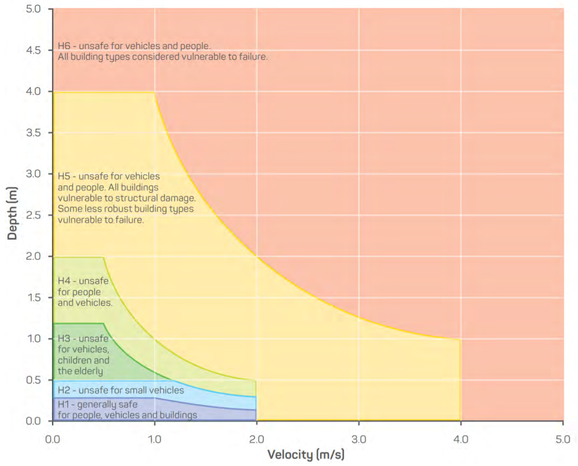
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NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Hazard Map
Scenario 3 - Future Development, Existing Infrastructure, Climate Change RCP 4.5

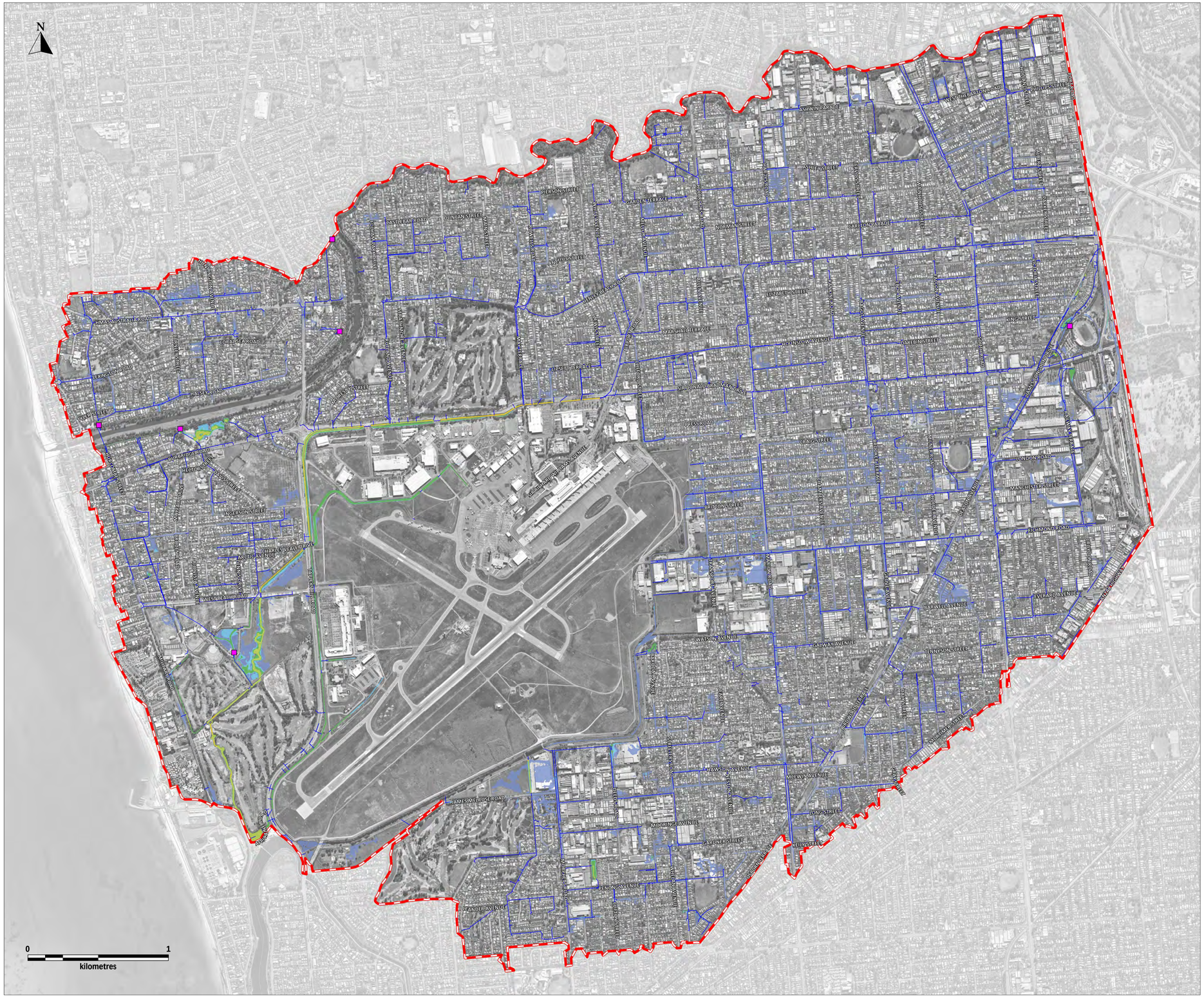


Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

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Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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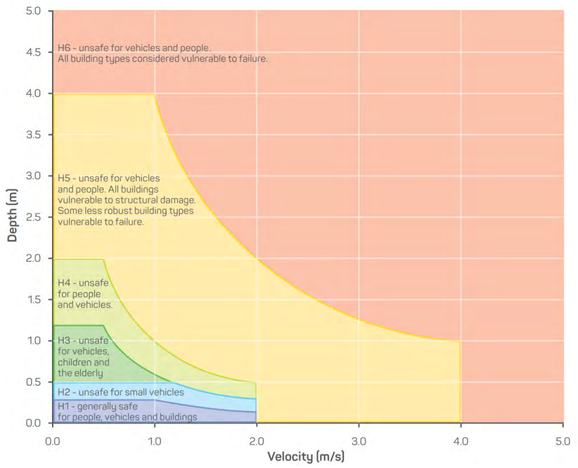
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NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Hazard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

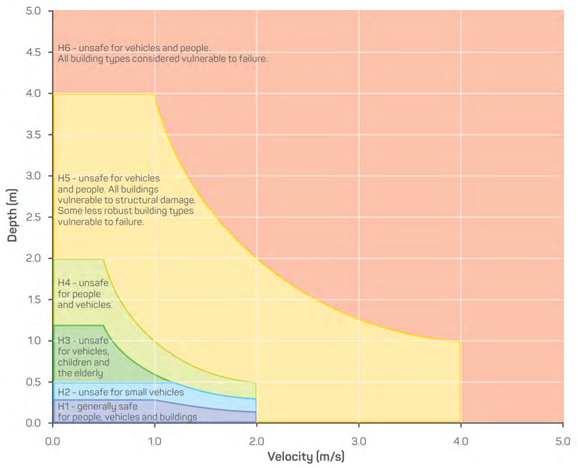
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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Hazard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

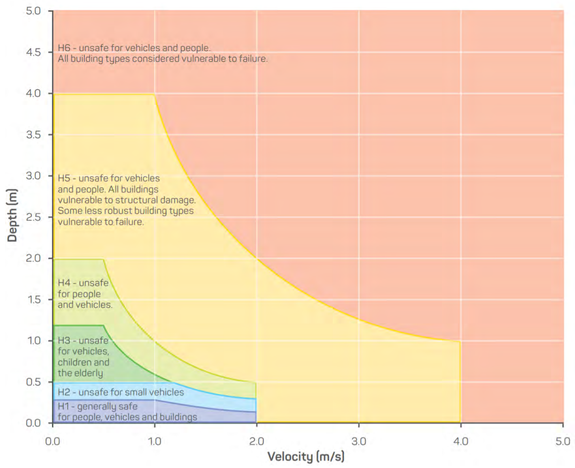
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Hazard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

