Gawler and Surrounds

Stormwater Management Plan

Town of Gawler, Light Regional Council & Barossa Council

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Contents

Project: Gawler and Surrounds | Stormwater Management Plan
Client: Town of Gawler, Light Regional Council & Barossa Council
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Tables

Figures

Appendices

Executive Summary

The Gawler and Surrounds stormwater management plan (SMP) covers the township of Gawler and the surrounding areas of Gawler Belt, Evanston Park, Bibaringa, Sandy Creek and Kalbeeba. There are two designated growth areas covered by the SMP: Gawler East and Concordia.

The SMP provides a framework for the holistic management of stormwater within the study area. It summarises the current state of the catchment, identifies problems and opportunities, defines objectives and develops a list of prioritised strategies for the management of stormwater. The plan, which has been prepared in accordance with the Stormwater Management Authority's (SMA's) *Stormwater Management Planning Guidelines* (2007) addresses issues of flood management, water quality, water harvesting, environmental enhancement and asset management.

The current state of the catchment

Stormwater runoff from the study area drains to the North and South Para Rivers which converge within the township of Gawler to form the Gawler River. The health of the aquatic ecosystem within the receiving waters is generally poor, largely due to human disturbance. An assessment of the tributaries within the study area determined that they are highly modified with little of the natural habitat remaining. Areas with medium to high erosion potential were also identified.

The urbanised areas of the study area have an extensive underground drainage network which discharges flows directly to the river via a large number of outfalls. Analysis of the existing system found that 67% of the network (by length) has the capacity to convey runoff during a 20% annual exceedance probability (AEP) event. The existing stormwater infrastructure also includes a number of gross pollutant traps (GPTs) and detention basins which reduce pollutant loads that are discharged into receiving waters.

The SMP area is located within the bounds of the Western Mount Lofty Regions Water Allocation Plan (WAP). Bunyip Water harvests up to 800 ML/year from the Gawler River downstream of the study area. There is also a harvesting and reuse scheme proposed for the Gawler Southern Urban Growth Area, located just outside the bounds of the SMP. Additional opportunities for harvesting and reuse have been considered but are limited by the constraints of the WAP.

The modelling undertaken to inform the development of the SMP is based on historical climate conditions. The current projections for a future climate suggest that despite warmer, drier average conditions there is likely to be an increase in rainfall intensities. The changes in future conditions will impact the management of water within the area.

Problems and opportunities

A combined one and two-dimensional hydraulic model was developed to identify key flood prone areas within the area. The modelling was based on estimates of long term development within the catchment. Flood events with annual exceedance probabilities (AEP) of 20% to 0.2% AEP were modelled. Review of the resultant flood maps identified six key flood prone areas:

- Greening Drive in Evanston South: flooding occurs at a localised low-spot as a result of overflow from the creek that runs through Trinity College. It is believed that the overflow results from the creek channel and culverts having insufficient capacity through the school grounds.
- Railway Crescent/Przibilla Drive (Evanston): a trapped low spot located in the lower part of the Clifford Road drain catchment that is subject to flooding in a 1% AEP event. The flooding is due to a combination of large flow volumes from the Clifford Road Drain catchment and insufficient capacity of the drainage system under the Gawler Bypass.
- First Street at Gawler South: a trapped low spot adjacent to the Gawler Racecourse. The modelling indicates that flooding occurs in events as frequent as a 20% AEP, with extensive inundation of private properties for events of a 5% AEP or less. The analysis indicates that the flooding is a result

of high runoff from the heavily urbanised catchment combined with limited capacity of the drainage system under the racecourse.

- Jarvis Street and Brooks Avenue in Willaston: the limited capacity of the drainage system downstream of a localised low-spot in Jarvis Street results in flooding in events as frequent as a 20% AEP. The cause of the flooding observed in the vicinity of Brooks Avenue is a result of the existing detention basin having insufficient capacity. The capacity of the basin is exceeded in floods larger than a 20% AEP, causing the flooding of adjacent properties.
- Jane Street and Davies Street in Willaston: flood modelling indicates that there is flooding of private properties in the 20% AEP event. The flooding is a result of the lack of underground drainage higher in the catchment. It is understood that Council have since installed an underground drainage network with a 20% AEP capacity standard along both Jane Street and Davies Street.
- Gawler Belt: there is a large depression which acts a drainage basin for the surrounding catchments. Due to the lack of any formal drainage in the area, beyond small roadside swale drains, there is extensive overland sheet flow through properties. Whilst many properties experience sheet flow few homes are flood affected.

A water quality model was developed to understand the patterns of pollutant generation within the study area and to identify opportunities for water quality improvement. The modelling shows that the generation of pollutants is relatively evenly distributed across the areas of current development. Opportunities for environmental protection and enhancement are also explored.

Stormwater management strategies

The SMP draws on the understanding of the study area and identification of problems and opportunities to specify a number of objectives for the management of stormwater within the study area. The objectives relate to flood management, water quality improvement, water use, environmental protection and enhancement and asset management. Structural and non-structural strategies are then developed to address each of the objectives.

Flood management

Strategies incorporating flood control basins, infrastructure upgrades, new drainage infrastructure and augmentation of the Gawler River levee banks have been proposed for the purpose of flood management. Non-structural strategies including education and awareness, the use of the mapping outputs from the SMP to inform flood warning and flood forecasting, changes to policy documents and an assessment of the potential impacts of climate change are also presented. The flood reduction effectiveness of the structural measures was assessed using the results of hydraulic modelling. Capital and ongoing maintenance costs have been estimated for each strategy. The benefits of the major flood management strategies have been quantified using calculations of the associated reduction in average annual damages (AAD).

The modelling found that a 23% ($374,000) reduction in AAD can be achieved across the study area if all of the structural flood management strategies are implemented. The greatest reduction in AAD ($167,000) occurs in the vicinity of the Potts Road and Gawler Racecourse detention basins. The Jarvis Street and Willaston drainage upgrades also result in a significant reduction ($120,000) in AAD.

Water quality improvement

The heavily developed nature of the urbanised sections of the study area combined with the distributed nature of the outfalls to receiving waters limits the opportunities for the implementation of additional water quality improvement measures. The construction of a wetland at the Gawler racecourse provides the greatest improvement in water quality. Gross pollutant traps, soakage systems and raingardens are also considered a possible strategy. Water quality modelling of the proposed strategies for areas of existing development show that, while it is not possible to meet the target pollutant load reductions, the proposed measures would provide a measurable reduction in the loads of pollutants discharged to the receiving waters.

The ability to influence water quality is greater in the Gawler East and Concordia growth areas. The recommended strategies for these areas are consistent with best practice principles of water sensitive urban design (WSUD). Works in these areas will focus on maintaining and enhancing natural features within the catchment, limiting peak flows to prevent erosion of downstream channels, WSUD elements to reduce pollutant loads within the catchment combined with instream works. As the planning and design of the growth area infrastructure progresses, water quality modelling should be undertaken to demonstrate that the proposed approaches can achieve the targeted levels of pollutant reduction.

Capital and maintenance costs have been estimated for each of the water quality improvement strategies proposed for the areas of existing development.

Water use

The opportunities for beneficial reuse of stormwater within the study area are limited by the constraints of the Western Mount Lofty Ranges Water Allocation Plan (WAP). The potential for establishing new water harvesting and reuse schemes was considered at two locations: at the racecourse and adjacent to the Clifford Road drain. However, the racecourse is within the bounds of the WAP and the Department for Environment and Water (DEW) have indicated that all water allocations in this zone are currently allocated. The ability to harvest water is therefore limited. Clifford Road Drain is outside of the WAP zone, however as it is immediately downstream of the area, DEW advised that harvesting from the drain would be subject to approval by the NRM board.

The most feasible options for water reuse within the study area are therefore considered to be at a smaller scale. Encouraging the installation of large rainwater tanks to facilitate residential block-scale harvesting and reuse is recommended. This will also help to limit the increase in flows that result from additional development. It is considered that the most effective way of encouraging the installation of rainwater tanks is via a Council funded subsidy scheme. Passive use of water through infiltration (such as rain gardens and tree pits) should also be considered.

Environmental protection and enhancement

The strategies to achieve the environmental protection and enhancement objectives are consistent with the conservation objectives stated in Council's development plan and draw on work undertaken as part of the Gawler Urban Rivers project. A combination of riparian habitat restoration and erosion protection is proposed. The cost of implementing these strategies is assumed to be an ongoing budget item.

Asset management

It is recommended that Council invest in investigations to provide an understanding of the existing condition of their stormwater assets and develop a sustainable asset maintenance plan.

Prioritised strategies

A multi-criteria analysis framework was used to rate the major stormwater management strategies against a wide range of benefits including reduction in flood risk, water reuse and water quality improvements.

Based on the outcomes of the analysis, the following strategies are considered to be high priority:

- Gawler Racecourse Flood Control Basin and Wetland: not only do the works provide significant flood reduction, but the wetland also provides water quality improvement and opportunities for habitat creation.
- Trinity College upgrades, Evanston Oval dual pipe and Evanston Park flood control basin: these works provide a reduction in flooding for a relatively low capital cost.
- Utilisation of flood mapping data when assessing new development applications.
- Corey Street flood control basin optimisation: low cost item to reduce downstream flood risks

- Installation of raingardens: these are suitable in areas where there is a wide road reserve and relatively flat topography. Raingardens not only treat stormwater but can also reduce annual runoff volume and provide amenity value.
- Installation of infiltration systems: Improve downstream water quality and allow for passive re-use of stormwater.
- Educating the public about the flood mapping that has been produced, such that they can proactively manage potentially flood impacts.

The following strategies have been assigned a medium priority:

- Jarvis Street drain upgrade and Willaston Drainage upgrade: these works result in a significant reduction in flooding, however, the capital costs are high.
- Gawler Belt railway culvert: the works provide an outlet to the deep ponding that occurs east of the railway line, thereby significantly lowering flood levels. The vegetated channel downstream of the railway culvert may provide some water quality improvement.
- Gawler East flow path improvements: formalising the drainage system would prevent nuisance flooding of private properties. The vegetated open channels would also provide some water quality improvement.
- Hewett rear-of-allotment drainage: the proposed rear of allotment drain will prevent nuisance flooding of private properties.
- WSUD in the backyard: this education program should provide periodic publicity to encourage residents to act at a domestic scale to improve water quality.
- Subsidising large rain tanks: encouraging the installation of large rainwater tanks will help to increase the volume of water harvested at the allotment scale. The tanks would also have the potential to reduce downstream flooding and to not dilute more polluted pavement runoff with cleaner roof runoff water.
- Updating floodplain mapping to include climate change to get a better understanding of the potential impacts for various scenarios.
- Installation of gross pollutant traps at key outfall locations to improve water quality prior to discharge into the Para Rivers and the Gawler River.
- Riparian habitat restoration and erosion management: the restoration of creek lines through introduction of native species and weed removal will provide for additional native habitat and provide an environment that is less susceptible to erosion.
- CCTV inspection program: a CCTV inspection program should be developed based on asset age and significance. Once an asset condition database has been established the inspection program can focus on infrastructure nearing the end of its service life, so that replacement of assets occurs before they fail.

