



Final

Mt Barker, Totness & Littlehampton Stormwater Management Plan

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Mt Barker, Totness & Littlehampton Stormwater Management Plan

District Council of Mount Barker

Southfront Ref: 14042-7H

Revision	Date	Approved	Details
A	27 Aug 2014	DJ	Sec 2
B	11 Nov 2014	DJ	Sec 4, 5, 6, 7
C	12 Mar 2015	DJ	Sec 3, 4.5, 6
D	13 May 2015	DJ	Complete
E	13 May 2016	DJ	Post Consultation Update
F	20 Jun 2016	DJ	Further revisions
G	30 Jun 2016	DJ	Final Draft
H	21 Oct 2016	DJ	Final

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Executive Summary

This Stormwater Management Plan (SMP) for the Mount Barker, Littlehampton and Totness townships 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 area is 33.5 km² and includes those areas zoned for future residential and industrial development. This area drains via a number of tributaries to Mount Barker Creek, which drains beyond the plan area to the Bremer River and then into Lake Alexandrina. The plan boundary area is entirely within the District Council of Mount Barker area.

Key issues identified by this Stormwater Management Plan include:

- Flood risk posed by watercourses to existing residential and commercial development
- Deficiencies in minor drainage systems, including a lower than suitable performance standard to residential properties at numerous 'trapped' low point locations.
- Insufficient water quality improvement measures to achieve contemporary water quality improvement standards
- Limited existing stormwater harvesting and reuse activity, albeit in the context of the *Eastern Mount Lofty Ranges Prescribed Water Resource Area Water Allocation Plan* which was introduced to manage allocation of surface water runoff
- The scope for future development, most of which will drain downstream through existing development, to amplify the issues described above

Relevant objectives contained within the *Strategic Plan 2012-2017* (District Council of Mount Barker, 2012a), *Natural Resources Management Plan* (South Australian Murray-Darling Basin Natural Resources Management Board, 2014a) and the *Eastern Mount Lofty Ranges Prescribed Area Water Allocation Plan* (South Australian Murray-Darling Basin Natural Resources Management Board, 2013), in addition to the State Government WSUD objectives were drawn on to develop a set of objectives specific to this Stormwater Management Plan, addressing:

- Provision of an acceptable level of stormwater drainage service
- Provision of an acceptable level of flood protection
- Improvements to stormwater quality released to watercourses
- Beneficial harvesting and reuse of stormwater
- Sustainable management of stormwater infrastructure
- Achievement of desirable outcomes associated with new development and management of open space

The Plan has developed a range of structural and non-structural actions, as summarised in the table below, by which these objectives can be achieved. A number of creek-related

flood mitigation projects are eligible for Stormwater Management Authority funding support.

Priority	Project / Activity	Suburb	Capital Cost (\$)
	Stormwater Infrastructure		
High	Follett Close to Mt Barker Road	Totness	\$330,000
High	North Terrace to Benjamin Gray Drive	L'mpton	\$390,000
High	Baker Street	L'mpton	\$50,000
High	Claret Ash Parade	Mt Barker	\$10,000
High	Hallmark Road	Mt Barker	\$20,000
High	Light Crescent	Mt Barker	\$130,000
High	Netley Street/Howard Close/Grivell Street/Craig Terrace	Mt Barker	\$430,000
High	Phillip Street/Princes Road/Edward Street/Hughes Street	Mt Barker	\$580,000
High	Wunderley Drive/Victoria Road/Wiland Street	Mt Barker	\$170,000
High	Albert Road (between Alexandrina Road & Wellington Road)	Mt Barker	\$20,000
High	Oborn Road	Mt Barker	\$670,000
High	Sims Road Detailed Investigation	Mt Barker	\$15,000
	Flood Mitigation		
High	Creek capacity works and Levee Banks – Fletcher Road to Mt Barker Creek ¹	Mt Barker	\$640,000
High	Floodsafe Program	-	\$10,000
	Water Quality		
High	Integrate identified WSUD opportunities within parks and reserves into relevant open space management strategies and plans	-	\$10,000
High	Update Development Plan provisions to mandate the use of 5kL rainwater tanks	-	\$20,000
	Stormwater Harvesting		
High	Review reserve management plans associated with the Duck Flat Creek and Secker Road wetland sites and ensure that the wetland concepts are appropriate and reflected in revised plans	Mt Barker	\$20,000
High	Prepare a Water Resource Management Plan for Mount Barker – Littlehampton - Totness	-	\$150,000
	Stormwater Infrastructure		
Medium	North Terrace	L'mpton	\$60,000
Medium	Junction Road	L'mpton	\$400,000