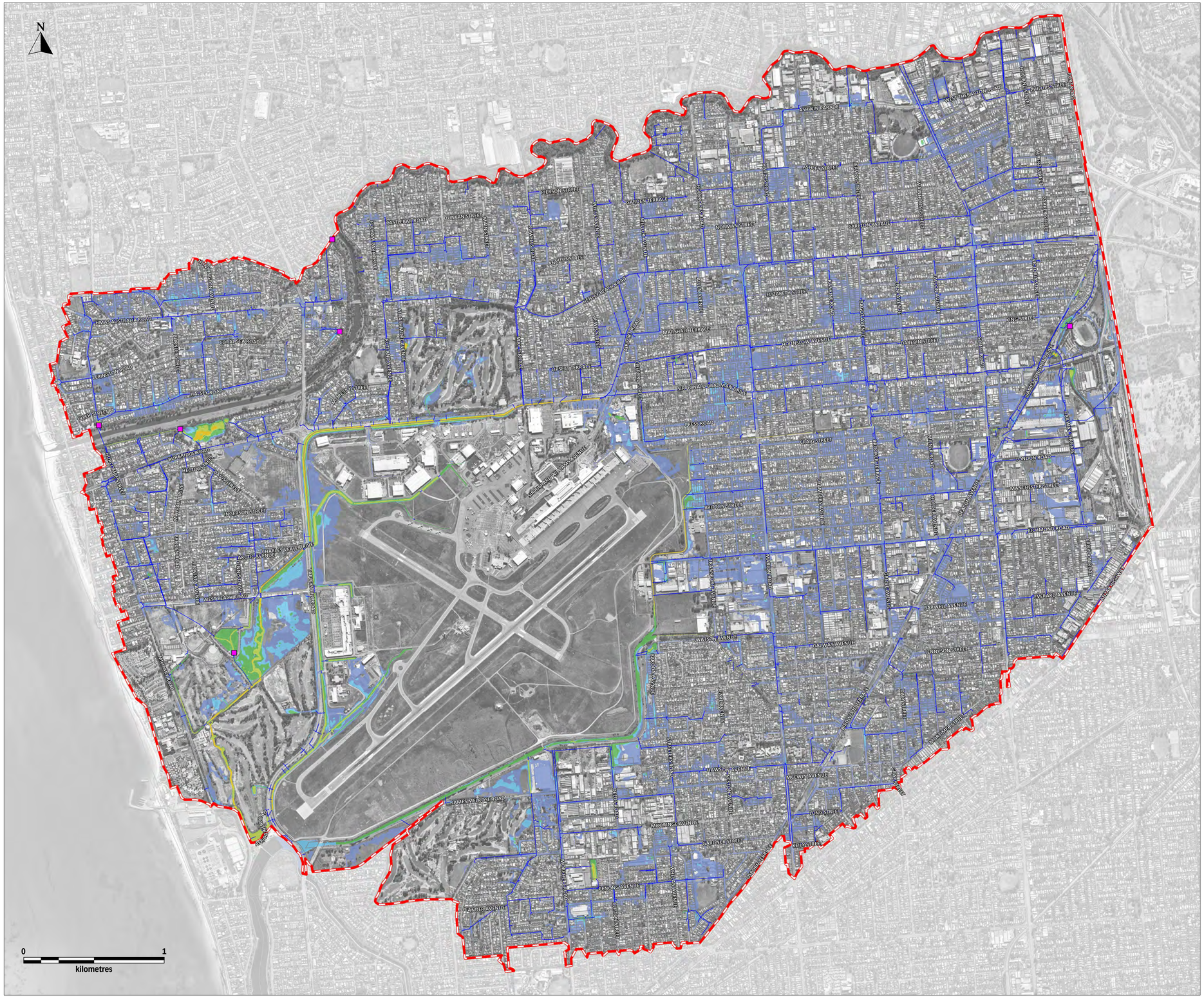


Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

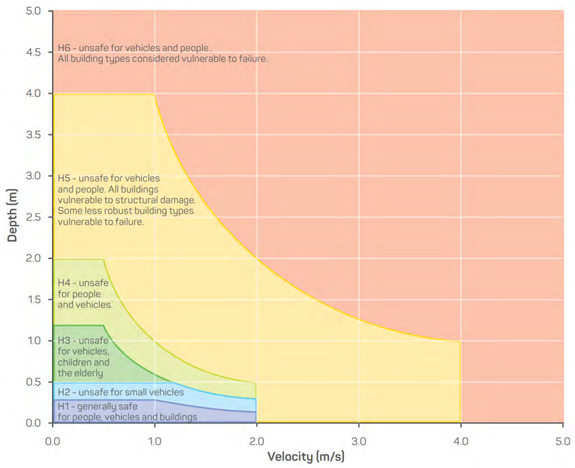
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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

5% AEP Hazard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Background

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Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

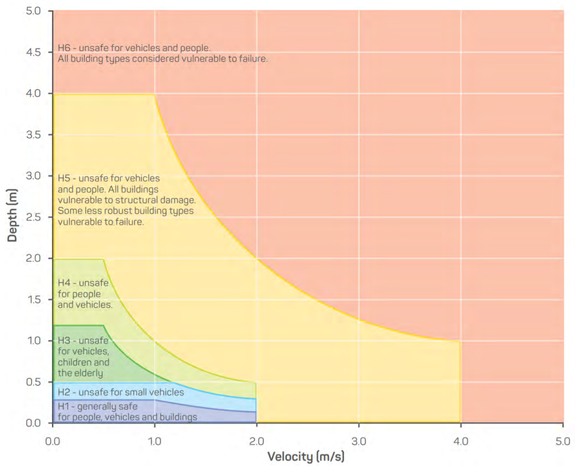
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

2% AEP Hazard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

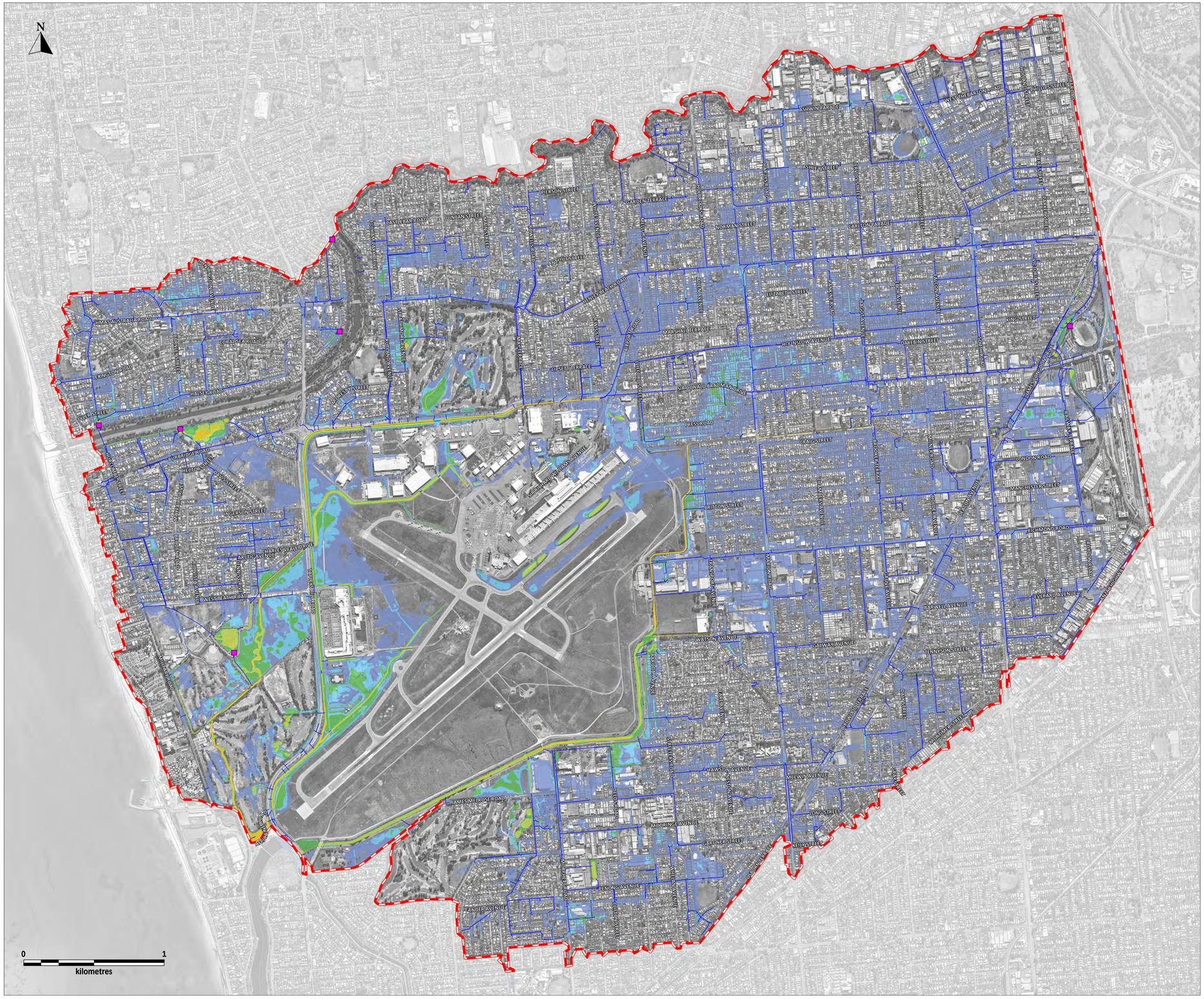


Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre



Background

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Flood Risk Probability

Flood risk can be considered in terms of:

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• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

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Storm Durations

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Scope of Mapping

The limit of flooding 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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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
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NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Hazard Map
Scenario 4 - Future Development, Existing Infrastructure, Climate Change RCP 8.5

Appendix F

Upgrade Scenario Flood Plain Mapping



Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Upgrade Stormwater Drain
- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.



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Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Floodplain Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Upgrade Stormwater Drain
- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

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Flood Risk Probability

Flood risk can be considered in terms of:

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

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The flood extents are not based on actual historical floods.