Implementation

The SMP identifies priority strategies for stormwater management. A number of the strategies require considerable expenditure. A 10-year capital works plan is presented based on a total expenditure of $1.2 million per year, which assumes that funding of $0.4 million per year can be secured from the SMA for projects that provide flood mitigation for catchments in excess of 40 ha. If the works do not secure SMA funding, implementation of the capital works program is expected to be delayed.

1 Introduction

The Gawler and Surrounds SMP covers the urbanised areas of Gawler; the rural and semi-rural areas of Gawler Belt, Gawler East, Evanston Park and Bibaringa. Also included is the currently undeveloped areas of Sandy Creek, Kalbeeba and Concordia. The study area is centred around the confluence of the North Para River and South Para River which join to form the Gawler River.

The study area can be characterised into eastern and western zones. Catchments east of the Gawler Bypass and Sturt Highway drain into the main river channels. The catchments west of these roads drain to a large, natural, trapped low-spot. If sufficiently large volumes of runoff reach the low spot, runoff eventually escapes to the west. Within the eastern zone runoff is collected by a formalised network of underground drains, channels and detention basins. In the western zone formalised drainage infrastructure is very limited.

This Stormwater Management Plan has been prepared in accordance with the Stormwater Management Authority's Stormwater Management Planning Guidelines (2007) and addresses issues of flood management, water quality, water harvesting and environmental enhancement associated with the management of stormwater.

Section 2 of this report provides a description of the study area including a summary of topography and existing stormwater assets.

Section 3 provides a summary of the key flood prone areas, based on the results of the flood mapping that has been undertaken as part of the project and the problems and opportunities with water harvesting, quality (etc.)

Section 4 provides a series of catchment specific objectives in relation to the areas of flood management, water quality, water reuse, environmental protection and asset management.

Section 5 provides a series of potential management strategies designed to achieve the objectives set out by Section 4.

Section 6 summarises the costs of the various strategies and identifies who would fund the works.

Section 7 provides a summary of the flood damages assessment work including an economic assessment by comparing costs to benefits.

Section 8 provides a multi criteria analysis framework for the various strategies and attempts to score them against a range of criteria.

Section 9 prioritises the works and lays out a ten year capital works program for the study area, in relation to implementing the various strategies.

2 Catchment Description

2.1 Catchment

The catchments of the Gawler and Surrounds SMP cover four distinct areas. These four areas are described below and are shown within Figure 2.1, while the land uses across the entire study area are shown in Figure 2.2.

2.1.1 Gawler Belt

The Gawler Belt area is predominantly comprised of rural living and semi-rural living on allotments ranging in size from one to six hectares. The area is bounded by the Gawler Bypass and Sturt Highway to the south and east, Redbanks Road to the north and Nottle Road to the west. A prominent feature is the dormant, but yet to be closed, Roseworthy Railway line.

The area is characterised by the peaks and troughs of quaternary period, inland sand dunes which run in a southeast to northwest direction. In the south-western corner of Gawler Belt there is a large 40 hectare depression which acts as a drainage basin for the surrounding catchments. Total catchment area draining to the depression is just under 2,500 hectares. The catchment extends outside of the study area to a point 3 km north of Roseworthy. If enough runoff (over 13.5 GL) enters the large depression floodwater eventually spills to the west and flows towards Ward Belt. An additional 240 hectares drains to several smaller depressions along the southern boundary of the study area.

Due the predominantly rural nature of the catchment, response time of the catchment is relatively slow. The critical design event duration for the largest catchment is 24 hours for both peak flow and runoff volume.

2.1.2 River catchments

The river catchments are the group of relatively small urbanised catchments that drain directly into the Gawler, North Para, or South Para rivers (or their main tributaries). These catchments are characterised by residential urban development with short, steep catchments draining directly into main rivers or creeks. These catchments cover the suburbs of Hewett, Willaston, Reid, Gawler, Gawler East, Gawler West, Gawler South and Kalbeeba. There are pockets of other land-use types, such as the industrial areas of Willaston and the commercial areas of Gawler.

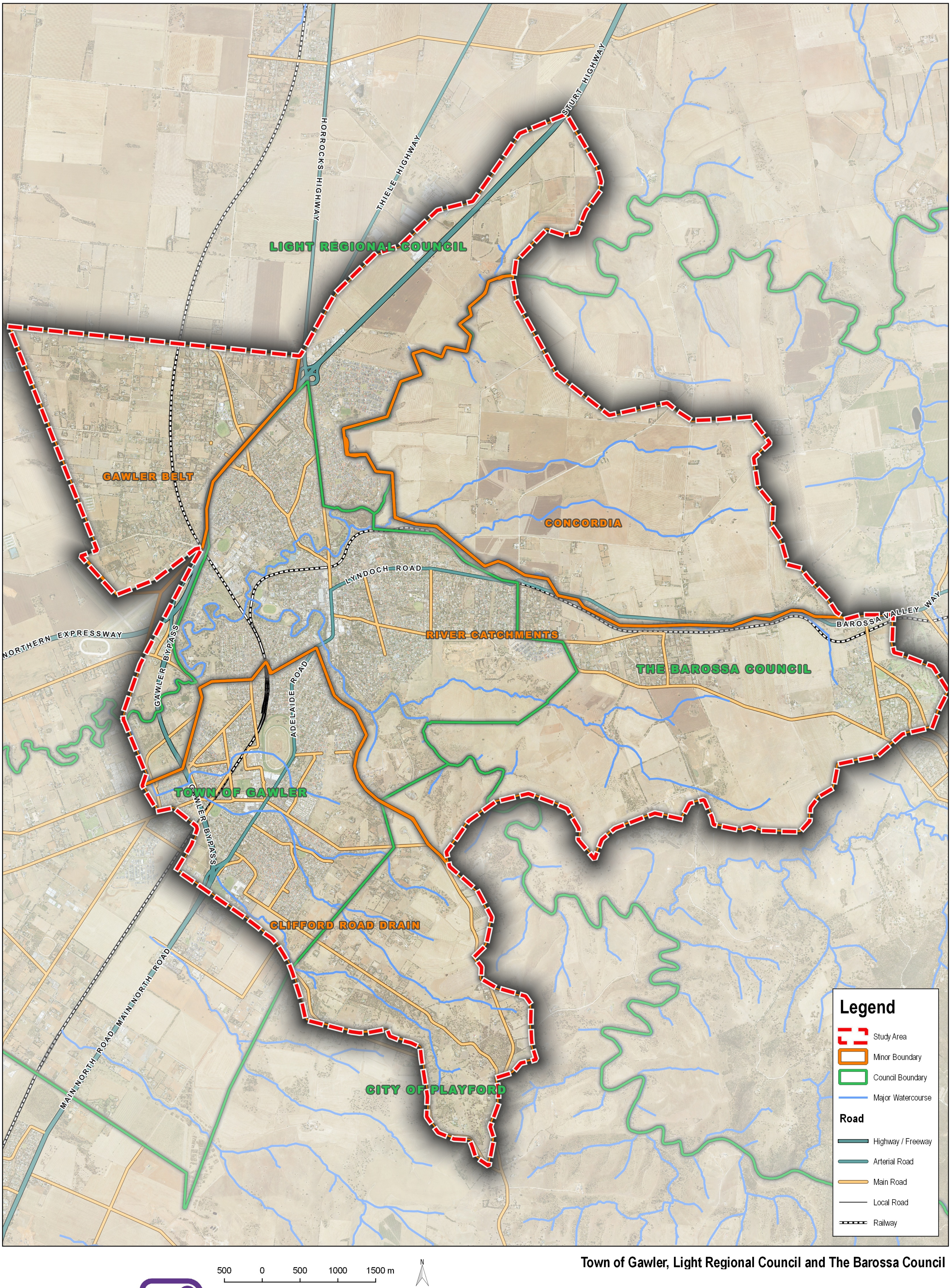
The majority of these catchments are on the steeper elevated slopes of the river valleys and thus are elevated above the main river channels. Most catchments are less than a kilometre in length.

In total the catchments have a combined area of 1,470 hectares. Due to the steep slopes and high imperviousness of the catchments, the response times of these catchments is very rapid. Typically the critical design event duration is 30 to 60 minutes.

2.1.3 Clifford Road drain

Land use is more varied than the other catchment areas. The lower half of the catchment is predominantly urban residential, however there are notable exceptions. The portion of catchment bounded by Main North Road and the Gawler Railway Line is dominated by the open space of the Gawler Race Course and the Gawler and District College. The Trinity College grounds and the Evanston oval are other notable areas of open space. The upper half of the catchment is characterised by rural living extending about 3 km from the urban boundary into the Adelaide Hills. Rural areas on the perimeter of the existing urban areas are expected to be transformed into new high-density urban residential living.

The catchment is bounded by the Gawler River to the north, Gawler – One Tree Hill Road to the east, and the Gawler Bypass and Kentish Road to the south and west. The catchment has an area of 1,400 hectares; roughly equal to that of the river catchments combined.



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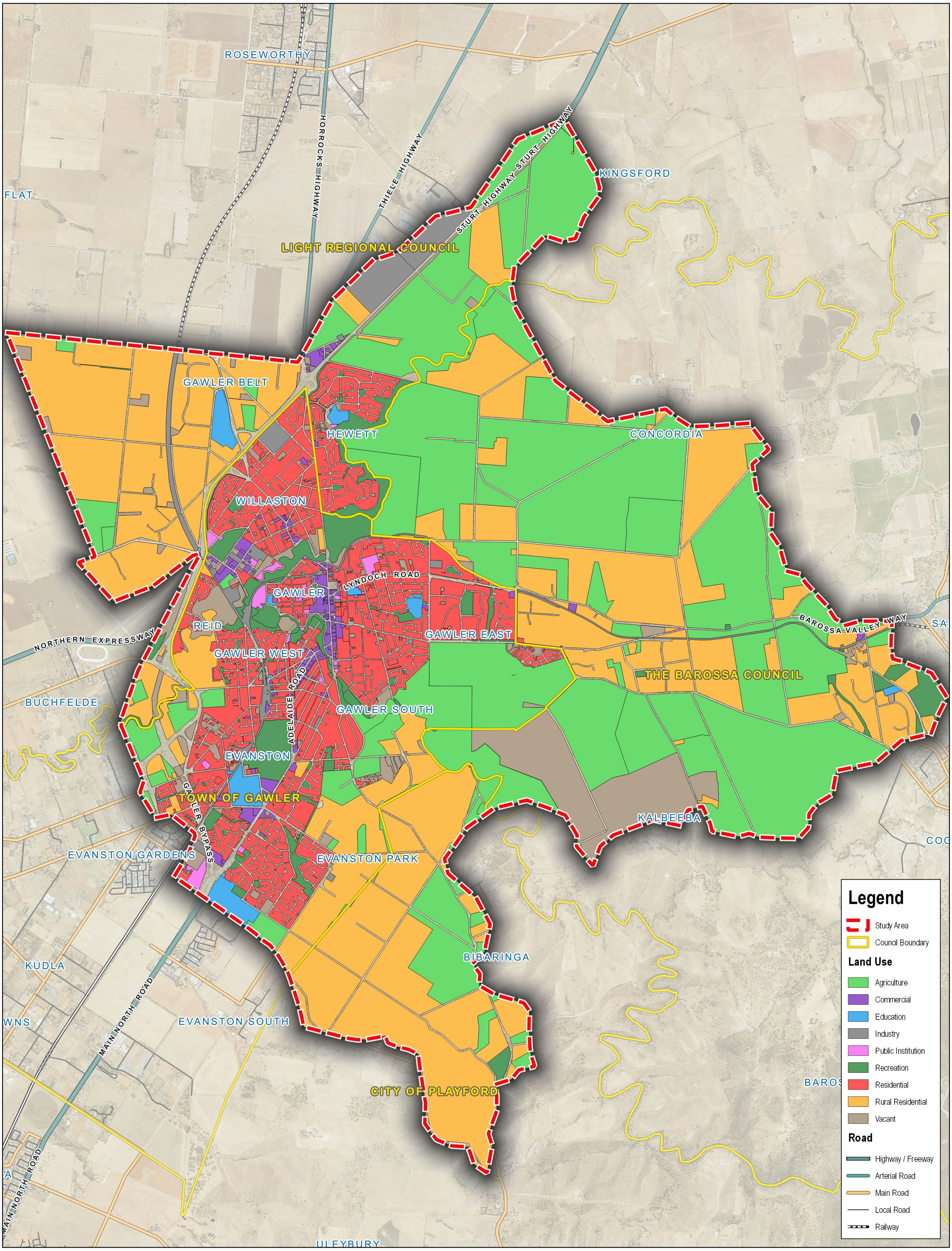
GAWLER AND SURROUNDS STUDY AREA