Priority	Project / Activity	Suburb	Capital Cost (\$)
Medium	West Terrace	L'mpton	\$180,000
Medium	Apollo Street	Mt Barker	\$10,000
Medium	Pridmore Terrace/Hutchinson Street	Mt Barker	\$240,000
Medium	Walker Street/Gawler Street/Mann Street	Mt Barker	\$260,000
Medium	Maurice Road/Wuttke Road/Allen Avenue	Mt Barker	\$360,000
Medium	Wunderley Drive/Victoria Road/Wiland Street	Mt Barker	\$410,000
Medium	Exhibition Road/Fletcher Road	Mt Barker	\$610,000
Medium	Junction Road Culvert	L'mpton	\$70,000
Medium	North Terrace Detailed Investigation	L'mpton	\$20,000
Medium	Hawthorn Road Culvert	Mt Barker	\$70,000
Medium	Bernhard Court	Mt Barker	\$370,000
	Flood Mitigation		
Medium	Bollen Road Storage ¹	Mt Barker	\$600,000
Medium	Adelaide Road to Railway Line Levee Banks ¹	Mt Barker	\$170,000
Medium	Druids Ave to Gawler Street Levees ¹	Mt Barker	\$140,000
Medium	Gawler Street to Home Maker Centre Levee ¹	Mt Barker	\$80,000
Medium	Totness Dam Overflow	Totness	\$70,000
	Water Quality		
Medium	Integrate WSUD opportunity identification into standard practice for relevant road asset management / replacement programs	-	\$10,000
Medium	Junction Road Reserve bioretention basin	L'mpton	\$80,000
Medium	Spring Park Farm Reserve constructed wetland and GPT	L'mpton	\$200,000
Medium	Benjamin Gray Reserve vegetated swale and GPT	L'mpton	\$100,000
Medium	Junction Road Culvert GPT	L'mpton	\$100,000
Medium	Mt Barker Road, Totness GPT	Totness	\$140,000
Medium	Mt Barker Showgrounds vegetated swale and detention basin	Mt Barker	\$80,000
Medium	Duck Flat Creek constructed wetland and GPT	Mt Barker	\$2,500,000
Medium	Secker Road constructed wetland and GPT	Mt Barker	\$2,000,000
	Stormwater Harvesting		
Medium	Undertake further feasibility assessment of the wetland and MAR concept at the Duck Flat Creek and Secker Road wetland sites and scope infrastructure associated to store harvested stormwater	Mt Barker	\$150,000

Priority	Project / Activity	Suburb	Capital Cost (\$)
	Stormwater Infrastructure		
Low	Mount Barker Road	Totness	\$140,000
Low	Fulford Tce to North Tce	L'mpton	\$760,000
Low	Spring Park Drive	L'mpton	\$40,000
Low	Saint James Drive/Edson Court/Gum Tree Drive	L'mpton	\$110,000
Low	Barrow Court/Durham Court	Mt Barker	\$120,000
Low	Pontiac Road	Mt Barker	\$50,000
Low	Sheridan Court	Mt Barker	\$90,000
Low	Wilkinson Court	Mt Barker	\$15,000
Low	Cook Court	Mt Barker	\$10,000
Low	Hill Street	Mt Barker	\$10,000
Low	Hawthorn Road/Adelaide Road	Mt Barker	\$180,000
Low	Cameron Road/Gollan Circuit	Mt Barker	\$10,000
Low	Hutchinson Street	Mt Barker	\$10,000
Low	Morphett Street/McLaren Street	Mt Barker	\$10,000
Low	Gawler Street	Mt Barker	\$10,000
Low	Cameron Street/Druids Avenue	Mt Barker	\$15,000
Low	Secker Road	Mt Barker	\$140,000
Low	Daw Avenue	Mt Barker	\$340,000
Low	Wunderley Drive / Victoria Road	Mt Barker	\$370,000
Low	Hack Street	Mt Barker	\$430,000
Low	Newland Street	Mt Barker	\$85,000
Low	Hutchinson Street/Victoria Crescent	Mt Barker	\$320,000
Low	Alexandrina Road	Mt Barker	\$270,000
Low	Madion Street/Wellington Road/Alexandrina Road	Mt Barker	\$580,000
Low	Stephenson Street	Mt Barker	\$15,000
Low	Lewis Avenue/Barton Circuit	Mt Barker	\$270,000
Low	Albert Road	Mt Barker	\$150,000
Low	Wellington Road (North Railway Terrace)	Mt Barker	\$490,000
Low	Wellington Road (South Railway Terrace)	Mt Barker	\$840,000
	Flood Mitigation		
Low	Clems Lane Flow Diversion ¹	L'mpton	\$390,000
Low	SGA Detention Basin Storages	Mt Barker	\$610,000
Low	Pipe Diversion – Adelaide Road to Western Flat Creek	Mt Barker	\$1,560,000

Priority	Project / Activity	Suburb	Capital Cost (\$)
Low	Creek Reconstruction – Faehrmann Avenue to Wellington Road	Mt Barker	\$1,620,000
Low	Cameron Road to Littlehampton Creek	Mt Barker	\$100,000
	Water Quality		
Low	Edward Street Reserve bioretention basin and GPT	Mt Barker	\$100,000
Low	Wellington Road GPT	Mt Barker	\$120,000
Low	Fletcher Road GPT	Mt Barker	\$80,000
Low	Ascent Estate Reserve GPT	Mt Barker	\$100,000
			\$24,495,000

¹ Item potentially eligible for Stormwater Management Authority funding

A draft report was prepared in May 2015 and utilised for consultation with the local community, interest groups, Council elected members and staff. Following the collation of feedback from this process, this final report has been prepared for submission to the District Council of Mount Barker, SA MDB NRM Board and the Stormwater Management Authority for final approval.

1 Introduction

This draft Stormwater Management Plan (SMP) for Mount Barker, Totness and Littlehampton has been prepared in accordance with the requirements of the Stormwater Management Planning Guidelines (Stormwater Management Authority, 2007).

The Plan provides an overview of the existing catchments and issues relating to current stormwater management. It also provides an overview of the opportunities to improve stormwater management to both address flood protection and the sustainable management of this resource and the environment.

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

The strategies outlines 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 draft plan has been prepared in consultation with the South Australian Murray Darling Basin Natural Resources Management Board (NRM Board) and Department of Planning, Transport and Infrastructure (DPTI) (acting on behalf of the Stormwater Management Authority (SMA)).

A draft report was prepared in May 2015 and utilised for consultation with the local community, interest groups, Council elected members and staff. Following the collation of feedback from this process, this final report has been prepared for submission to the District Council of Mount Barker, SA MDB NRM Board and the Stormwater Management Authority for final approval.