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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Floodplain Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Upgrade Stormwater Drain
- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

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Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

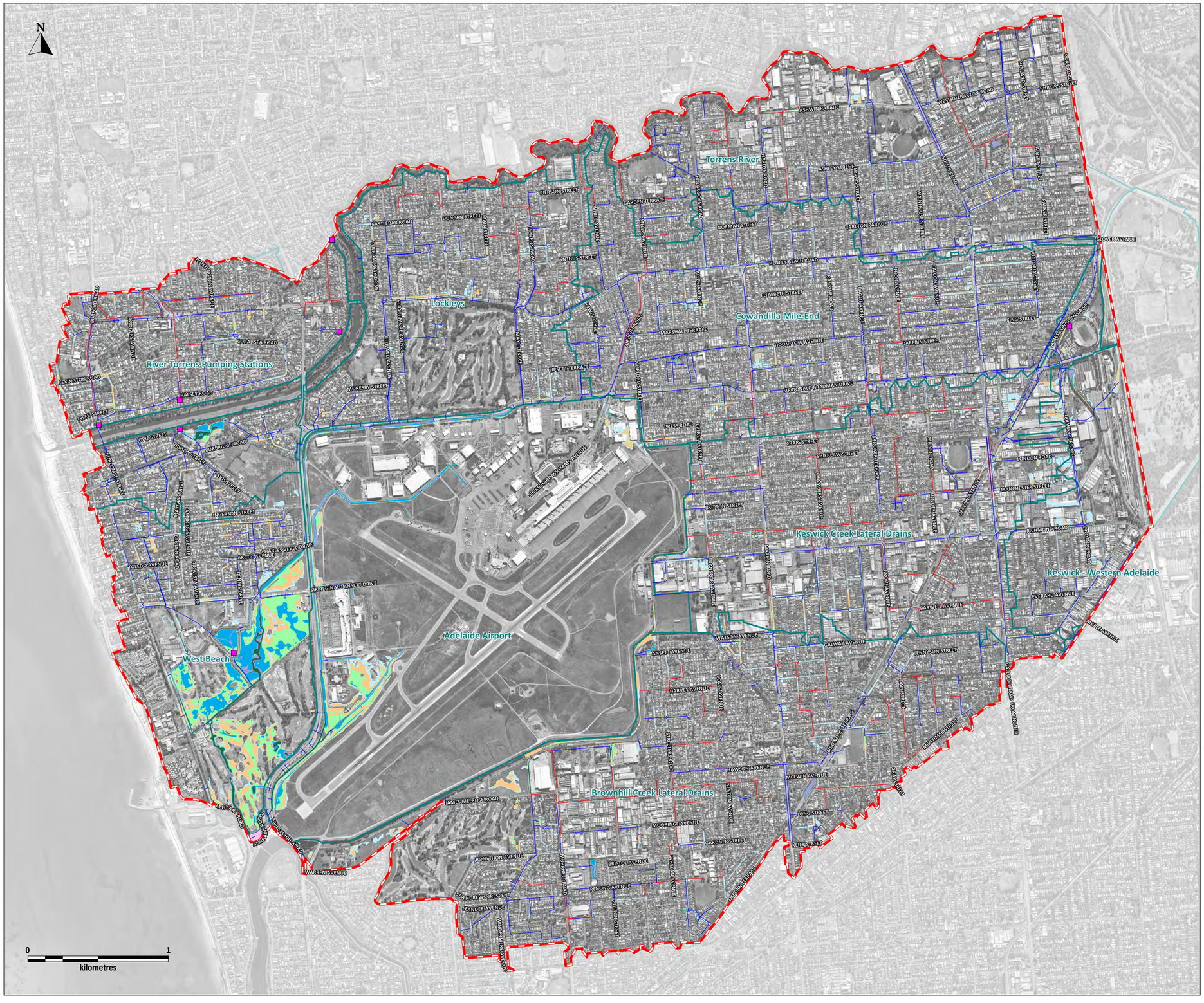
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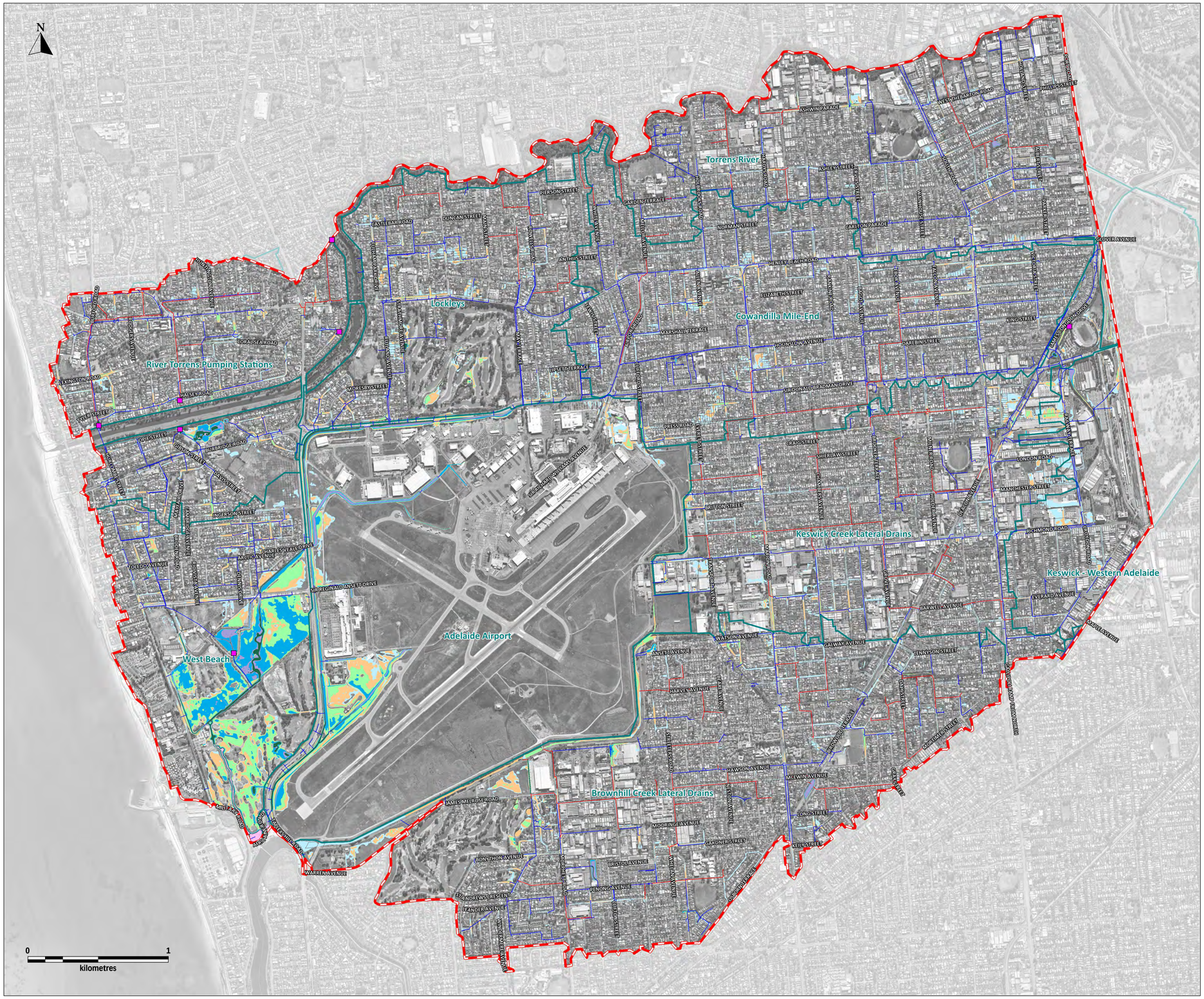
West Torrens
Stormwater Management Plan

10% AEP Floodplain Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
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- Upgrade Stormwater Drain
- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