Figure 2.1



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Land Use type from DataSA, 2017

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LAND USE

Figure 2.2

There are three main creeks that flow from the hills face into and through the urban areas. Two of these creeks discharge into large underground pipe systems. The catchment eventually discharges to the Gawler River via the concrete lined Clifford Road drainage channel. There is a 200 metre elevation change from the top of the catchment to the outfall.

The catchment has two distinct responses to rainfall: an early and rapid response from urban areas, followed by a secondary response from the rural areas several hours later that is dependent on storm duration and intensity. This phenomenon has been observed many times in other semi-urban catchments along the Adelaide suburban fringe.

2.1.4 Concordia

The Concordia area is currently used for agriculture on large rural allotments of varying sizes between 25 hectares and 100 hectares; typically the allotments are 30 to 40 hectares in size. Most roads in the area are not sealed and there are few houses. The area is earmarked as a major urban growth area that will undergo significant redevelopment. The proposed developed site coverage is 65%.

The Concordia area comprises two catchments in gently sloped gullies. The southern gully is named Bergen Gully; the northern gully is unnamed. The total catchment area of the two gullies is 890 hectares. The catchments are bounded by the natural terrain rather than constructed features.

The existing response of the catchments is commensurate with other (rural) hills face catchments of similar size and slope. The critical design event duration for both catchments is 6 hours.

These two catchments are unique in that they are proposed to undergo the most transformative development of any of the catchments within the study area. If the Concordia development proceeds, considerable changes to the hydrological cycle will occur; such as changes to catchment response time, water quality, and runoff volume. Careful management of these changes is required to minimise the impact on receiving waterways.

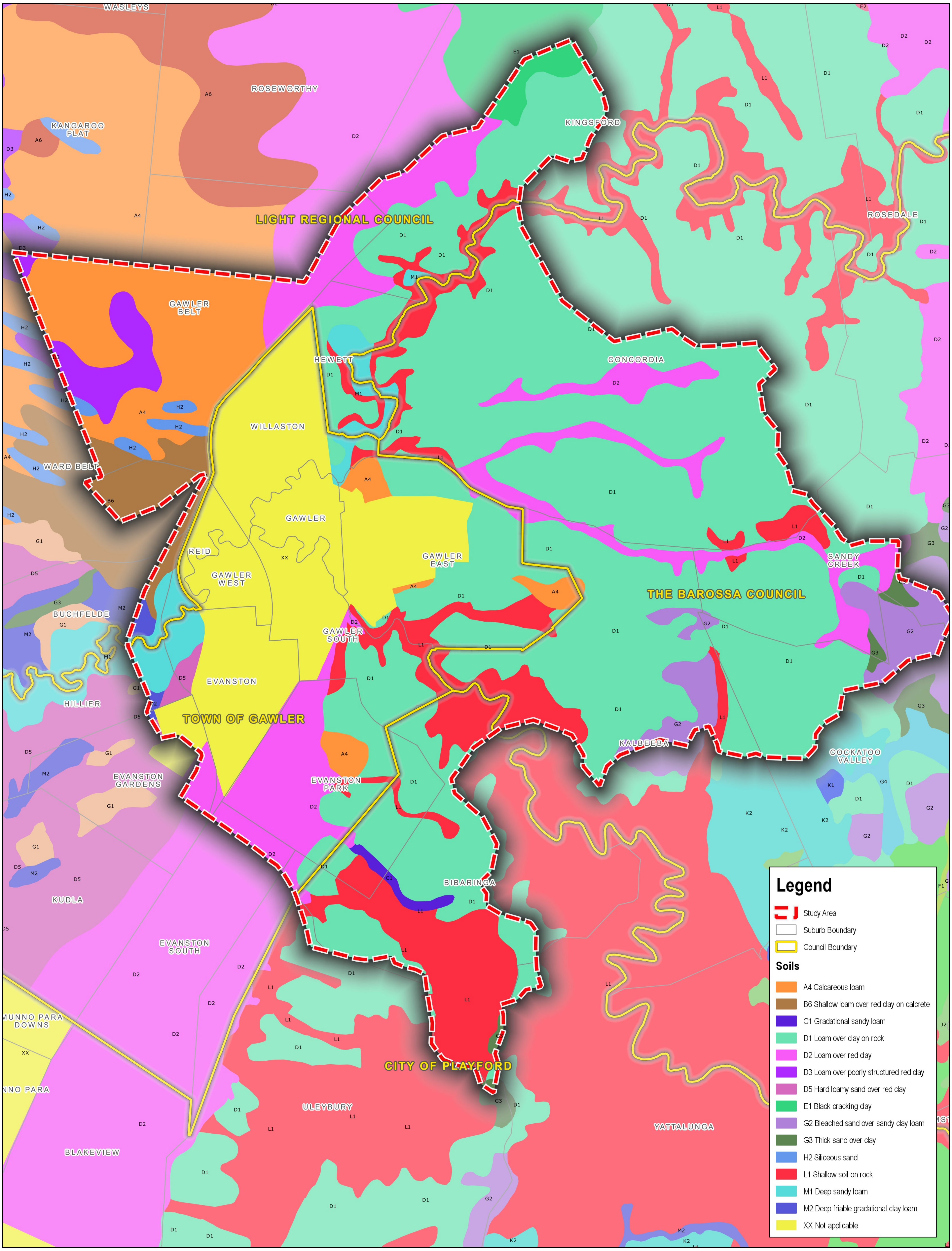
2.2 Soils

The distribution of soils across the study area was determined from data contained in the Department for Environment and Water (DEW) Soils Database and is shown in Figure 2.3 .

The hills of the eastern section of the study area are characterised by loam over clay on rock (type D1) with patches of loam over red clay (type D2) along some of the larger tributaries. The predominant soil type in the western sections of the study area is hard loam sands over red clay (type D5). The soils of the Gawler Belt region are typically shallow loams over red clay on calcrete) (type B6). The soils along the North Para River and South Para river are predominantly classified as shallow soil on rock (type L1). Along the Gawler River west of the study area the soils are deep loams (type M1 and M2). The soils within the urban area have not been classified, but it is likely that they reflect the characteristics of the soils in the surrounding area.

The presence of relatively shallow rock in the eastern part of the study area may impact the constructability and/or costs of mitigation measures such as basins. Similarly, the presence of clay and calcrete may limit the rates of infiltration that can be achieved.

It is recommended that site specific geotechnical investigations be undertaken during the detailed design phase for any proposed works.



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Soil type from Data SA, 2016

Town of Gawler

SOIL TYPES WITHIN THE GAWLER AND SURROUNDS STUDY AREA

Figure 2.3

2.3 Existing stormwater infrastructure

The urbanised areas of the study area rely on an extensive underground stormwater drainage system. The vast majority of the systems are relatively short and drain via gravity directly to the surrounding river system. There are many small to medium detention basins spread across the study area. Additionally, there are two large flood control basins that act to mitigate flows from the hills face catchments. There are a number of other large hydraulic structures as well, such as the Gawler Bypass culvert and associated detention basins and the Clifford Road drain.

The Gawler River has a number of levee banks within the study area which increase the capacity of the main channel before flood flows reach a level that they are able to overtop the levees.

The Gawler Belt rural-living area has minimal formal drainage and primarily relies on small open channels and a few detention basins to manage stormwater.

The main stormwater quality related infrastructure in the study area are gross pollutant traps.

The Concordia area is served by existing creek lines and some formal structures under roadways. Similarly, the eastern rural living area of Kalbeeba has little to no formal drainage, relying on existing creek lines and short culverts beneath roadways.

Details of the stormwater assets and infrastructure were obtained from the Town of Gawler, Light Regional Council, Barossa Council, and the Department for Planning, Transport and Infrastructure. Additional details were collected from field measurements and inspection of aerial imagery. A plan showing all existing stormwater infrastructure is shown in Figure 2.4.

2.3.1 Capacity of existing stormwater system

A 1D hydraulic model of the existing drainage systems was created to investigate their capacity. This model assumed that inlets to the drainage system do not limit inflow. This assumption ensures that the capacity of the conduits is not overestimated. The hydraulic model was used to assess each pipe segment on the basis that all runoff from upstream areas would be conveyed through the system without restriction. This approach ensures that the capacity of the drainage system is not overestimated in the lower parts of the catchment due to upstream restrictions that would otherwise limit flow.