2 Catchment Features

2.1 Plan Boundary

The boundary adopted for this Stormwater Management Plan is shown in Figure 2.1 and Figure 2.2. The plan area is 33.5 km², which is defined as the urban areas of the three townships, including those areas zoned for future development. The plan area is within the upper portion of the Mount Barker Creek catchment, with each of the towns having upstream rural areas that flow through the urban areas.

The plan boundary area is entirely within the District Council of Mount Barker area.

Mount Barker Creek is a tributary of the Bremer River, which drains to Lake Alexandrina. The context of this Stormwater Management Plan boundary within these broader catchment areas is shown in Figure 2.1 below.

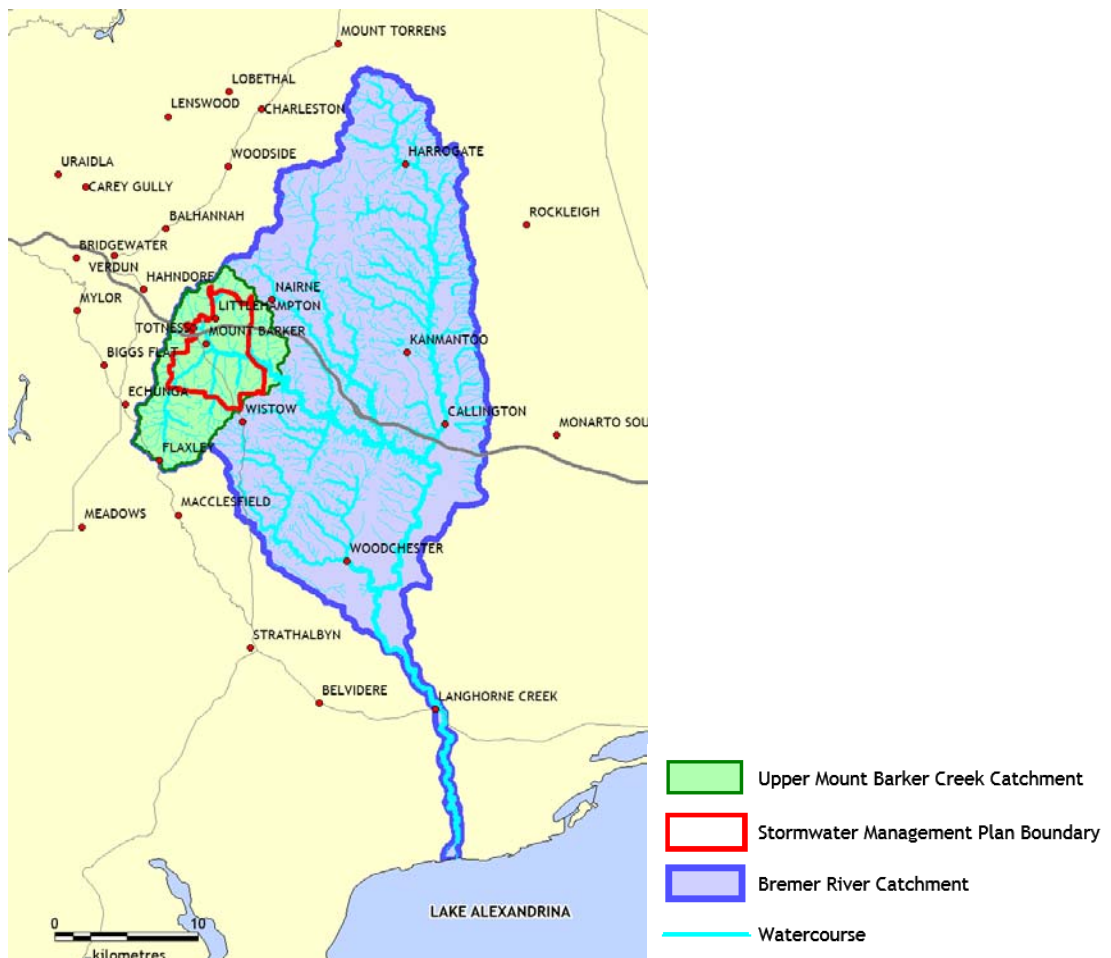
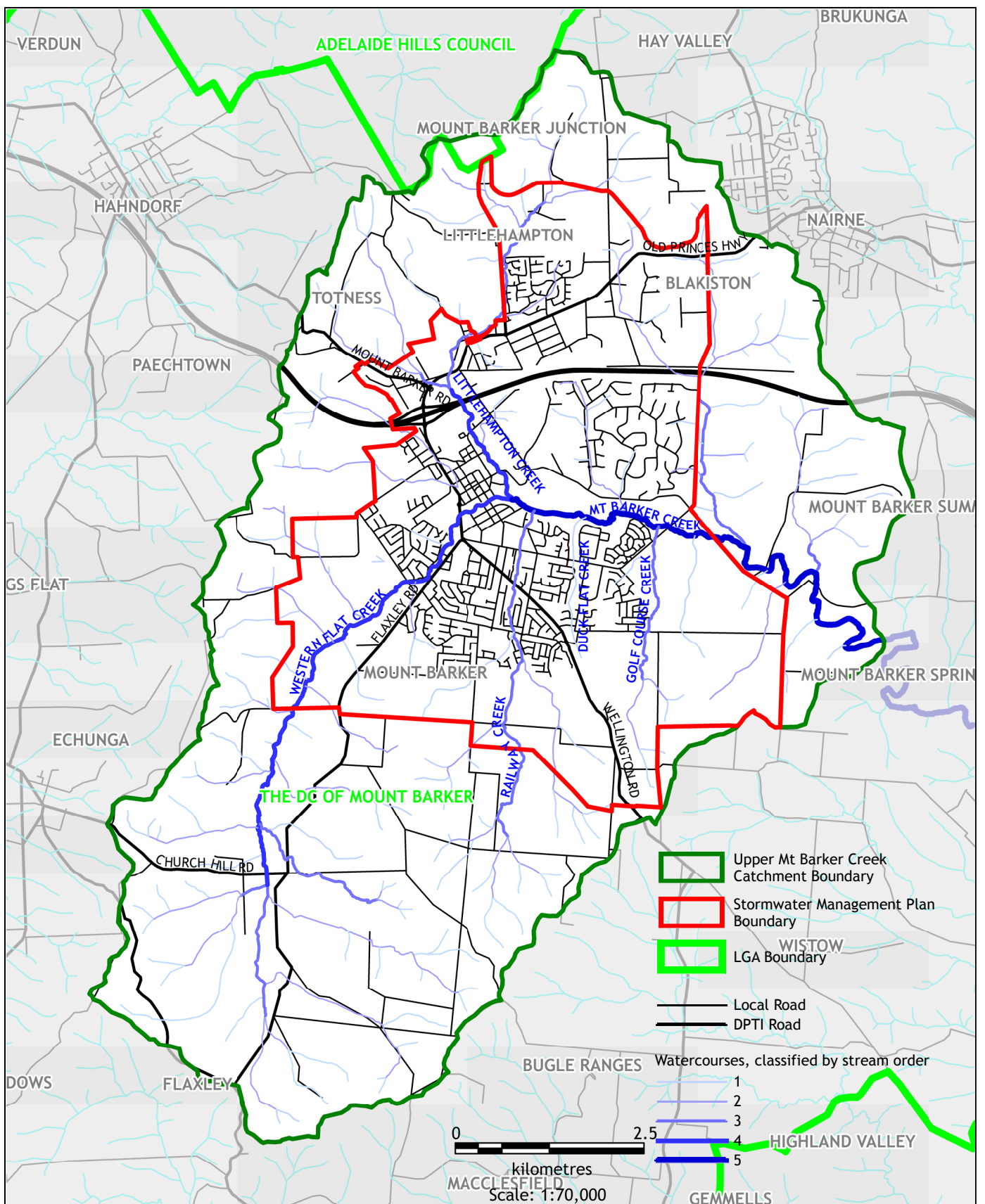