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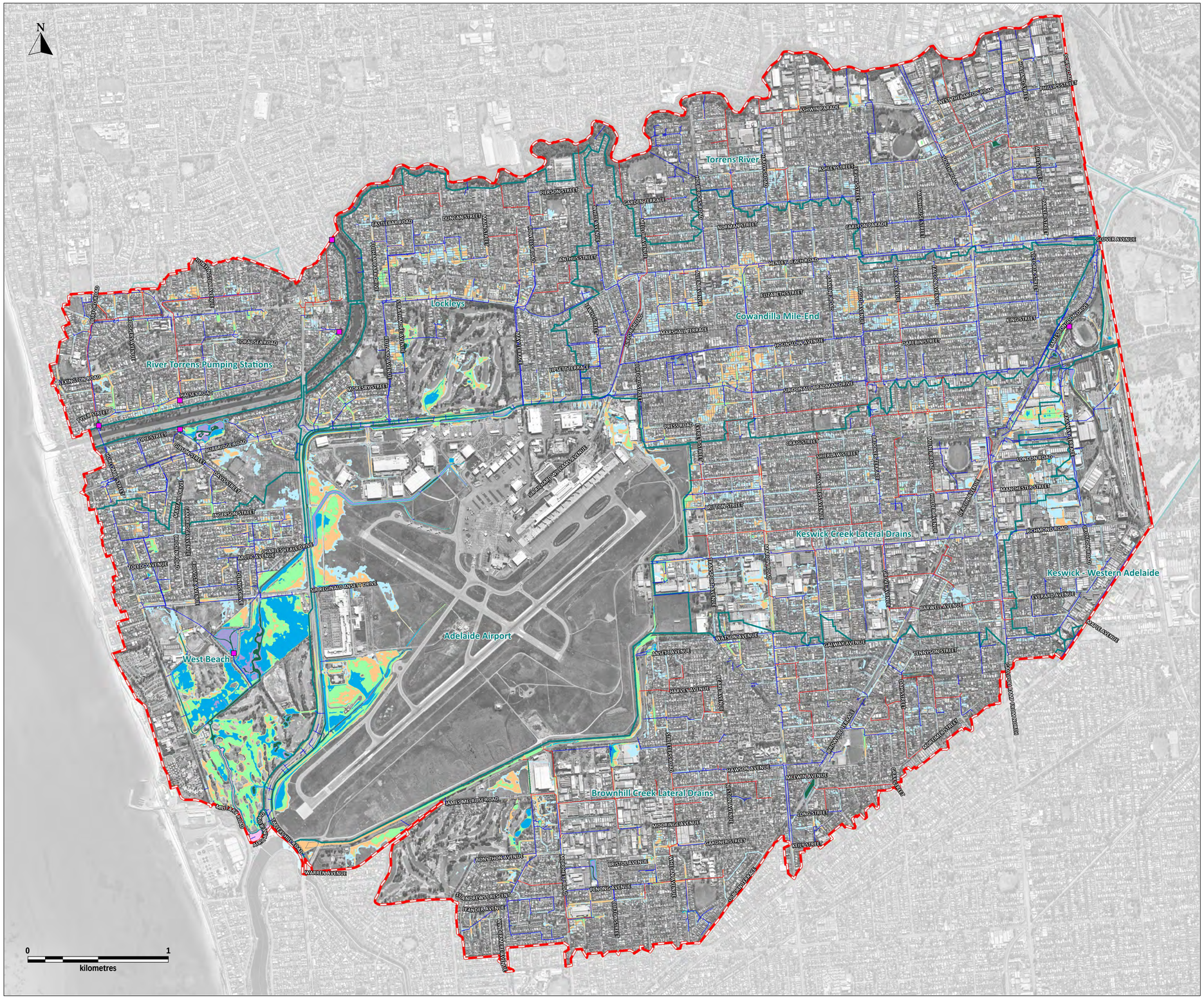
West Torrens
Stormwater Management Plan

5% AEP Floodplain Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Upgrade Stormwater Drain
- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Areas of flooding with depth of less than 25mm have been cropped from the flood plain extent.

Effect of debris on flood extent

Vegetation and other debris are likely to be carried by flood flows and may cause blockages in creeks and culverts. This cannot be predicted and consequently the impact of blockages is not modelled. If blockages do occur, flood extents will vary from those shown on the map.

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The flood extents are not based on actual historical floods.

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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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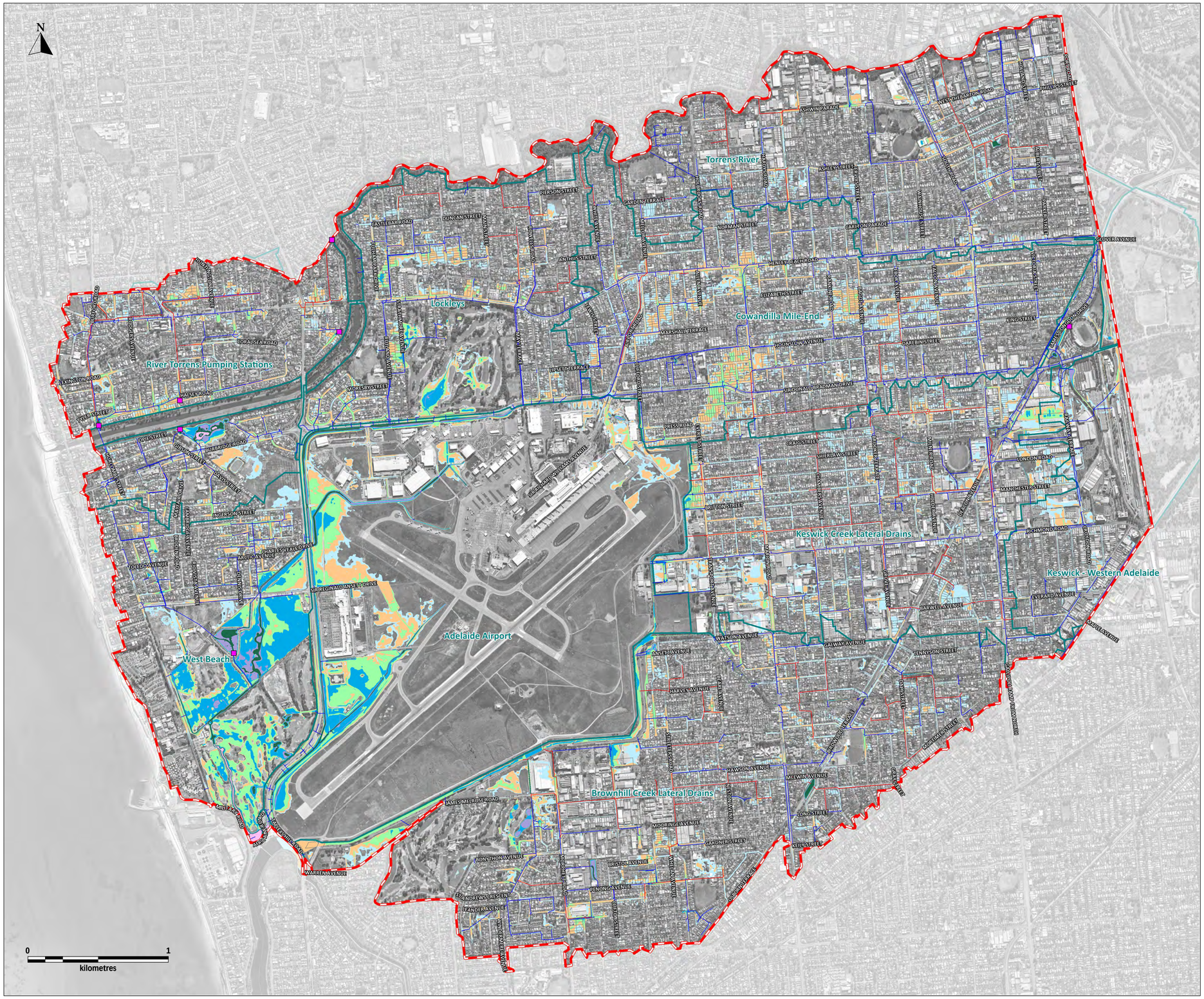
West Torrens
Stormwater Management Plan

2% AEP Floodplain Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5

Flood Depth Contour Band

- 0.025 – 0.1 m
- 0.1 – 0.25 m
- 0.25 – 0.5 m
- 0.5 – 1.0 m
- 1.0 – 1.5 m
- 1.5 – 2.5 m
- 2.5 – 5.0 m
- > 5.0 m

- Upgrade Stormwater Drain
- Existing Stormwater Drain
- Pump Station
- Model Boundary
- Major Catchments
- Cadastre



Background

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Scope of Mapping

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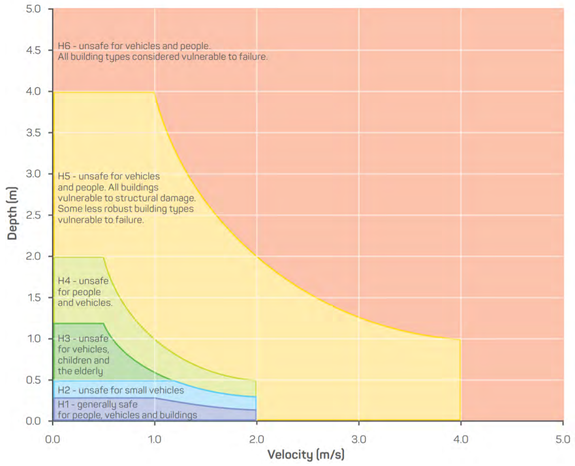
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

1% AEP Floodplain Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Upgrade Stormwater Drain

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

The limit of flooding 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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• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

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Effect of debris on flood extent

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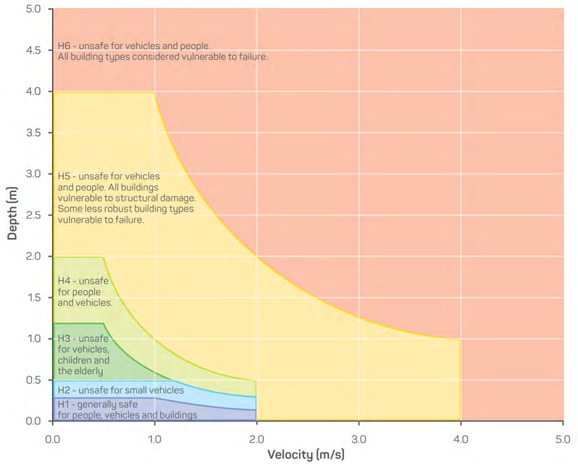
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City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upgrade Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.5 EY Hazard Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Upgrade Stormwater Drain

Background

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Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

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Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

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Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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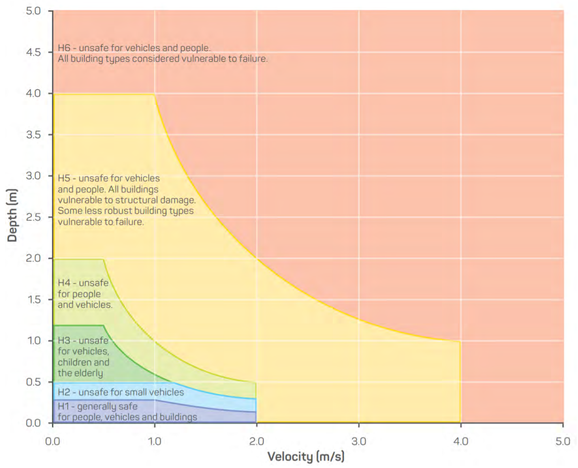
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

0.2 EY Hazard Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Upgrade Stormwater Drain

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

• Exceedances per Year (EY): the number of times an event is likely to occur or be exceeded within any given year;

• Annual Exceedance Probability (AEP): the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage.