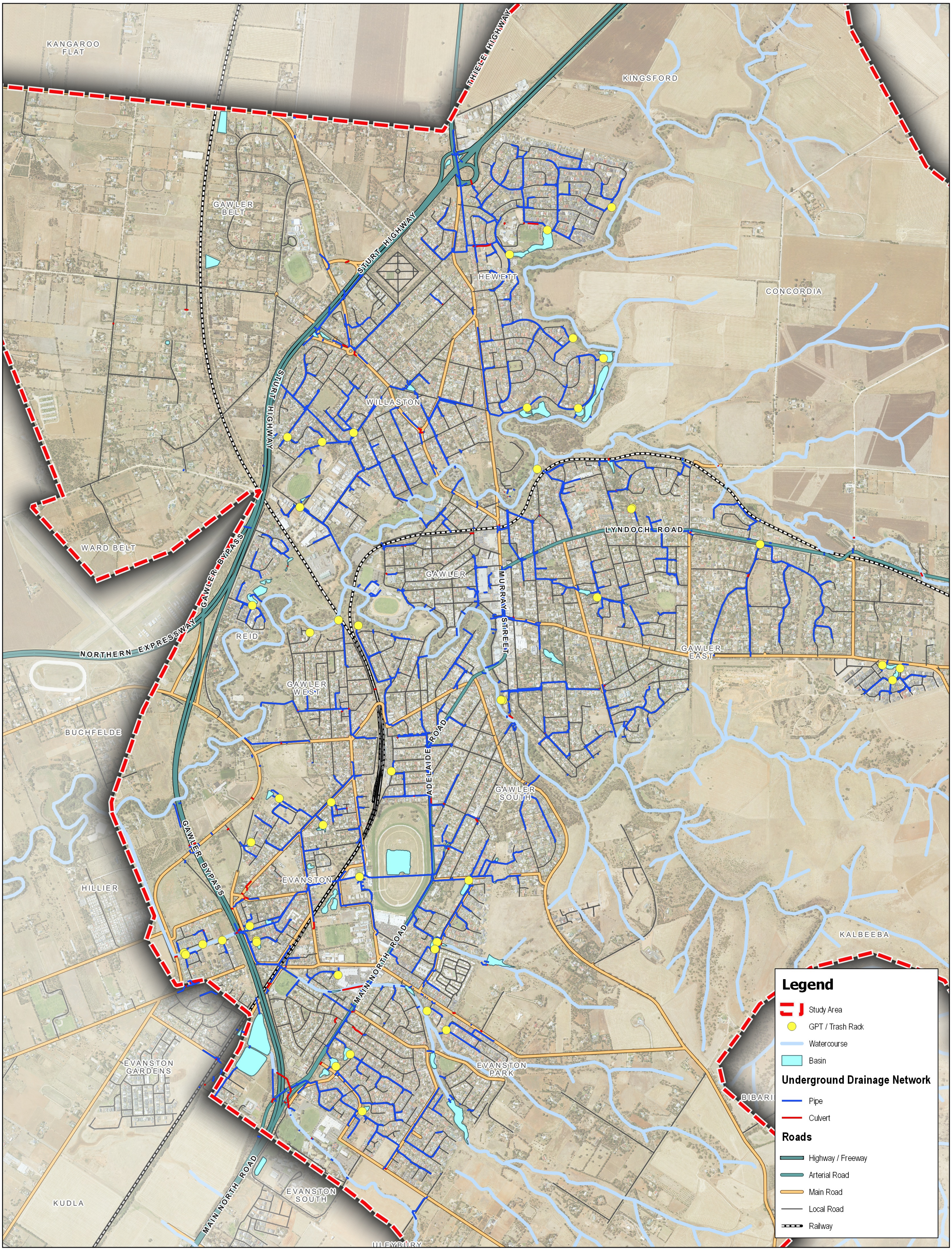
The hydraulic model was run for the 39.35% (equivalent to a 2 year average recurrence interval), 20% and 10% AEP events to assess the standard of each drain. The model was run to provide estimates of the design flow for each pipe for each event. The design flow was compared against the existing pipe capacity to determine the point at which the design flow would exceed the pipe capacity and thus determine the standard of each pipe. Figure 2.5 shows the colour coded results of the capacity assessment across the study area. Drains highlighted in red indicate drains that they may require future upgrade works to reach the desired standard of protection.

Figure 2.5 shows that approximately 80% of the assessed drains (by length) have capacity to convey the estimated flow for a 39.35% AEP event (equivalent to a 2 year ARI). Approximately, 60% have capacity to convey the estimated flow for a 20% AEP event (equivalent to a 5 year ARI).

2.4 Receiving waters

The North Para River and South Para River flow through the Gawler and Surrounds SMP study area, merging within the township of Gawler to form the Gawler River which flows across the Adelaide Plains, discharging into the Gulf St Vincent.

The North Para River and South Para River have a combined catchment area of approximately 1,000 km^2. Land use in the catchments is mixed and includes the townships and vineyards of the Barossa Valley, dryland farming areas, grazing and forests. The Gawler River is a perched river system and receives very little inflow from the land through which it flows downstream of Gawler (AWE, 2015).



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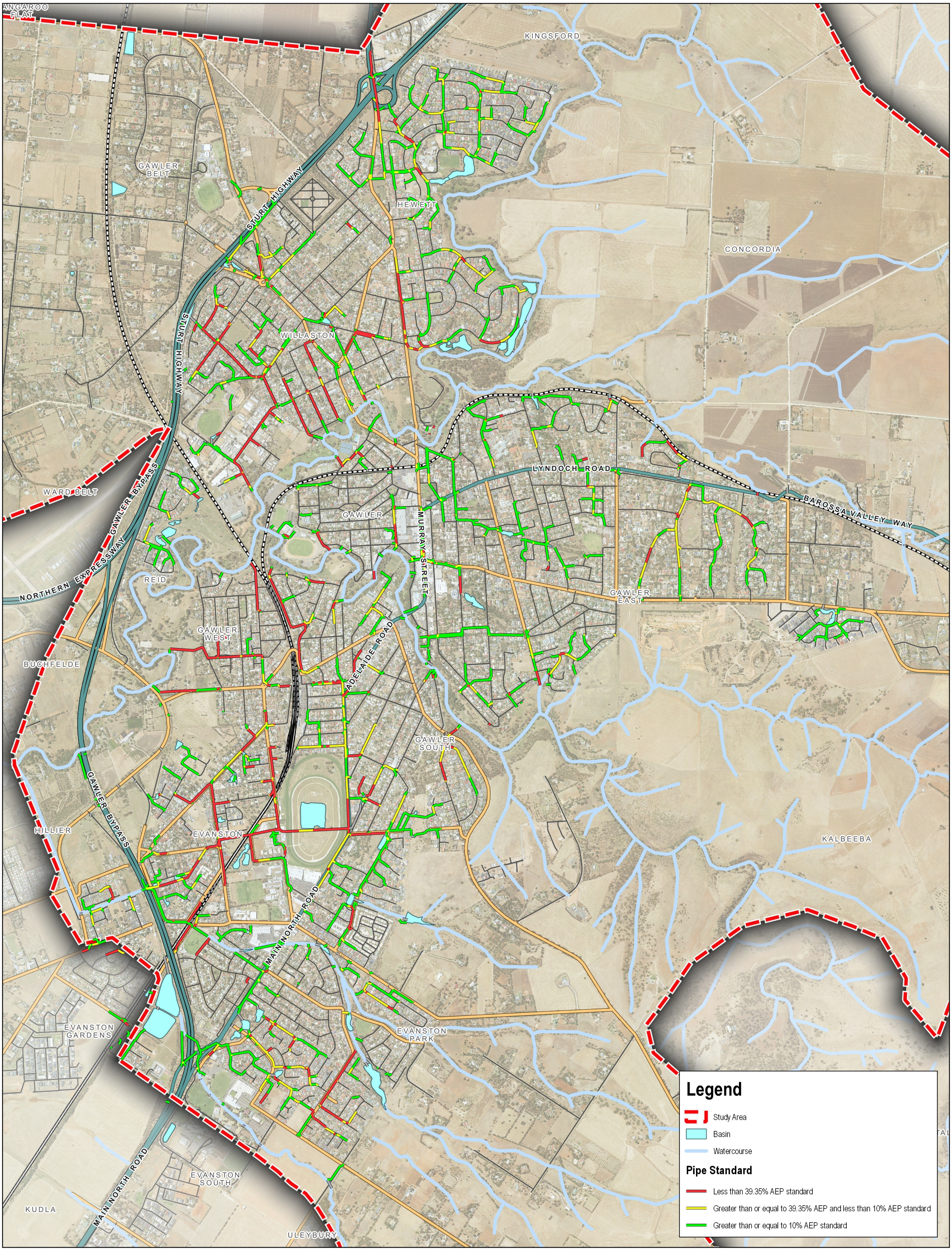
Town of Gawler, Light Regional Council and The Barossa Council

EXISTING STORMWATER INFRASTRUCTURE

Figure 2.4



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Town of Gawler, Light Regional Council and The Barossa Council

STANDARDS MAP SHOWING THE CAPACITY OF THE EXISTING STORMWATER SYSTEM

Figure 2.5

Stormwater from the SMP study area discharges into the rivers at over 50 locations, either directly or via tributaries.

2.5 Existing stormwater quality

This section provides a summary of the existing water quality within the study area. The assessment of quality and priorities for water quality improvement have been identified via consultation with an NRM representative, review of published studies and studies and modelling undertaken specifically to inform the development of this SMP.

The study area is heavily developed. The land use is mostly residential, with pockets of commercial and industrial areas. The primary pollutants in runoff from urban areas include:

- gross pollutants
- sediment
- dissolved pollutants
- pathogens.

The water quality of runoff from the study area was modelled using the eWater Model for Urban Stormwater Improvement Conceptualisation (MUSIC). The purpose of the modelling was to understand the quality of stormwater runoff from the catchment, identify areas with a high concentration of pollutants and to assess the effectiveness of the existing water quality improvement measures. Following identification of the problems, the MUSIC model will be used to assess the effectiveness of proposed water quality improvement strategies.

2.5.1 Existing water quality improvement measures

The MUSIC model of the current state of the catchment includes:

- Detention and retention basins (as identified during the hydraulic model development)
- Gross Pollutant Traps (GPTs).