Figure 2.1 Bremer River Catchment Boundary

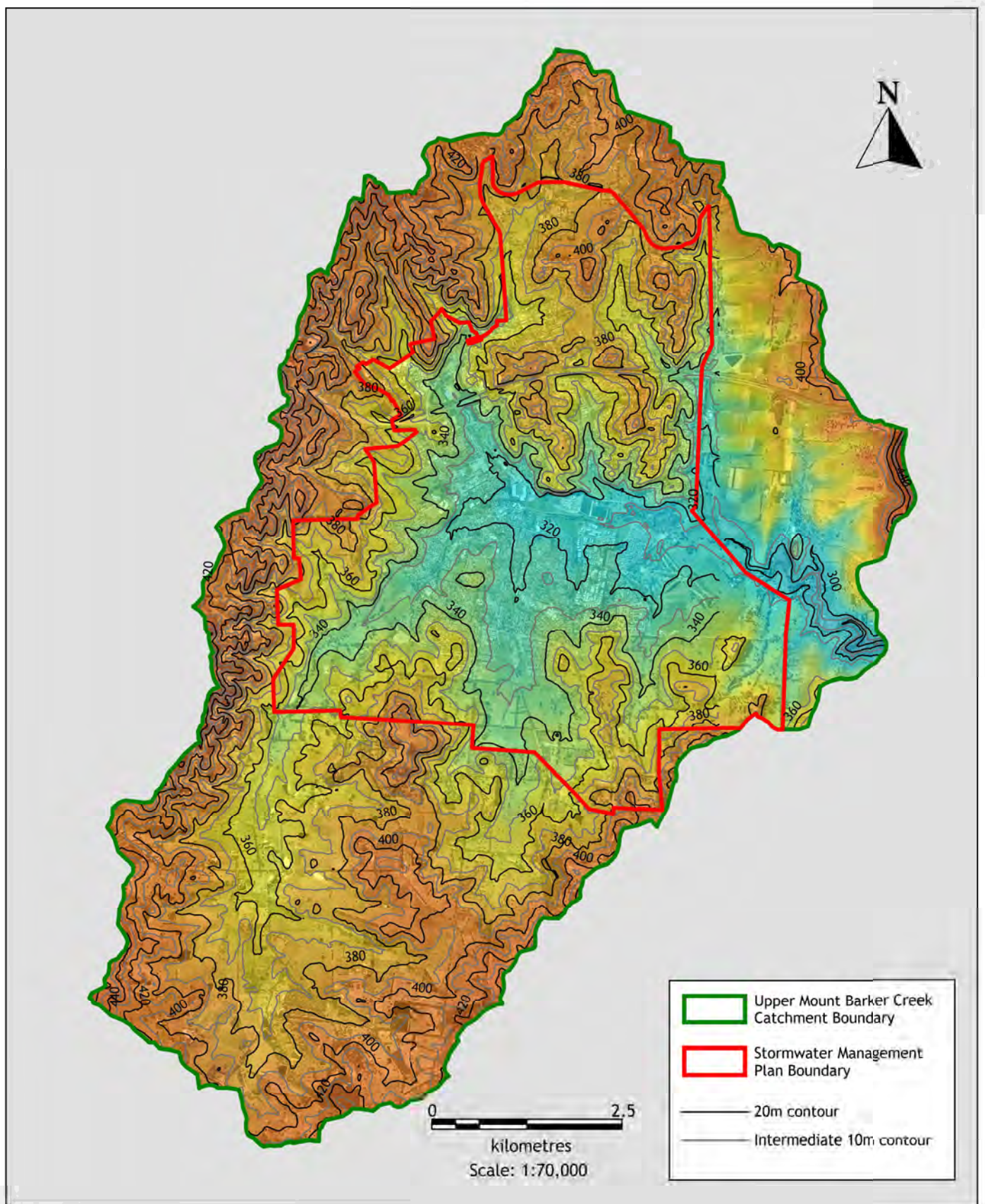


Copyright Southfront 2014

Data Sources:
 District Council of Mount Barker (Roads)
 DPTI (Suburbs), DEWNR (Watercourses), Southfront (SMP Boundary)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