Generally, EY terminology is used for Very Frequent design rainfalls and AEP (%) terminology is used for Frequent and Infrequent design rainfalls.

Storm Durations

The flooding response of a catchment is dependent on the duration of any storm event. Generally shorter, more intense storms produce the greatest flows from urban areas. Longer duration, but less intense storms produce the greatest flow from undeveloped rural areas.

As a result of this interaction this map combines the outer envelope or flood extent from the various storm events each of which produce the maximum flood extent in different parts of the catchment. Because of this, the extent of flooding shown may not occur across the entire area at the same time or during any one storm event.

Scope of Mapping

The limit of flooding 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:

• Storms with different Annual Exceedance Probability;

• Flooding from local drainage systems which can occur as a result of localised intense rainfall or drain blockage.

Areas of very shallow flooding

In areas shown as being affected by flood depths of less than 0.1m, machine plant, temporary stockpiles, fences, land excavation and buildings will affect the flow of floodwaters. Resolution to this level of detail is beyond the capabilities of the modelling process and consequently the level of certainty in relation to flood depths in these areas is reduced.

Effect of debris on flood extent

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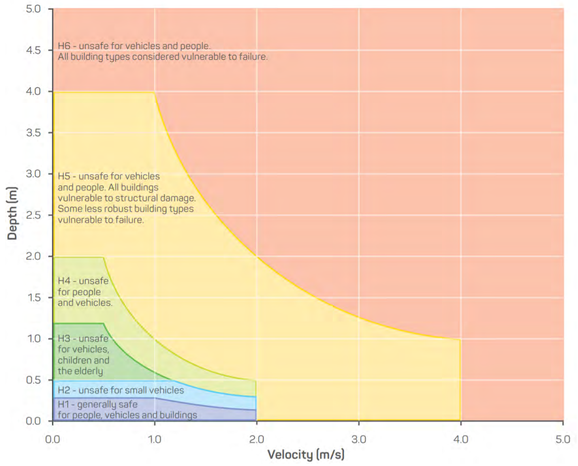
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

10% AEP Hazard Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Upgrade Stormwater Drain

Background

This map has been prepared using currently available technology to a standard of accuracy sufficient for broad scale flood risk management and planning. The map does not increase the risk or affect the level of flooding over an area or property. It merely seeks to identify the extent of flooding over a given set of conditions. Limitations to the information shown on this map and a brief description of some concepts upon which it is based are set out below.

Flood Risk Probability

Flood risk can be considered in terms of:

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Storm Durations

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Scope of Mapping

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Land outside the flood extent shown on this map could be affected by:

• Storms with different Annual Exceedance Probability;

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Areas of very shallow flooding

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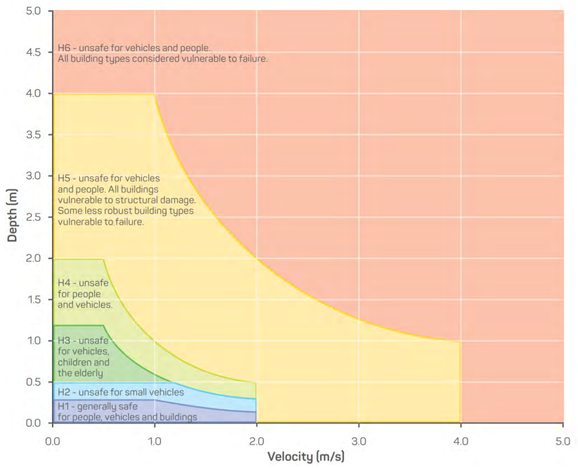
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

5% AEP Hazard Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Upgrade Stormwater Drain

Background

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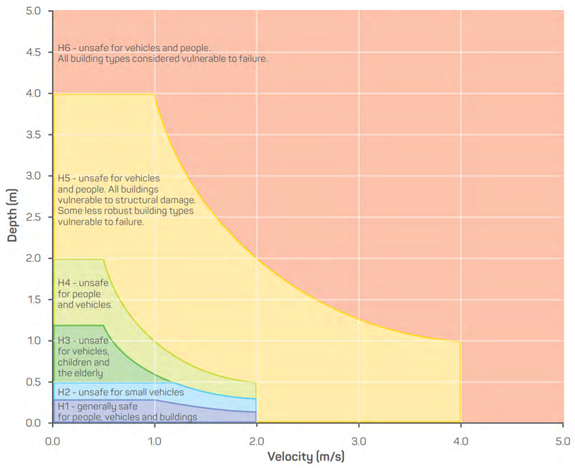
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Data Sources:
City of West Torrens [Existing Stormwater Network]
Southfront [Floodplain Mapping, Upograde Stormwater Infrastructure]
NearMap [Aerial Photograph]

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West Torrens
Stormwater Management Plan

2% AEP Hazard Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5



Model Boundary

Pump Station

Existing Stormwater Drain

Cadastre

Upgrade Stormwater Drain

Background

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NearMap [Aerial Photograph]

southfront

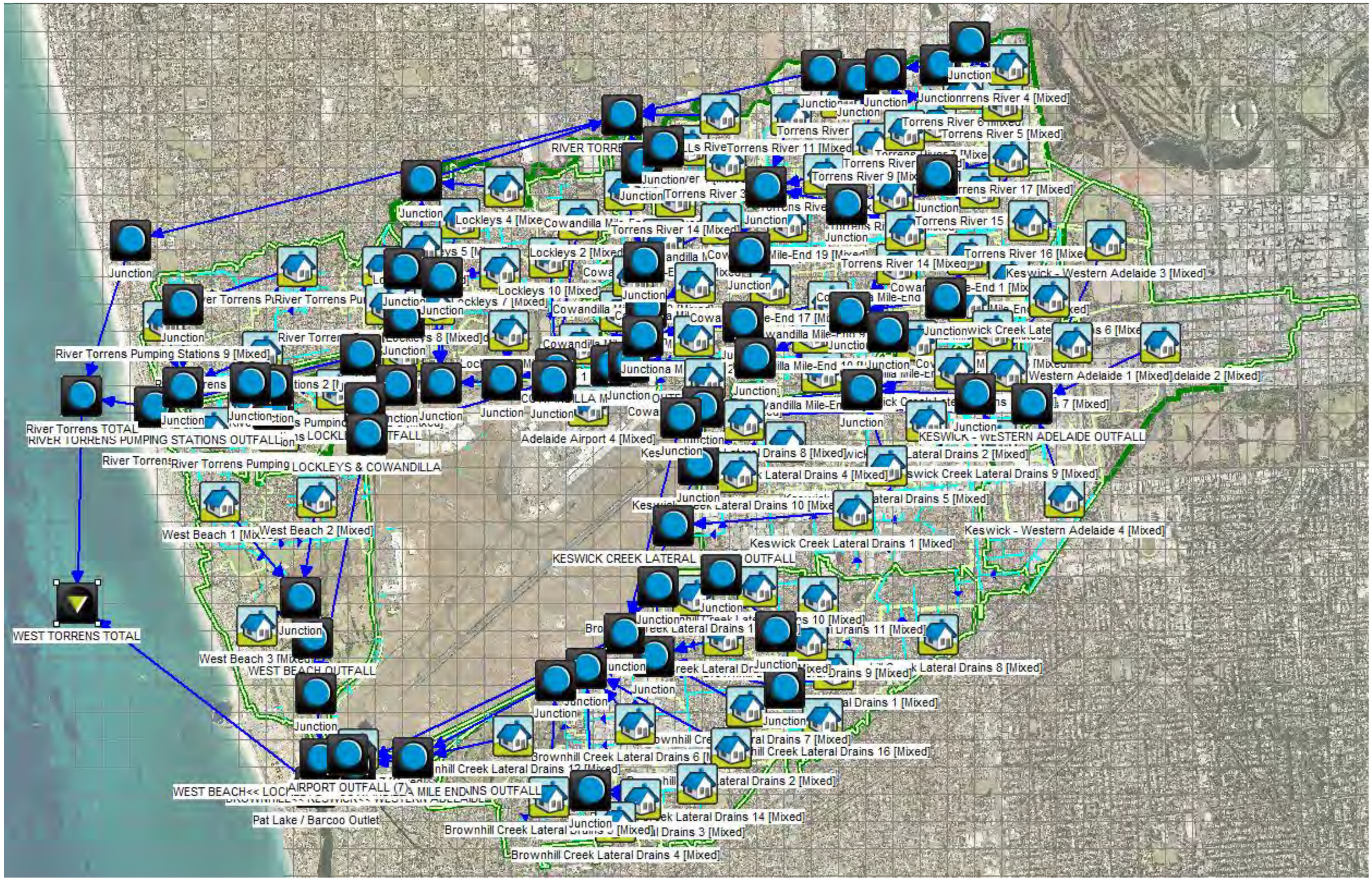
West Torrens
Stormwater Management Plan

1% AEP Hazard Map
Upgrade - Future Development, Upgrade Infrastructure, Climate Change RCP 8.5