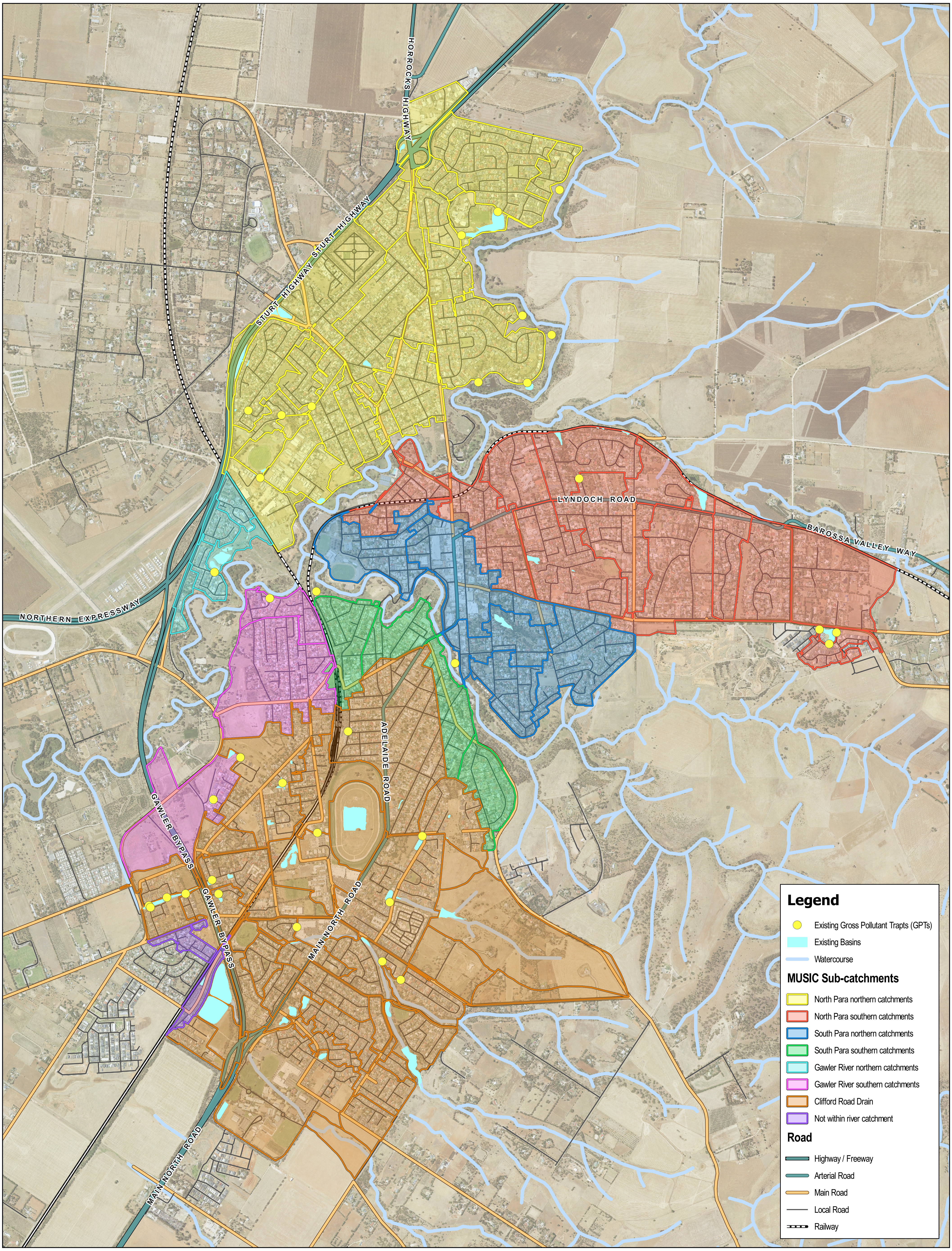
Due to the scale of the model, only water quality improvement measures that are considered to have a significant impact on the water quality at the downstream end of the sub-catchments are included in the model. Small basins, and GPTs that are located in the upper sections of the catchments are not included as it is considered that at a catchment scale, the contributions to water quality improvement will be negligible.

A schematic of the MUSIC model is shown in Figure 2.6. The modelling assumes infrastructure is appropriately maintained and that the pollutant removal efficiencies of the GPTs are as per the manufacturer's specifications. The location of the downstream node is indicatively located within the Gawler River immediately downstream of the study area such that it captures pollutants generated within the study which are discharged into the North Para River, South Para River and Gawler River.

2.5.2 Water quality modelling

The MUSIC model was run to understand the patterns of flow and pollutant generation based on the current level of development and historic climatic conditions for the study area.

The results of the 'base case' model (at the downstream end of the model) are summarised in Table 2.1 and Table 2.2. The residual load reflects the flows and pollutants arriving at the downstream end of the model and take into account the existing water quality improvement measures included in the model. It should be noted that the modelling does not include consideration of block-scale treatment measures including rainwater tanks. It is not considered that these will have a significant impact on the estimates of loads from the area. A break down by sub-catchments (as shown on Figure 2.6) is provided in Table 2.3. The source loads represent total flows and pollutants generated within the study area.



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MUSIC MODEL LAYOUT

Figure 2.6

Table 2.1 Annual loads for MUSIC base case model (downstream node)

	Sources	Residual Load	% reduction
Flow (ML/yr)	2,310	2,270	1.5
Total Suspended Solids (kg/yr)	456,000	291,000	36.2
Total Phosphorus (kg/yr)	938	701	25.3
Total Nitrogen (kg/yr)	4,830	4,400	8.9
Gross Pollutants (kg/yr)	93,600	41,300	55.9

Table 2.2 Daily statistics for MUSIC base case model (downstream node)

	mean	standard deviation	maximum	10th percentile	90th percentile
Average daily flow (m^3/s)	0.07	0.25	3.94	0.00	0.15
TSS Concentration (mg/L)	37.90	43.70	184.00	16.10	130.00
TP Concentration (mg/L)	0.16	0.07	0.45	0.13	0.31
TN Concentration (mg/L)	1.54	0.33	2.47	1.41	1.93
TSS Load (kg/day)	802	3310	62700	0.13	1620
TP Load (kg/day)	1.92	7.46	130	0.00	4.02
TN Load (kg/day)	12.10	43.50	711	0.01	25.40
Gross Pollutant Load (kg/day)	113	402	3350	0	121

Table 2.3 Annual loads for MUSIC base case model by sub-catchment

	Flow (ML/yr)	TSS (kg/yr)	TP (kg/yr)	TN (kg/yr)	GP (kg/yr)
North Para northern catchments	649	125,275	256	1,326	27,815
North Para southern catchments	432	85,233	177	887	17,645
South Para northern catchments	176	35,723	83	455	7,619
South Para southern catchments	101	20,339	42	209	4,310
Gawler River northern catchments	37	7374	15	76	1,491
Gawler River southern catchments	117	23,336	48	238	4,244
Clifford Road Drain	783	155,753	310	1,608	29,843
Not within River catchment	15	2,967	6	30	632

2.5.3 Comparison with previous study

Richard Clark and Associates developed a water balance model of the Gawler Region as part of a study to estimate water availability and identify options for water supplies for future developments in the Greater Gawler Area. Details of the study are provided in the report Estimation of Water Availability and Preliminary Modelling of Options for Water Supplies to Future Developments in the Greater Gawler Area (Clark, 2010).

As part of the SMP development, and at Council's request, the outputs from the Gawler and Surrounds SMP MUSIC model were compared to the results of the Richard Clark study for the purpose of validating the model.

Comparison of study areas

The Clark (2010) modelling focused on the Greater Gawler region with a total area of 14,600 ha. The modelling area included catchments discharging to the North Para and South Para Rivers (total area 8,224 ha) and areas to the north of the Gawler township, centred around Roseworthy which drain in a south westerly direction.

By comparison, the Gawler and Surrounds SMP MUSIC model includes a total catchment area of 1,767 ha. The area included in the MUSIC model roughly corresponds with the urban portions of the Gawler Town and Evanston areas defined by Clark (area 1,915 ha). Review of the catchment parameters modelled by Clark show a total impervious area of 512 ha. By contrast, the MUSIC model includes a total impervious area of 592 ha.

The modelling undertaken by Clark (2010) estimated the annual average stormwater runoff from the Gawler Town and Evanston areas to be 983 ML/year, which is significantly less than the 2,310 ML/year estimated by the MUSIC modelling. Limited details regarding the assumptions underlying the Clark model are provided.

Not only do the two models cover different areas, but the models were developed for very different purposes and it is difficult to understand the reasons behind the difference in the estimates of runoff. The catchment definition and the catchment characteristics adopted in the MUSIC model are based on real data and are reflective of the current state of the catchment at the time at which the study was undertaken. The other modelling parameters are consistent with best practice guidelines for MUSIC modelling in South Australia.

The MUSIC model is a simplistic model of flows and pollutant loads and is a useful tool for modelling relative changes to flows and water quality. It is therefore considered suitable for application to the water quality improvement modelling as part of the Gawler and Surrounds SMP.

3 Problems and Opportunities

3.1 Introduction

The problems and opportunities identified within this section are based on the results of flood and water quality modelling undertaken for this project. A detailed description of the flood modelling methodology is contained within the *Hydraulic Modelling Report* (refer Appendix B).

3.2 Key flood prone areas

The key flood prone areas are described in this section. For reasons of brevity this list does not describe areas that experience only minor flooding. For the descriptions below, areas have been identified based on flooding that occurs during the long-term development scenario. Flood depth shown in figures below corresponds with the legend shown in Figure 3.1.

Flood depth (m)

- Less than 0.025m (not shown)
- 0.025m to 0.1m
- 0.1m to 0.2m
- 0.2m to 0.3m
- 0.3m to 0.4m
- 0.4m to 0.5m
- 0.5m to 0.6m
- 0.6m to 0.7m
- 0.7m to 0.8m
- 0.8m to 0.9m
- 0.9m to 1.0m
- 1.0m to 2.0m
- Greater than 2.0m

Figure 3.1 Inundation depth legend

3.2.1 Greening Drive (Evanston South)

Greening Drive is a localised low spot immediately east of the Main North Road interchange of the Gawler Bypass. Stormwater predominantly arrives in the low-spot as a result of overflow from the creek within the grounds of Trinity College (see Figure 3.2). The creek line passes through the Trinity College site before entering a large culvert beneath Main North Road and the Gawler Bypass. The culvert discharges into two large flood detention basins which then discharge slowly into the Clifford Road outfall drain via a swale along the western edge of the Gawler Bypass. A significant volume of runoff is diverted away from the large detention basins because water spills from the creek line upstream of the large culvert beneath the Gawler Bypass. The primary reason that water spills from the creek, is that the creek and culverts within the school grounds are too small to convey floodwaters in rare flood events. The floodwater that overtops the culverts is directed away from the creek due to the surrounding terrain. A comparatively small amount of stormwater also arrives from nearby streets when the capacity of underground systems is exceeded. This causes the floodwater to pond along Greening Drive. Once the low spot at Greening Drive is full, excess floodwater flows along Main North Road and contributes to flooding in Przibilla Drive, Evanston. Trapped stormwater along Greening Drive causes flooding up to 0.6 m deep in the 1% AEP flood event.