Figure 2.2
Catchment Plan



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Data Sources:
DEWNR (Contours, Watercourses)
Southfront (SMP Boundary)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

Figure 2.3
Topographic Plan

2.2 Topography

The Study Area is characterised by well-defined catchments drained by a network of watercourses, typical of the Mount Lofty Ranges region.

Contour data for the catchment area was provided by the Department for Environment, Water and Natural Resources (DEWNR). For the purpose of illustrating the topography, the contour data was processed into an elevation grid model presented in Figure 2.3. The catchment varies in elevation from 270mAHD at its most downstream point, to the catchment outer boundary that is generally in the range of 420 – 450mAHD, rising to a maximum elevation of 517mAHD at the Mount Barker summit. The urban areas within the catchment are generally within the lower portions of the catchment, adjacent to watercourses, in the 320 to 400mAHD elevation range.

2.3 Stormwater Infrastructure

2.3.1 Existing Infrastructure

The District Council of Mount Barker maintains a GIS database of existing stormwater infrastructure, which has been utilised for a number of tasks undertaken for this plan. Figure 2.4 shows the location and extent of existing stormwater infrastructure within the catchment. A summary profile of existing infrastructure is provided in Table 2.1 below.

Table 2.1 Stormwater Infrastructure Profile Summary

Asset	Quantity
Pipe	
90, 100, 110 dia	2,494m
150 dia	20,304m
180 dia	169m
225 dia	6,555m
300 dia	14,993m
375 dia	31,822m
450 dia	5,194m
525 dia	3,039m
600 dia	4,040m
675 dia	1,469m
750 dia	1,551m
825 dia	638m
900 dia	497m
1050 dia	44m
1200 dia	618m
1350 dia	627m
1500 dia	305m
1650 dia	310m
Subtotal	94,669m
Node	
Side-entry pit	1549
Headwall	285
Field Gully / Grated	30

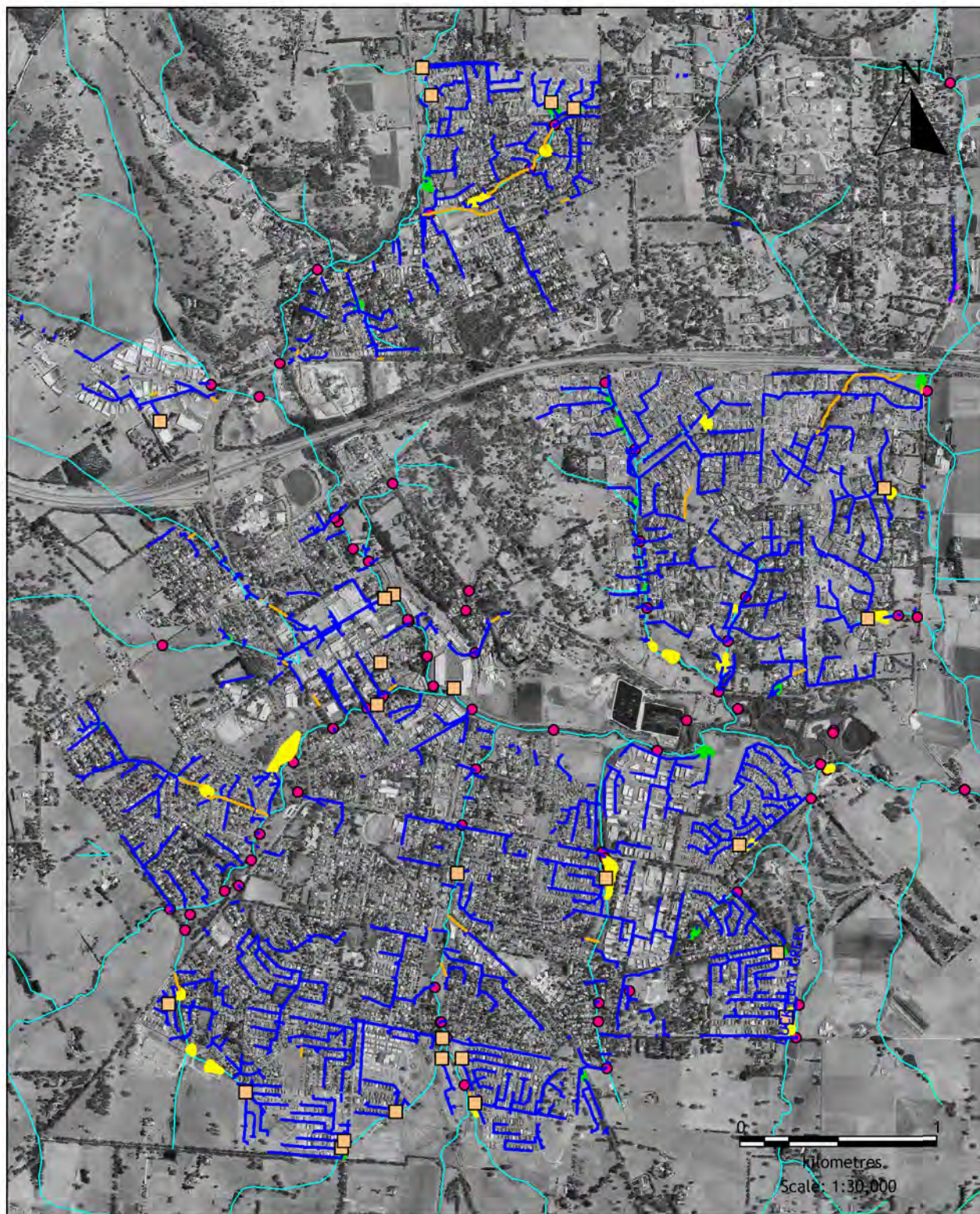
Asset	Quantity
Inlet	
Inlet / Outlet / Outlet Control	49
Junction Box / Sump / Inspection Point	1292
Box Culvert	
<= 1200 wide	26m
> 1200 wide	-
Open Drain	
<i>Natural</i>	1,836m
<i>Constructed</i>	1,062m
Subtotal	2,898m
Bridges	95
Gross Pollutant Traps	27
Detention Basins	18
Retention Basins	20