Appendix G

Baseline MUSIC Model Structure



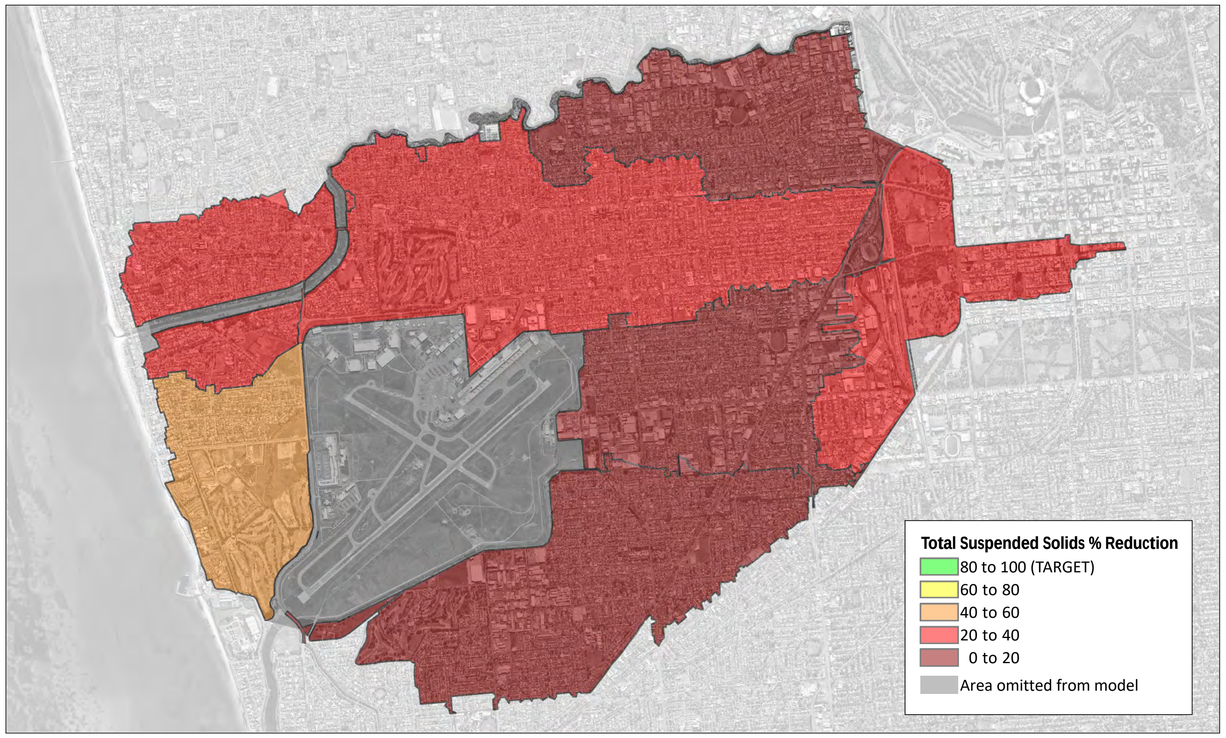


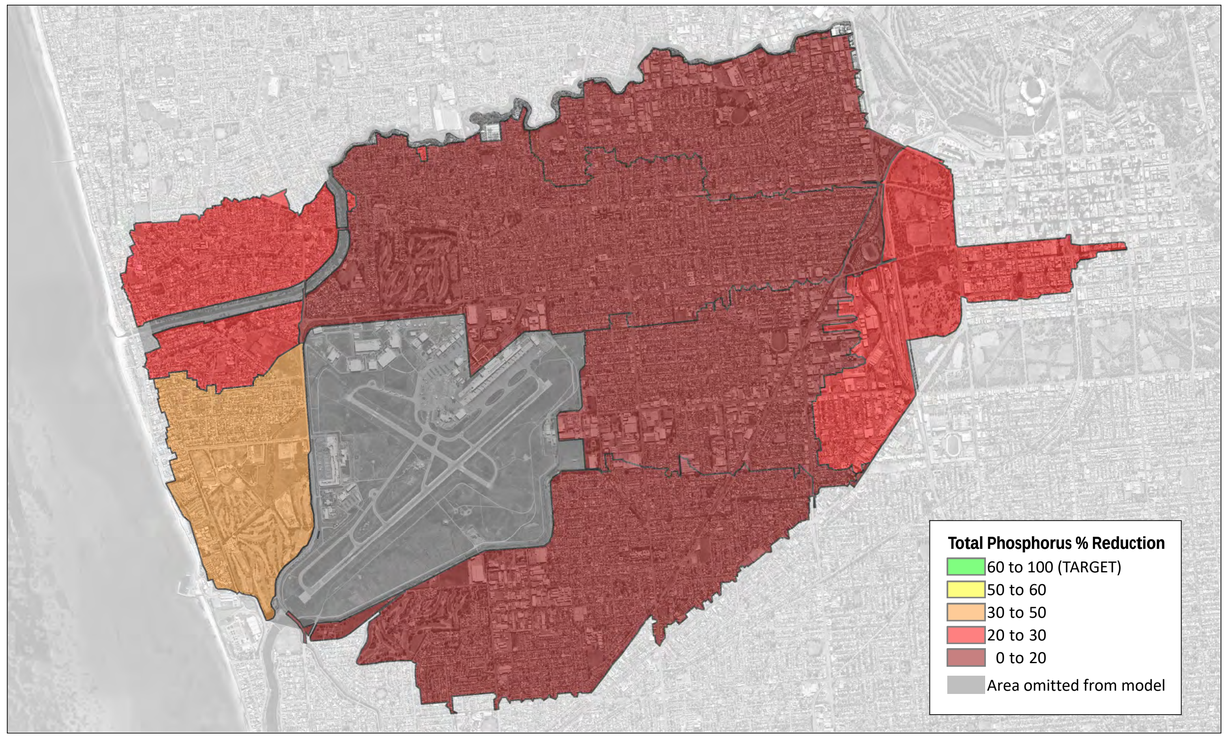
West Torrens SMP – Baseline MUSIC Model Structure