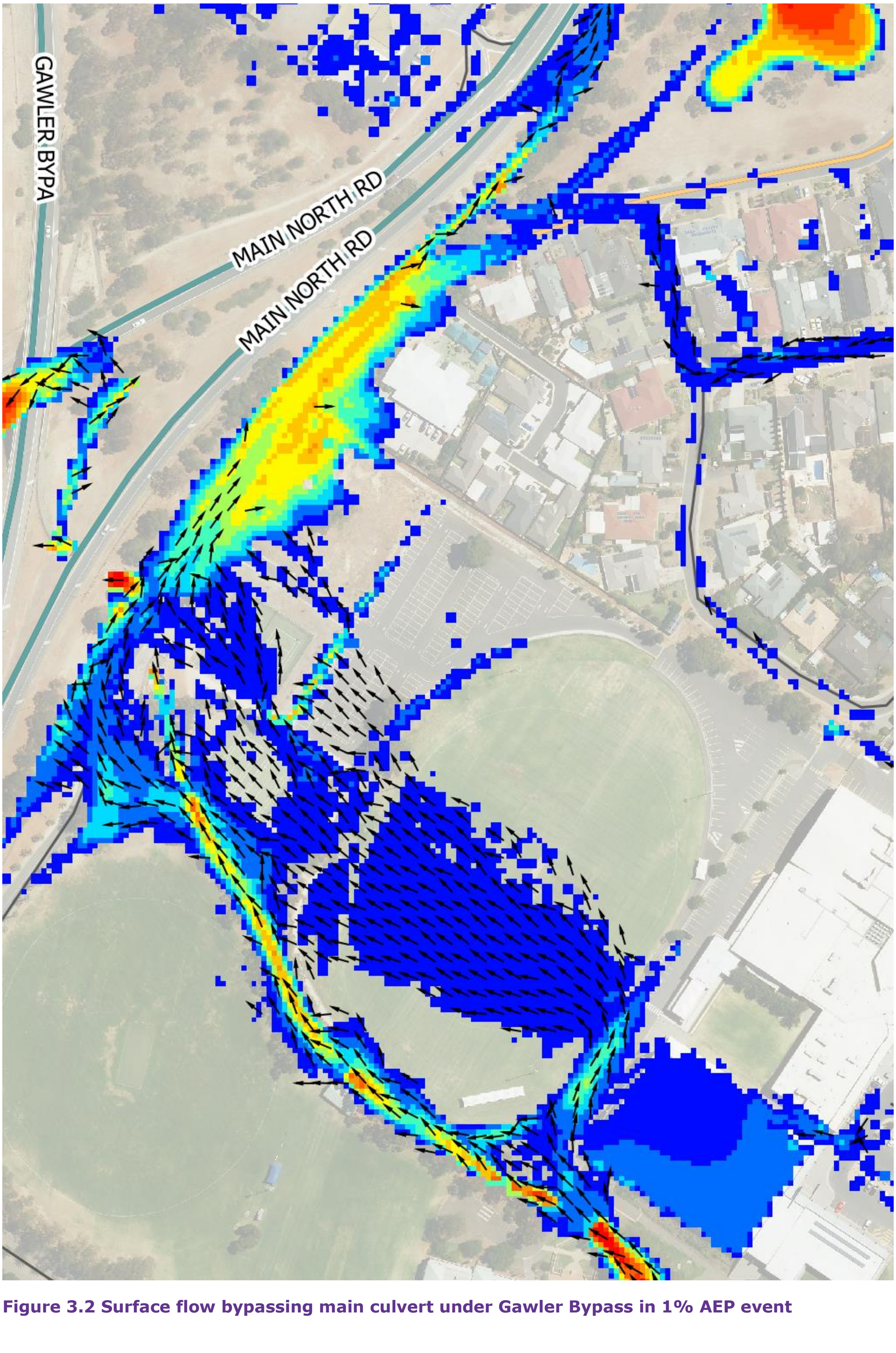


Figure 3.2 Surface flow bypassing main culvert under Gawler Bypass in 1% AEP event

3.2.2 Railway Crescent/Przibilla Drive (Evanston)

This location is a trapped low-spot adjacent the Gawler Bypass located in the lower part of the Clifford Road Drain catchment. This area experiences significant flooding in the 1% AEP event (see Figure 3.3) but not in the 5% AEP or 20% AEP events. The primary cause of flooding is the significant amount of floodwater arriving from the upstream areas of the Clifford Road drain catchment and the insufficient capacity of large drains under the Gawler Bypass. These two elements combine to cause floodwater to pond upstream of the Gawler Bypass road embankment.

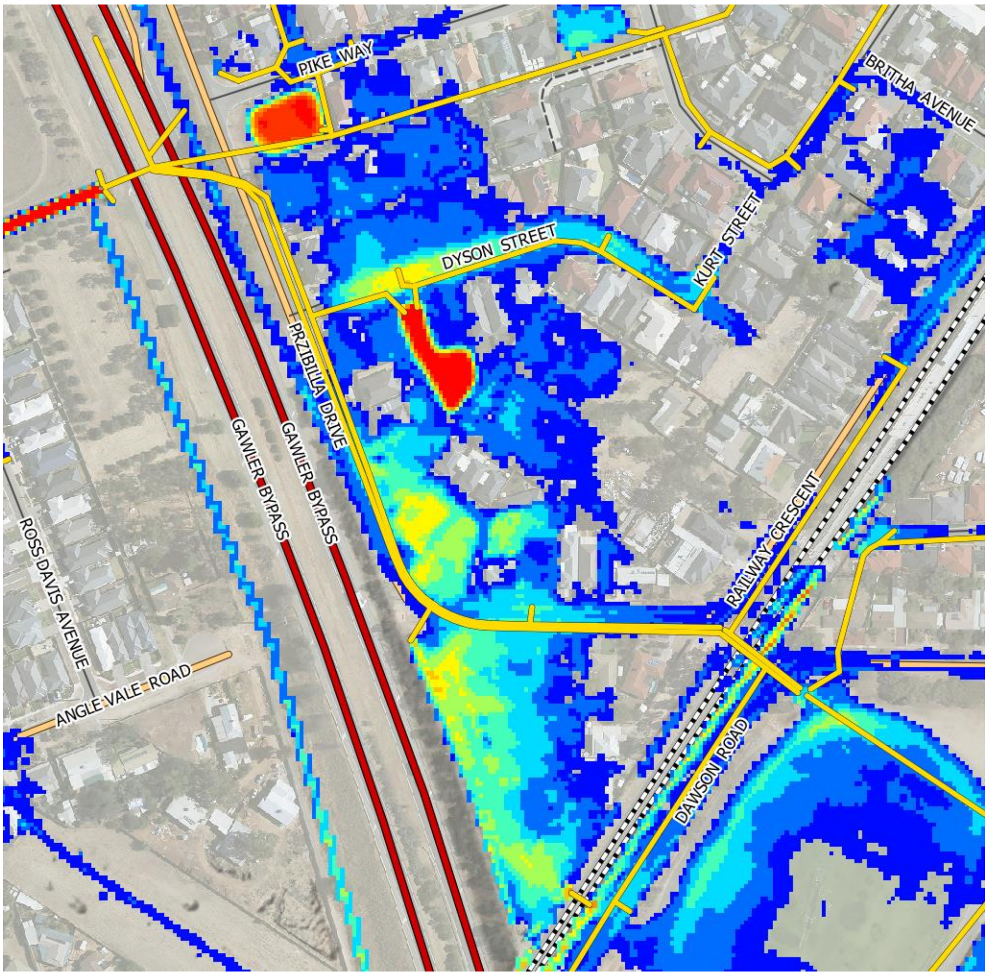


Figure 3.3 Railway Crescent/Przibilla Drive 1% AEP inundation

3.2.3 First Street (Gawler South)

This location is a trapped low-spot adjacent the Gawler Racecourse with a predominantly urban catchment of just under 220 hectares. Currently, there is little flooding in the 20% AEP event and only slightly more flooding during the 5% AEP event when stormwater inundates the road. During the 1% AEP event there is significant inundation of the road and surrounding properties (see Figure 3.4), as well as significant sheet flow through properties from Coleman Parade and Mount Terrace. Long-term predictions also show significant inundation and sheet flow through properties during the 5% AEP event.

The primary cause of flooding is the capacity of the pipe system that passes beneath the Gawler Racecourse. This pipe system is the only means of draining the low spot as there are no low-level overland flow routes from this area due to the elevation of the racecourse surface.

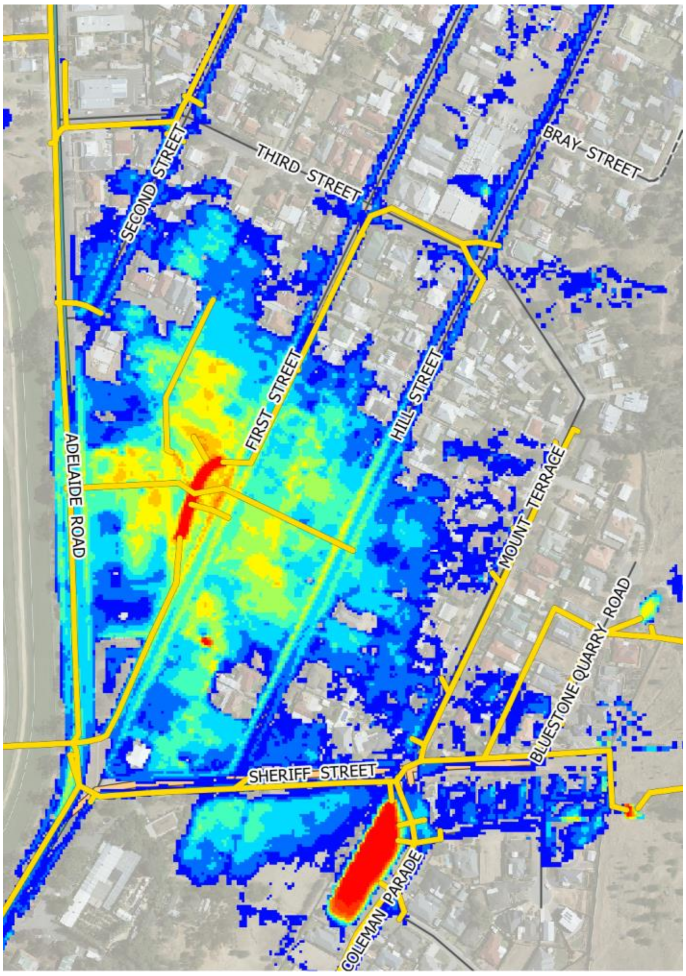


Figure 3.4 Predicted inundation during 1% AEP event (long-term development scenario) at First Street.

3.2.4 Jarvis Street and Brooks Avenue

These two locations are situated in the suburb of Willaston on the western side of the North Para River.

The Jarvis Street location (see Figure 3.5) is a localised low-spot with steep sided hills on three sides. Jarvis Street currently floods in events as frequent as the 20% AEP event due to the capacity of the downstream drains along Jarvis Street and Paxton Road. Stormwater will eventually escape the low-spot by flowing along Jarvis Street but not before inundating several properties. Some of these properties have residences that are located below road level.

The Brooks Avenue location (see Figure 3.6) is a trapped low-spot caused by the Sturt Highway road embankment. A small elongated detention basin is located between the highway and residential properties in the lowest part of the low-spot. The contributing catchment area upstream of the basin is 45 ha; the predominant land use is urban residential development. The basin is capable of managing stormwater in the 20% AEP event, but has insufficient capacity to prevent flooding of adjacent properties during larger floods (such as the 5% and 1% AEP events). Outflow from the basin is restricted by the downstream pipe system which runs against the natural surface and is assumed to have minimal grade. The outflow pipe is a DN600 along Busbridge Way, increases in size to a DN750 pipe after Haines Road and continues along Woodall Court. Approximately 70 m west of Gawler River Road the system descends steeply and reduces to a DN450 pipe. The transition from DN750 to DN450 occurs within a junction box with secured lid. The total energy head at this transition peaks up to 0.55 m above natural surface level and controls the capacity of the basin outlet.