As with any database, the accuracy and completeness is not expected to be absolute. Accordingly it is anticipated and accepted that there may be errors and omissions and that works that are triggered by this plan will necessitate targeted data capture and truthing.

Council does not currently operate any stormwater pump stations or aquifer storage and recovery (ASR) schemes within the catchment.

2.3.2 Stormwater Asset Age

Data on estimated asset condition is contained within Council's stormwater asset data and is shown in Figure 2.5. It is understood that this information is largely drawn from a desktop assessment of likely construction age. This information confirms that a large proportion of the pipe network was constructed relatively recently in association with a number of greenfield land developments. No pipe networks are identified as having a 'poor' or 'very poor' condition rating.



Drains, by Asset Type
 — Box Culvert
 — Pipe

Dams, by Asset Type
 ■ Detention
 ■ Retention

■ Gross Pollutant Trap
 — Open Drain
 ■ Bridge

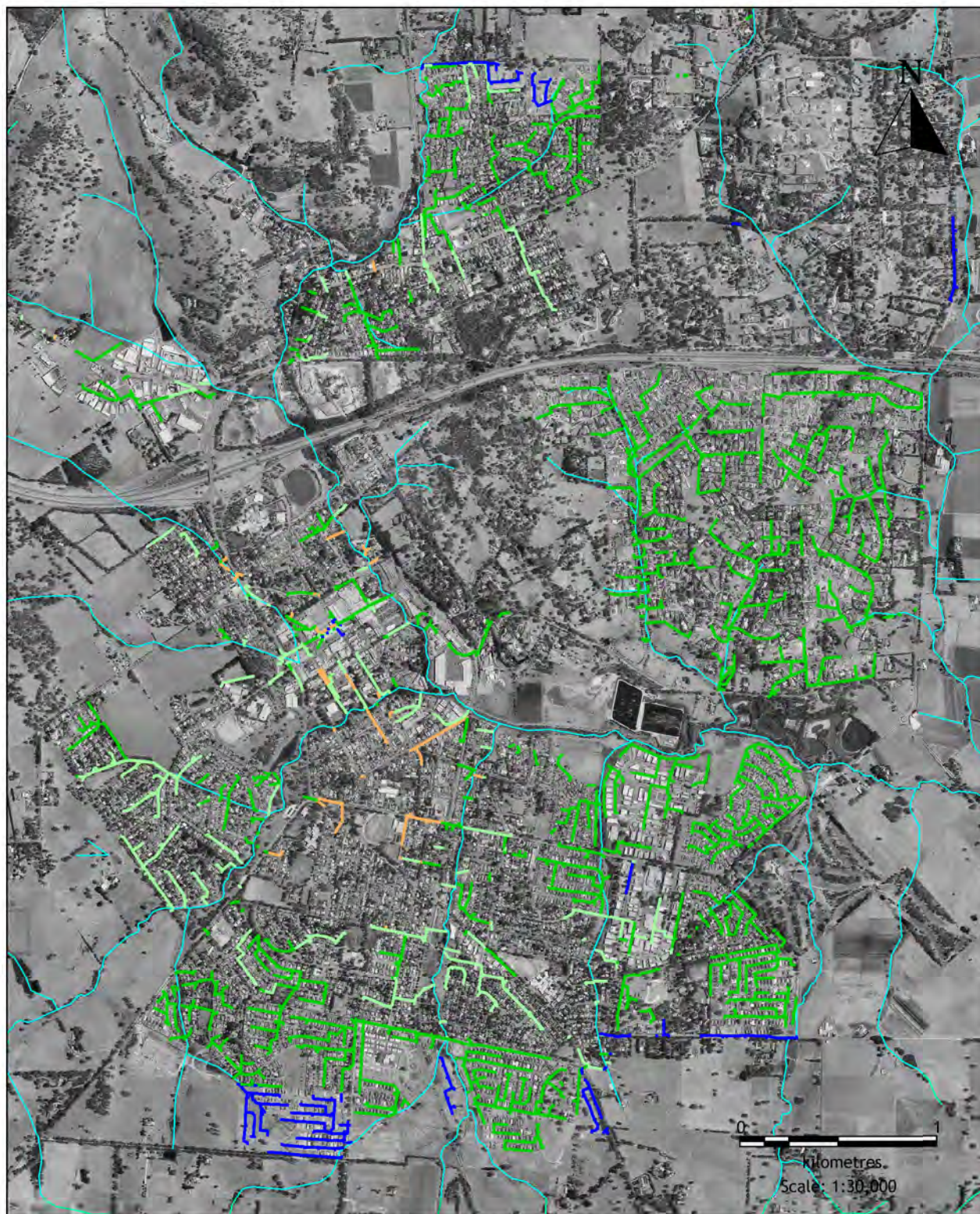
— Watercourse

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Data Sources:
 DEWNR (Watercourses)
 District Council of Mount Barker (Stormwater Assets, Aerial Photo)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