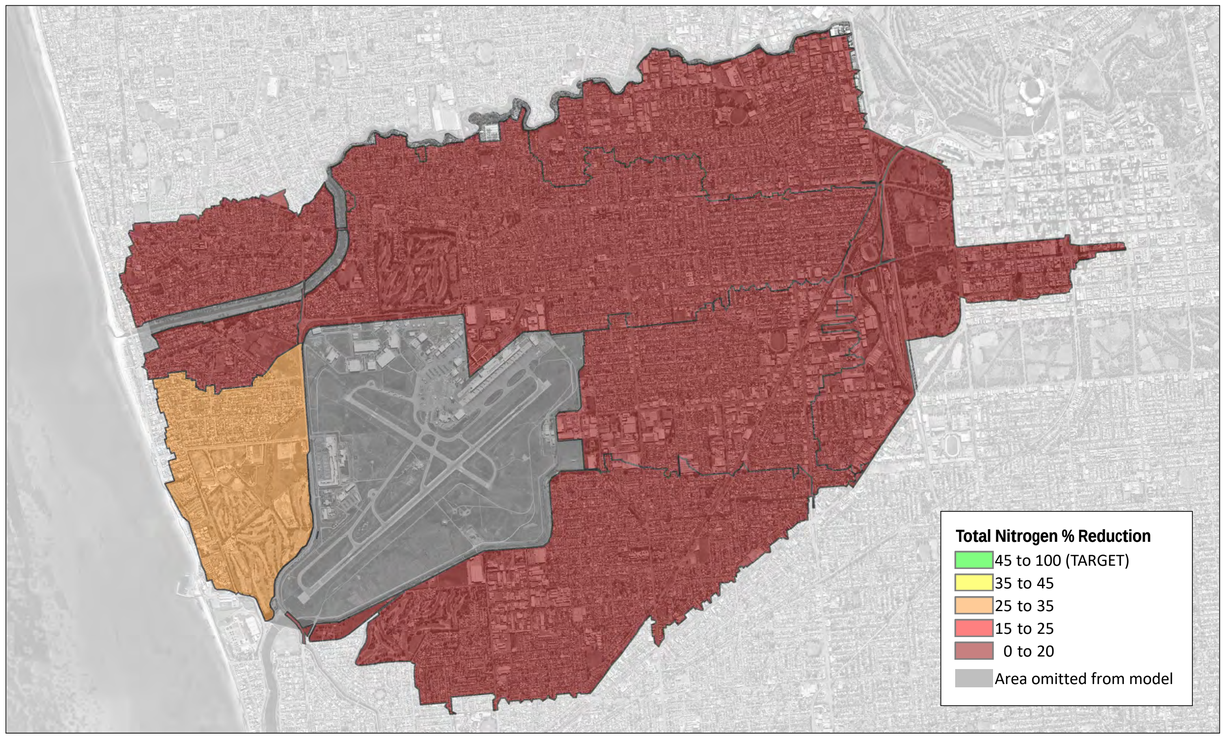
Appendix H

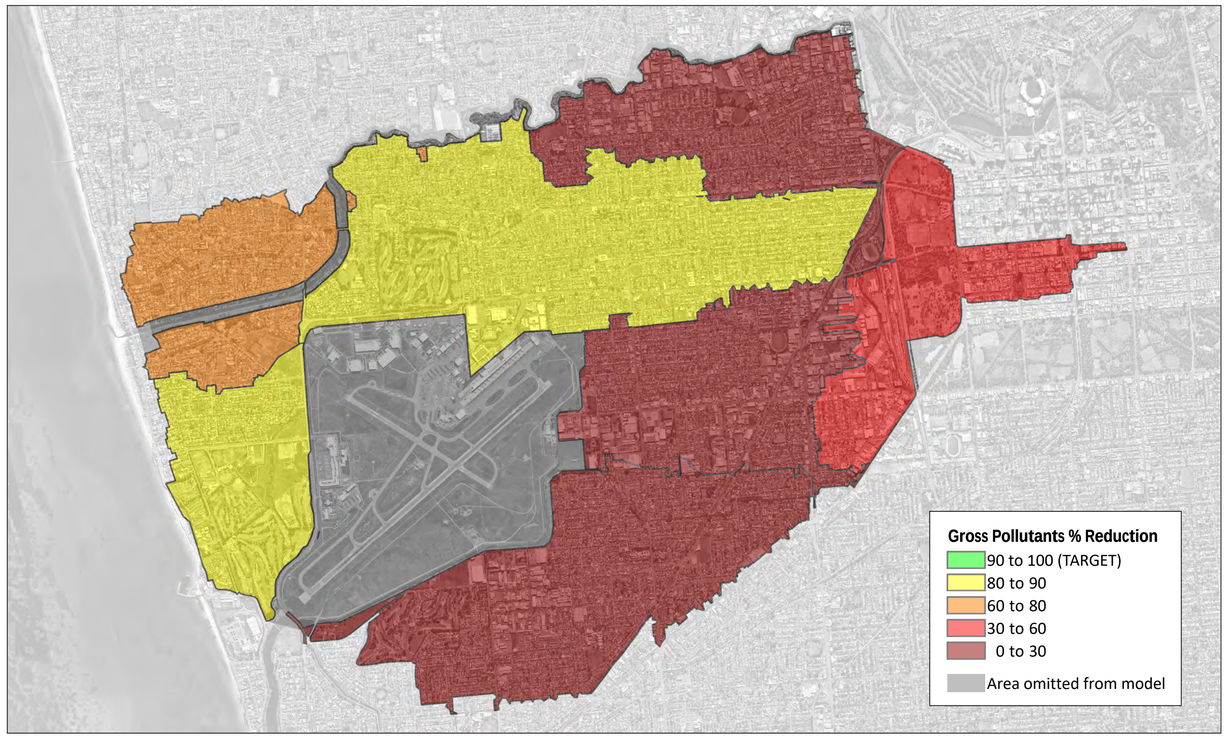
Existing Scenario Water Quality Heat Maps











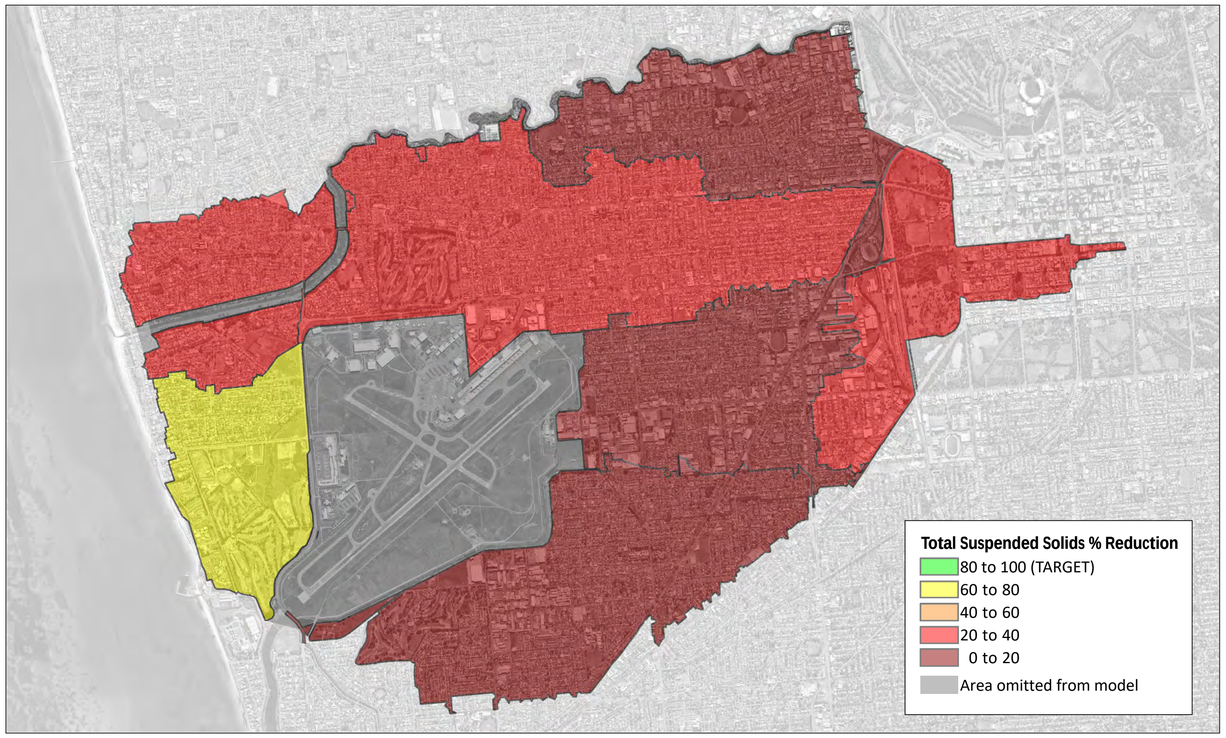
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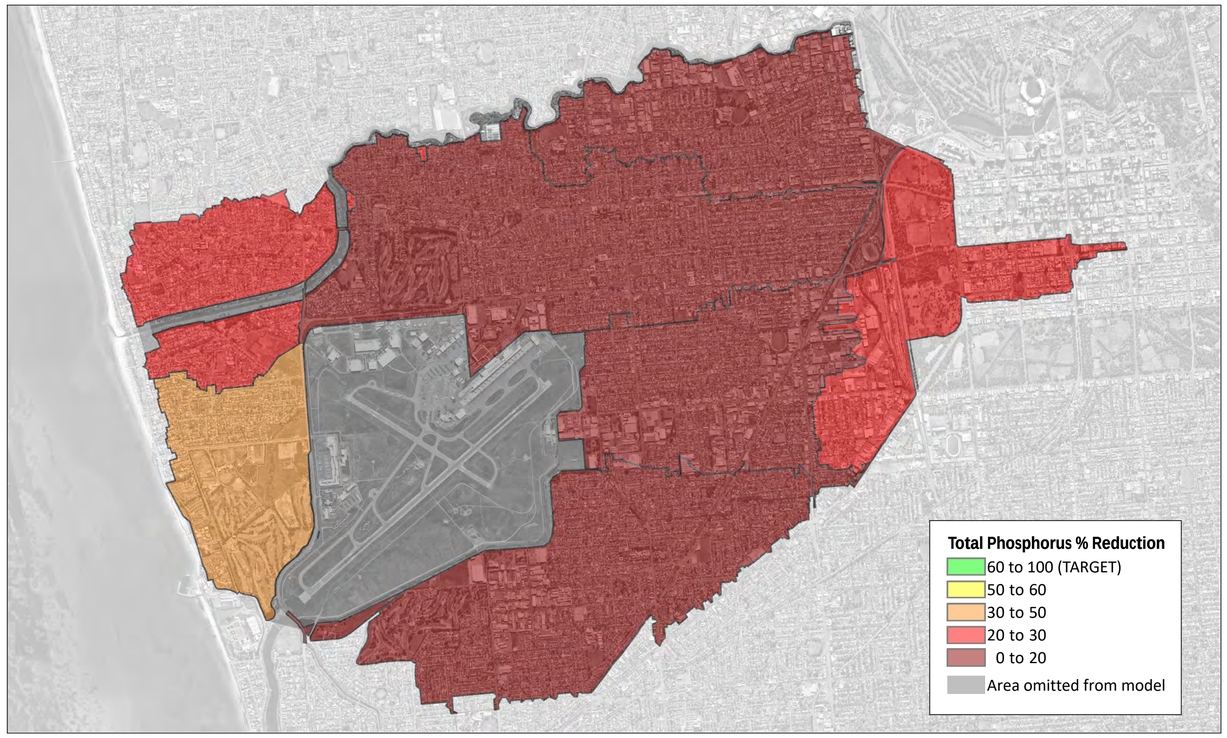
Data Sources:
Southfront [Water Quality Heat Mapping]
NearMap [Aerial Photograph]