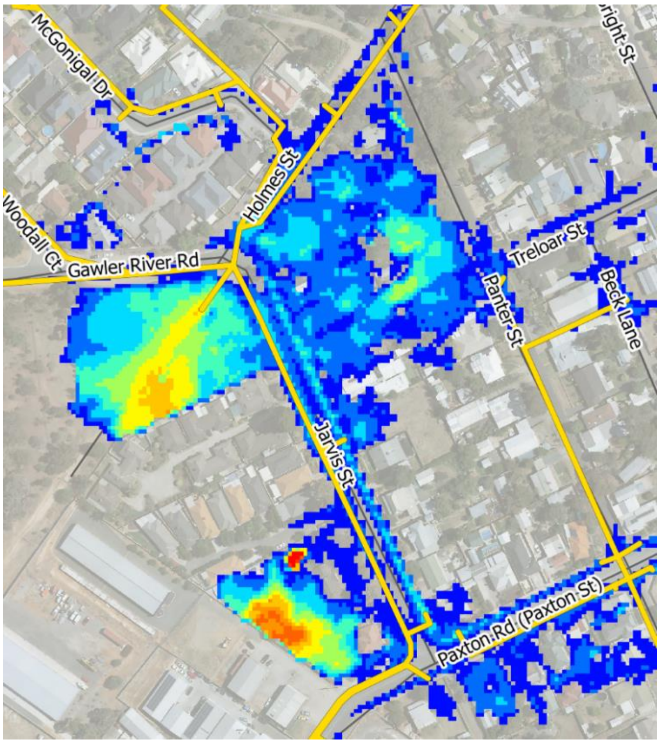


Figure 3.5 Flooding at Jarvis Street during the 1% AEP event (long term development scenario)

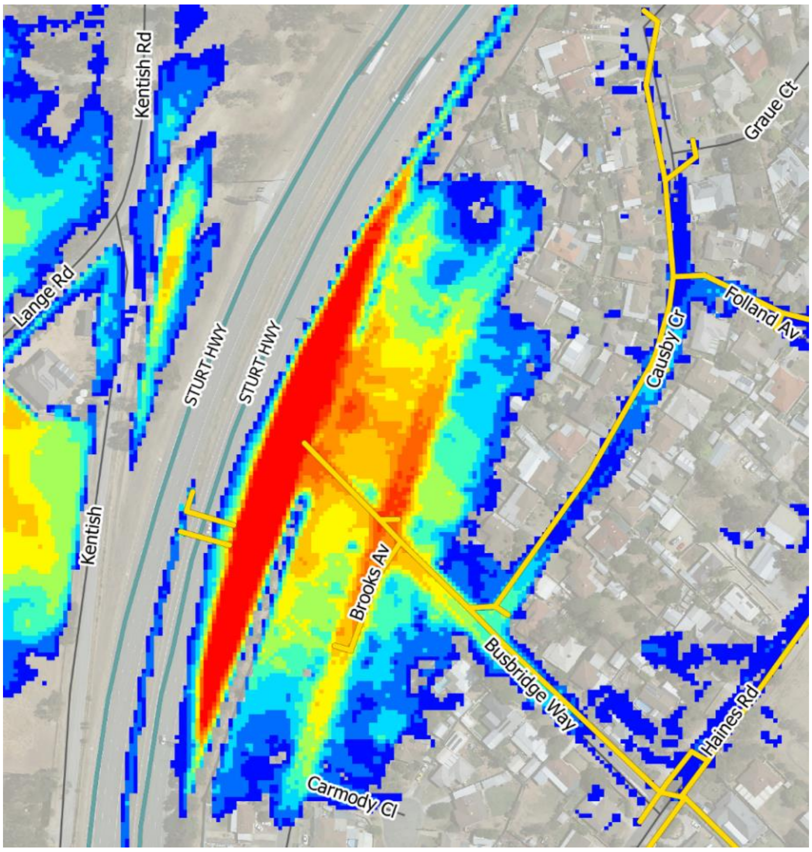


Figure 3.6 Flooding at Brooks Avenue during the 1% AEP event (long term development scenario)

3.2.5 Jane Street and Davies Street

Both Jane Street and Davies Street are well known to Council as locations of frequent flooding. Modelling indicates that flooding occurs in the 20% AEP event with extensive sheet flow of stormwater through properties. Despite there being a detention basin on the corner of Princess Street and Davies Street, the lack of underground drainage higher up in the catchment leads to flooding of properties. At the time modelling was undertaken (2017) there was no underground drainage network in this area. Council have since undertaken to install 20% AEP standard underground drainage along both Jane Street and Davies Street; flooding is still expected for rarer events.

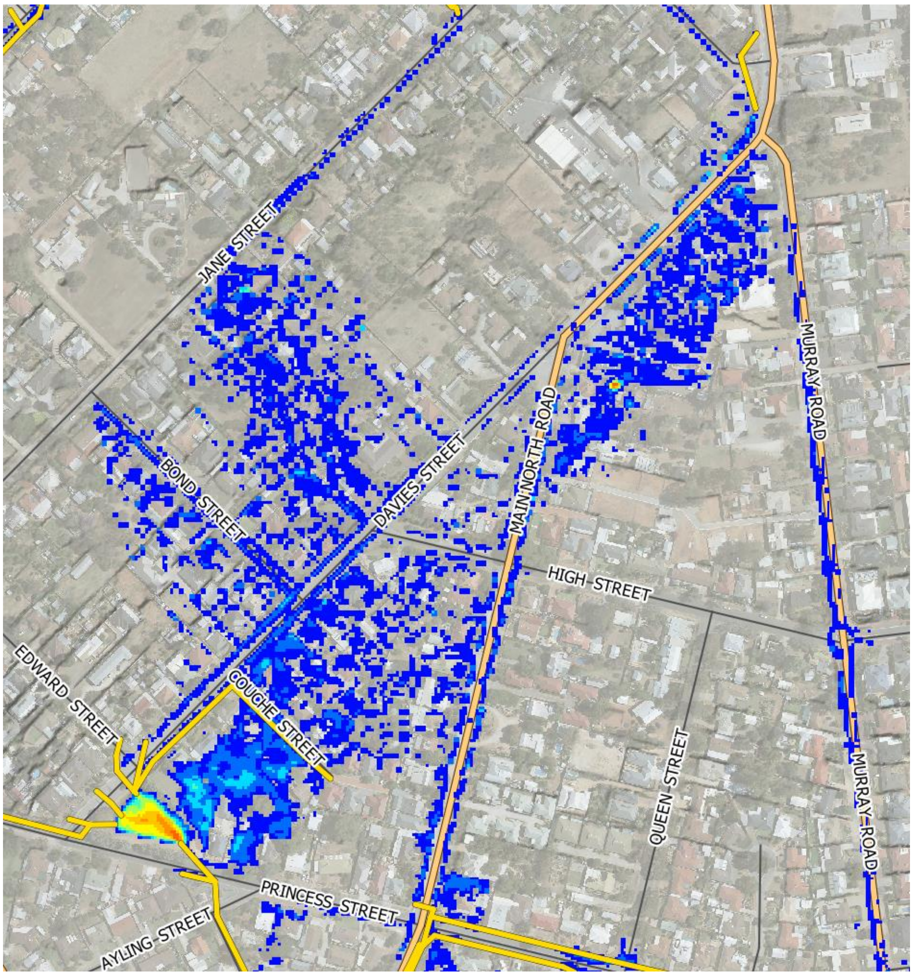


Figure 3.7 Jane and Davies streets 20%AEP inundation

3.2.6 Gawler Belt

The Gawler Belt area is characterised by the peaks and troughs formed by inland sand dunes which run in a southeast to northwest direction. In the southwestern corner of Gawler Belt there is a large 40 hectare depression which acts as a drainage basin for the surrounding catchments—total catchment area draining to the depression is just under 25 km^2. There is extensive flooding of the low spot in the 1% AEP flood (see Figure 3.8); the maximum depth of flooding is 1.9 m.

Due to the lack of any formal drainage in the area, beyond small roadside swale drains, there is extensive overland sheet flow through properties. Whilst many properties experience sheet flow few homes are flood affected. A more detailed investigation would be required, such as obtaining individual floor levels, to better assess how many dwellings are flood prone.

A significant amount of future development is proposed in the catchment that drains towards the Gawler Belt Area, near Roseworthy. Mitigation measures to deal with the additional stormwater runoff generated by the development is not within the scope of this SMP. However, it is understood that there are strategies in place that will ensure that both the rate and volume of runoff draining towards the Gawler Belt area will be no higher than current levels.

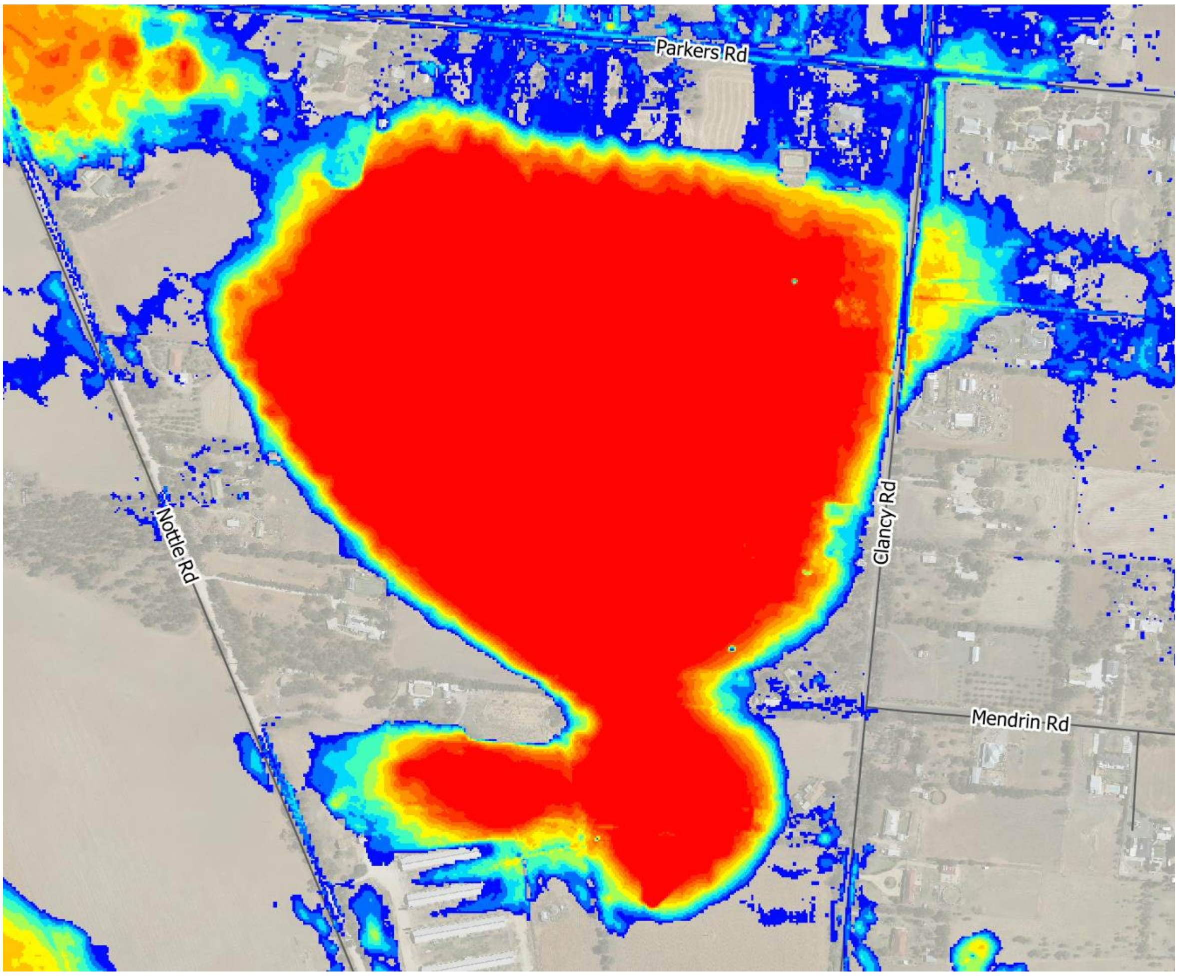


Figure 3.8 Predicted inundation of the Gawler Belt area during the 1% AEP flood event

3.3 Climate Change

The Intergovernmental Panel on Climate Change (IPCC) has concluded that 'it is now certain' that the climate is changing (IPCC 1990). The projections of climate change for the Gawler and Surrounds SMP study area include warmer and drier conditions. Despite the projected decrease in average annual rainfall, there is also a projected increase in the intensity of extreme rainfall events.