Figure 2.4
Stormwater Infrastructure



Drains, by Condition

- 0 (Not Rated)
- 1 (Very Good, est 75 years remaining life)
- 2 (Good, est 55 years remaining life)
- 3 (Fair, est 40 years remaining life)

— Watercourse

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Data Sources:
 DEWNR (Watercourses)
 District Council of Mount Barker (Stormwater Assets, Aerial Photo)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

2.3.3 Previously Known Stormwater Management Issues

Information in relation to locations where stormwater management issues exist across the Study Area was collated from Council sources, recent infrastructure assessment investigations and flood plain mapping. The known problems were as follows:

- Flood plain risks identified by flood plain mapping (AWE, 2011), most notably associated with Western Flat Creek below Adelaide Road, Littlehampton Creek near the junction with Western Flat Creek, Railway Creek below Fletcher Road, Mt Barker Creek near the rail line and major drainage through the Town Centre
- Minor flooding / poor local drainage performance in Bollen Road and Memorial Drive during times of high flow in Western Flat Creek
- Numerous nuisance drainage hotspots across the townships
- Lack of suitable easements for some drains that pass through private property
- Lack of formal drainage along some roads that have progressively become urbanised

Records of historical flooding events affecting Mount Barker and Littlehampton have been researched by Council's Local History Officer. Along with additional references contained in McCarthy D, Rogers T, Casperson, K (2006), these events are summarised in Table 2.2 below.

Table 2.2 Historical Flooding Events

Date	Notes	24hr Rainfall ¹
1847	The first report of floods in Mt Barker comes from 1847. A number of dwellings in the surrounding areas were destroyed and a man died trying to cross a river in Strathalbyn.	Not available
1861	Major floods in May forced residents in low lying areas of Mt Barker from their homes. In addition, one family in Littlehampton "lost all they were possessed of [and] barely escaped with their lives". The Register reports that firewood 300 yards from the stream was picked up in floodwaters and deposited in the handrail of a bridge. These floods also affected Strathalbyn, Woodside and Oakbank. Further heavy storms in December that year also flooded some of the district.	Not available
1866	Heavy rain in January led to minor flooding in the streets of Mount Barker, however, Hahndorf suffered the majority of the damage from the storm.	Not available
4-9 October 1867	Heavy floods in Mt Barker in October forced residents out of their homes with the "greater part of Mount Barker flat... under water". Five bridges in the district were washed away.	Not available
17 February 1873	Mount Barker was hit by a severe thunderstorm with some flooding of the township.	Not available
1883	Major floods in Mt Barker and surrounding areas destroy the Finnis Terrace Bridge.	Not available
1884	Heavy rain in May turns the tributaries of the Mt Barker Creek into rushing torrents. Flood	Not available

Date	Notes	24hr Rainfall ¹
	water crosses the road at the Hutchinson Street Bridge.	
1885	Minor floods in the district had become common enough that gardening advice in The Courier included how to protect your flowers from flood water.	Not available
1887	Major flooding in August submerges the cricket "paddock", the rifle range and some farmland. The Mt Barker and Littlehampton Creeks ran with a very strong current and were each 20ft wide at their junction. Water entered some houses but there was no significant damage.	Not available
12-14 August 1890	Heavy rain was experienced at Mount Barker and the flats below the town were underwater for a quarter of a mile in width	61mm (3 days)
June 1893	The "main street" of Mt Barker and several houses were struck by a minor flood which subsided quickly.	
July, September 1923	Heavy rain in July caused the Mt Barker Creek to break its banks and flood large portions Mt Barker including the bowling green, the Methodist Church, Cameron's and Railway Bridges and a number of houses. The town flooded again in September (reportedly the biggest flood in 70 years) with knee deep water damaging houses and gardens.	Not available
27 October 1963	There was some flooding and property damage in Adelaide and more severe flooding in Mount Barker	97
9 April 1970	A thunderstorm in the Adelaide Hills recorded 5 inches of rain in a violent ninety minute thunderstorm, causing flooding, power cuts and extensive damage to businesses and homes in Mount Barker. (McCarthy et al, 2006) Western Flat Creek and Mt Barker Creek flooded causing significant damage and claiming one life. (Council History Officer)	129.8
13-28 August 1981	Heavy rains led to a number of creeks in the Adelaide Hills overflowing	86mm (7 days)
16 August 1984	Heavy rain led to minor flooding in ... Mount Barker	55mm (2 days)
21 June 1987	Mount Barker Creek ... overflowed	32.2
23 August 1987	The spillway on a large dam at Littlehampton began to break up causing a nearby unsealed road to become flooded.	31
1987	Mt Barker Creek broke its banks and flooded the Bernhardt Court area following heavy rain damaging twelve Housing Trust homes.	

Date	Notes	24hr Rainfall ¹
23-27 August 1991	Minor flooding of creeks and roads occurred in Mount Barker	34.4
19-21 February 2000	Heavy rains led to minor flooding in ... the Adelaide Hills	97 mm (3 days)
7 July 2002	Several reports of localised flooding resulted from an electrical storm that hit Adelaide and surrounding areas, most notably Littlehampton.	15
25-26 November 2002	Heavy rains caused flash flooding... areas affected include... Littlehampton	35.4
12 July 2012	Maurice Road, Memorial Drive, Kay Road and Bollen Road were flooded after a heavy storm.	34.8

¹ Bureau of Meteorology Data reported by Mount Barker gauge 023733



Maurice Road, Mount Barker (The Courier, 18 July 2012)

There has been significant historical investment to reduce creek related flood risk to adjoining land. This has included works part funded by the former State Government Stormwater Drainage Subsidy Scheme in Mount Barker Creek near the railway line (1988) and Western Flat Creek adjacent to Memorial Drive and at Keith Stephenson Park (1991).