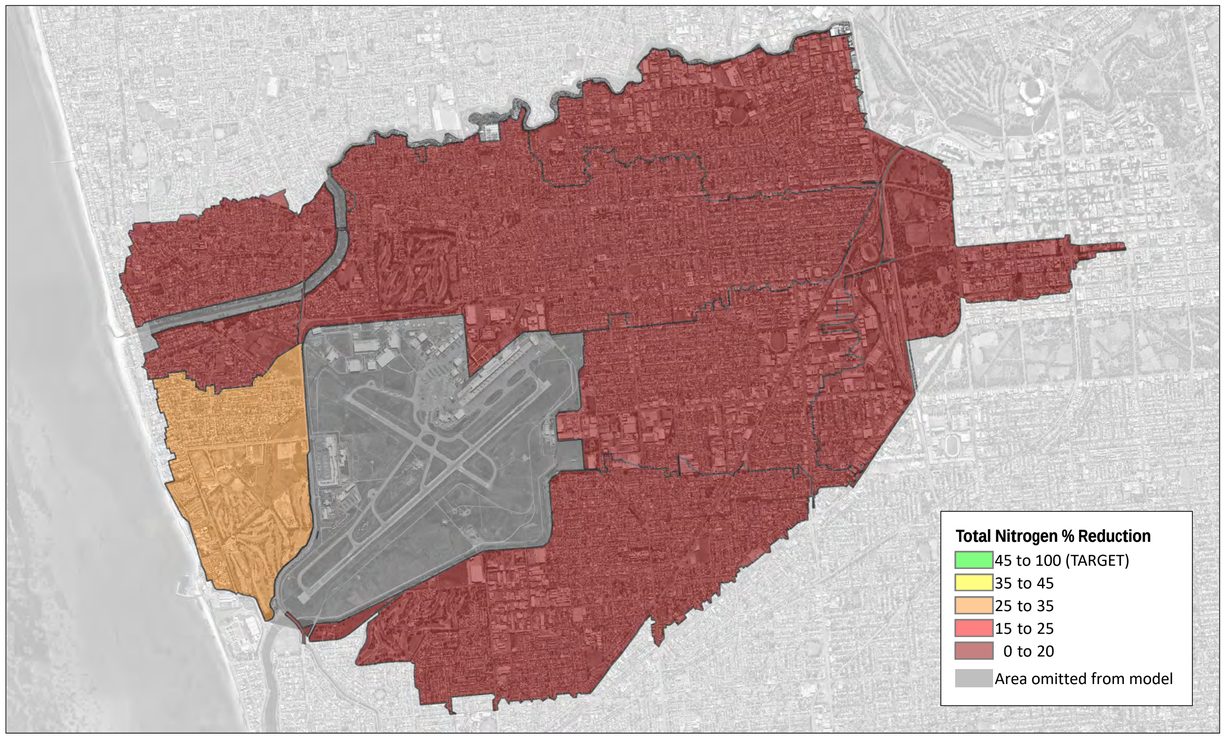
southfront

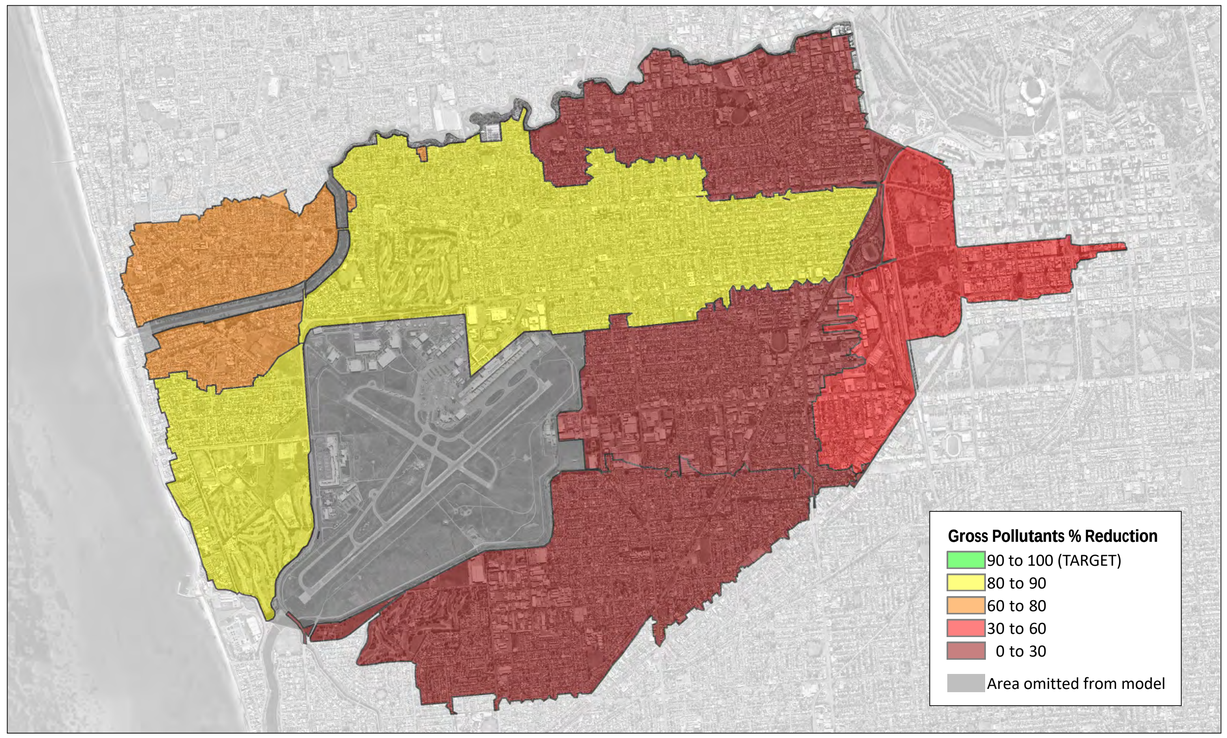
West Torrens
Stormwater Management Plan

Future Development, Existing Infrastructure (Scenario 2) Water Quality Heat Map









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Data Sources:
Southfront [Water Quality Heat Mapping]
NearMap [Aerial Photograph]

West Torrens
Stormwater Management Plan

Future Development, Existing Infrastructur, Climate Change (Scenario 3 and 4) Water Quality Heat Map

Appendix I

Total Direct Damages: 1:500 year AEP Event and Probable Maximum Flood



1:500 year AEP and PMF Total Direct Tangible Damages, Existing vs Upgrade Drainage Infrastructure

Land Use	Total Damages Estimate ($000)			
	1:500 year AEP		PMF	
	Existing	Upgrade	Existing	Upgrade
Residential	$82,700	$47,300	$1,199,200	$1,179,900
Commercial – Office	$39,400	$33,000	$180,000	$178,100
Commercial – Retail	$34,200	$28,300	$329,500	$323,600
Industrial	$45,600	$37,900	$297,800	$292,500
Total	**$201,900**	**$146,500**	**$2,006,400**	**$1,974,100**

1:500 year AEP and PMF Total Direct Tangible Damages per Catchment, Existing vs Upgrade Drainage Infrastructure

Catchment	Total Damages Estimate per Catchment ($000)			
	1:500 year AEP		PMF	
	Existing	Upgrade	Existing	Upgrade
West Beach	$3,000	$3,000	$91,200	$89,200
River Torrens Pumping Stations	$8,900	$5,600	$144,400	$141,600
Lockleys	$9,500	$7,800	$109,600	$109,100
Torrens River	$28,400	$24,300	$310,400	$308,300
Cowandilla Mile-End	$52,400	$31,500	$563,700	$550,900
Keswick Creek Lateral Drains	$57,700	$42,900	$453,600	$442,500
Keswick - Western Adelaide	$11,800	$12,000	$50,600	$50,500
Brown Hill Creek Lateral Drains	$27,200	$17,600	$265,900	$265,300
Adelaide Airport	$2,800	$1,900	$17,000	$16,600
Total	**$201,900**	**$146,500**	**$2,006,400**	**$1,974,100**