Review of the climate projections for the study region shows that under a high emissions scenario (RCP 8.5) for the end of the century (2090) average annual rainfall is expected to decrease by 9%, with an associated 10.2% increase in evapotranspiration. The greatest reductions in rainfall are expected to occur in the winter and spring months. Seasonal estimates of changes to rainfall for the RCP8.5 2090 scenario are provided in Table 3.1 .

Table 3.1 Seasonal changes to rainfall and annual evaporation for a high emission scenario (Webb,2015)

	% change
Rainfall	
Summer	-3%
Autumn	+2%
Winter	-19%
Spring	-19%
Annual evapotranspiration	+10.2%

The projected changes to the current climate will impact the management of water resources within the study area – it will reduce the volumes of runoff available for reuse, impact water quality and may increase the frequency and severity of flooding. The potential impacts of climate change on water harvesting schemes and water quality are discussed in this SMP (refer to Section 3.7.4).

For the Gawler SMP region the intensities of heavy rainfall events may increase by up to 17%. Previous studies have found that the resultant percentage increase in peak flows is greater than the increase in rainfall, with the greatest difference in catchments with a large proportion of pervious areas. A single climate change run for the 1% AEP event, with mitigation measures in place has been undertaken to assess what impact climate change may have on the size of the proposed mitigation infrastructure.

3.4 Future projections of water quality

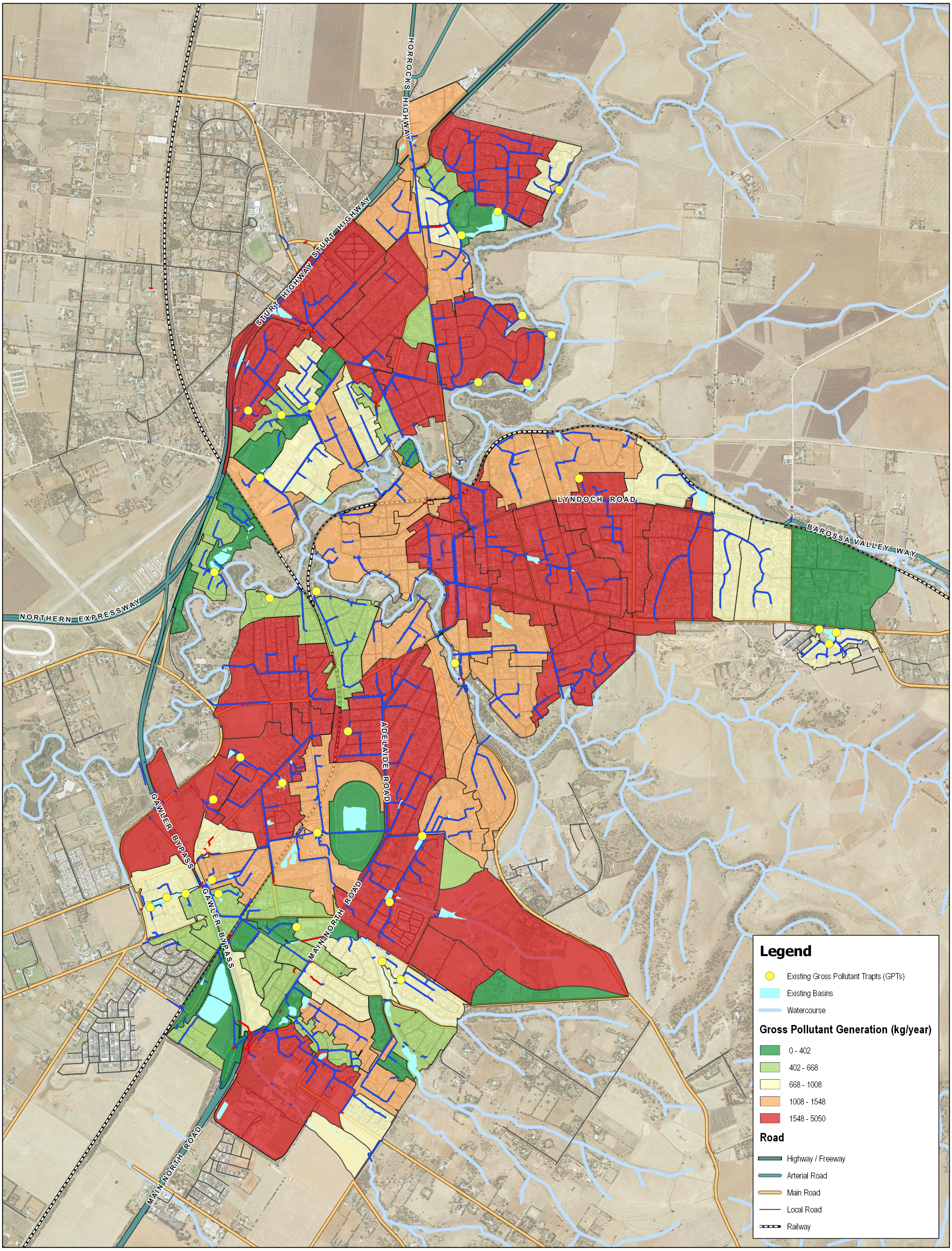
The catchment parameters within the MUSIC model were revised to reflect the long term state of development within the study area (as calculated for the hydrology and hydraulic modelling). As a result of the predicted development, the impervious areas within the study area increased by approximately 119 ha from 33.3% to 39.7% of the total area. Two simulations were performed; one assuming the current climate and one including consideration of the effects of a warmer, drier climate as a result of the changing climate.

The results for the node downstream of the study area (representative of total discharges into the receiving waters) are summarised in Table 3.2. Estimates of pollutant loads for the long term climate change scenario are not provided due to limitations associated with the MUSIC model's ability to model the relative changes to pollutant loads in a drier climate. Further details of the limitations are provided in the following section.

The distribution of gross pollutant generation is shown in Figure 3.9. Review of the patterns of pollutant generation for the other modelled pollutants shows that the distribution of gross pollutants is indicative of the patterns of generation for the other pollutants.

As expected, the MUSIC modelling suggests that development within the catchment will increase the flows, with a resultant increase in the annual pollutant loads. The 6.4% increase in impervious area results in a 12% increase in annual average flows.

When the projected changes to climate are taken into account (reflective of the end of the century for a high emission scenario), the resultant decrease in flows more than offsets the modelled impacts of long term development. Based on the climate change projections it is estimated that by 2050, the reduction in rainfall will likely be of a sufficient magnitude to offset the increased flow volumes as a result of development.



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Revision: REV B
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Drawn: Dylan Bone

Data Acknowledgement:
Aerial Imagery from Metromap, 2017
Roads and Railways from DataSA, 2017

Town of Gawler, Light Regional Council and The Barossa Council

PATTERNS OF POLLUTANT GENERATION WITHIN THE STUDY AREA

Figure 3.9

Table 3.2 Annual loads for MUSIC models (downstream node)

	Existing	Long Term	Long Term (with CC)
Flow (ML/yr)	2,270	2,590	1,880
Total Suspended Solids (kg/yr)	291,000	328,000	n/a
Total Phosphorus (kg/yr)	701	790	n/a
Total Nitrogen (kg/yr)	4,400	5,010	n/a
Gross Pollutants (kg/yr)	41,300	44,000	n/a

3.4.1 Impacts of climate change on water quality

MUSIC models the generation of pollutants based on user-defined statistical distributions linking pollutant generation to flow. In reality, the generation of pollutants within a catchment is far more complex than can be modelled in MUSIC. It is dependent on a range of factors, including the primary source of each pollutant and the mechanism by which each pollutant is deposited within the catchment. There is no information in the literature as to the potential changes to patterns of pollutant generation for drier climates.

MUSIC is not able to realistically model the impacts of climate change on water quality, as the assumption that the statistical distribution linking flows and pollutant loads is unchanged with a changing climate results in the model predicting reduced pollutant loads for a drier future climate.

It is likely that under a future drier climate (and ignoring changes to the level of development within the catchment), the total annual average pollutant loads will be unchanged. With reduced runoff volumes, it can therefore be expected that the concentrations of pollutants will be higher, particularly with 'first flush' events. Warmer temperatures may also lead to reduced water quality in permanent water bodies due to increased stagnation.

3.4.2 Summary of existing water quality

MUSIC modelling simulates patterns of pollutant generation for urban areas. It demonstrates that under a long term scenario, in an average year the study area may discharge over 330 tonnes of suspended solids, 49 tonnes of gross pollutants, 5 tonnes of nitrogen and 0.7 tonnes of phosphorus into the receiving waters downstream of the catchment. For the South Para River the receiving waters is as defined in Section 2.4, at the confluence of the North and South Para rivers. This feature signifies the start of the Gawler River. The modelling shows the generation and discharge of pollutants is broadly distributed, with no obvious 'hot spots' in Figure 3.9. While figures have not been shown for suspended solids, total phosphorus or total nitrogen, the relatively loadings are linked closely to the generation of gross pollutants within the MUSIC model.

The opportunity exists to implement additional water quality improvement measures within the catchment to reduce pollutant discharges to the receiving waters, thereby contributing to the improved health of the receiving waters.

3.5 Receiving water values

Stormwater from the SMP study area discharges into the North Para, South Para and Gawler Rivers, either directly or via tributaries. There are over 50 piped outlets which discharge stormwater from the urban areas into these watercourses.

The relative contribution of the study area to flows and pollutant loadings at the point at which the Gawler River discharges into the Gulf of St Vincent is relatively small. Given the large upstream