It is evident that at some locations (such as those depicted in photographs below), improved flood protection has been achieved through significant widening of the creek channel. This has typically resulted in loss of the original channel form and biodiversity, replaced with a broad channel base that is overgrown with reeds. It is understood that routine maintenance activities, or removal of reeds to facilitate revegetation with native plants is particularly challenging due to the dominant colonising behaviour of the reed vegetation.



Mount Barker Creek, below railway line



Western Flat Creek, below Bollen Road

2.3.4 Proposed Infrastructure

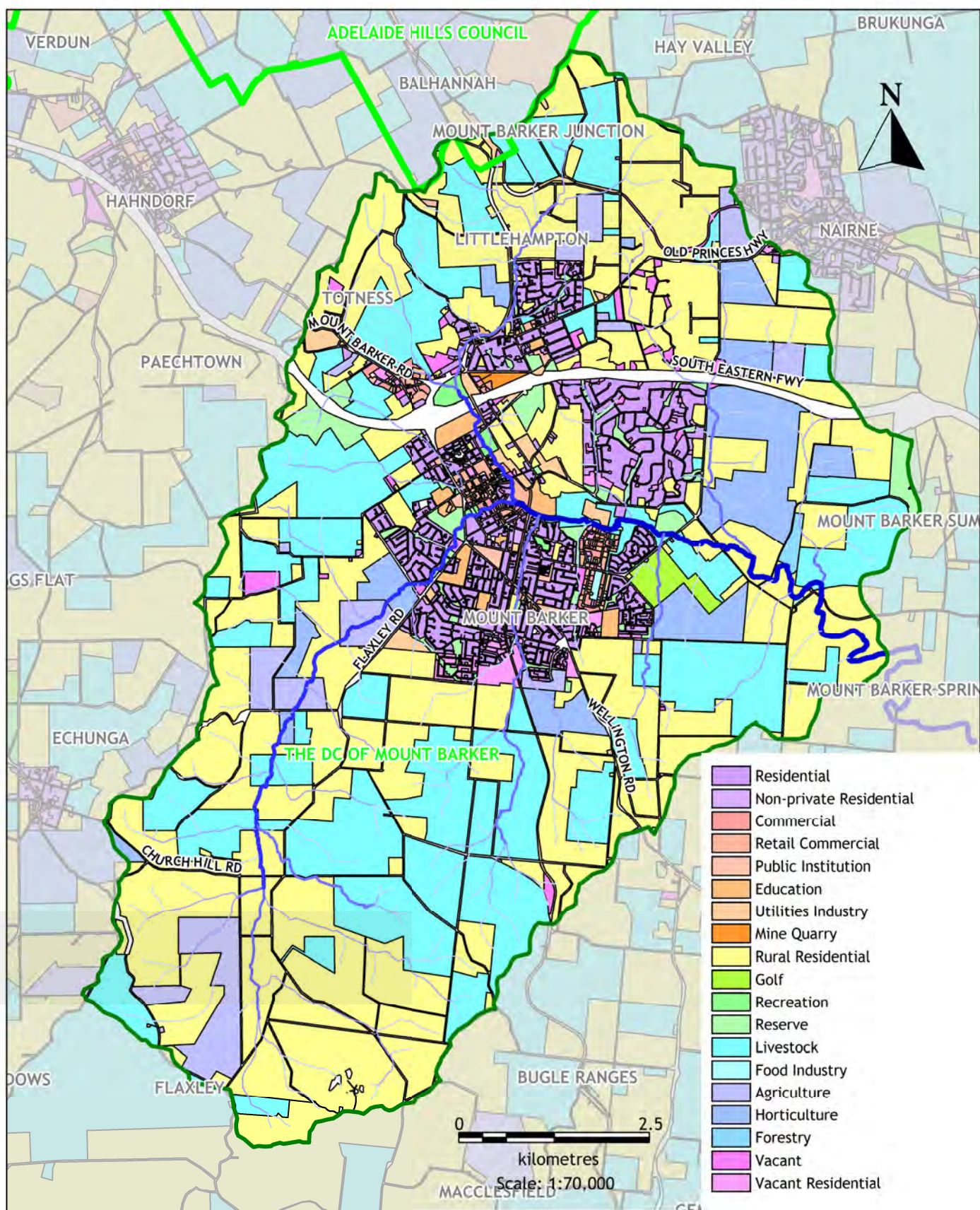
No Council stormwater management projects of note are known to be in the planning, design or implementation phases.

2.4 Existing Land Use

Dominant characteristics of current landuse across the catchment area (refer to Figure 2.6) are as follows:

- Residential development associated with the urban centres of Mount Barker and Littlehampton
- Rural living land development in the area bounded by the Freeway, Bald Hills Road, Mount Barker Creek and the railway line
- Ongoing greenfield residential development south of Hurling Drive in Mount Barker
- Industrial estate developments within Totness and at Alexandrina Road, Mount Barker
- Quarrying activities in Littlehampton
- Primary production and associated rural land uses across the balance of the catchment area

The current zoning of the catchment (refer to Figure 2.7) provides for additional greenfield residential development within the catchment, predominantly to the east, south and west of Mount Barker, which is described further in Section 2.5.

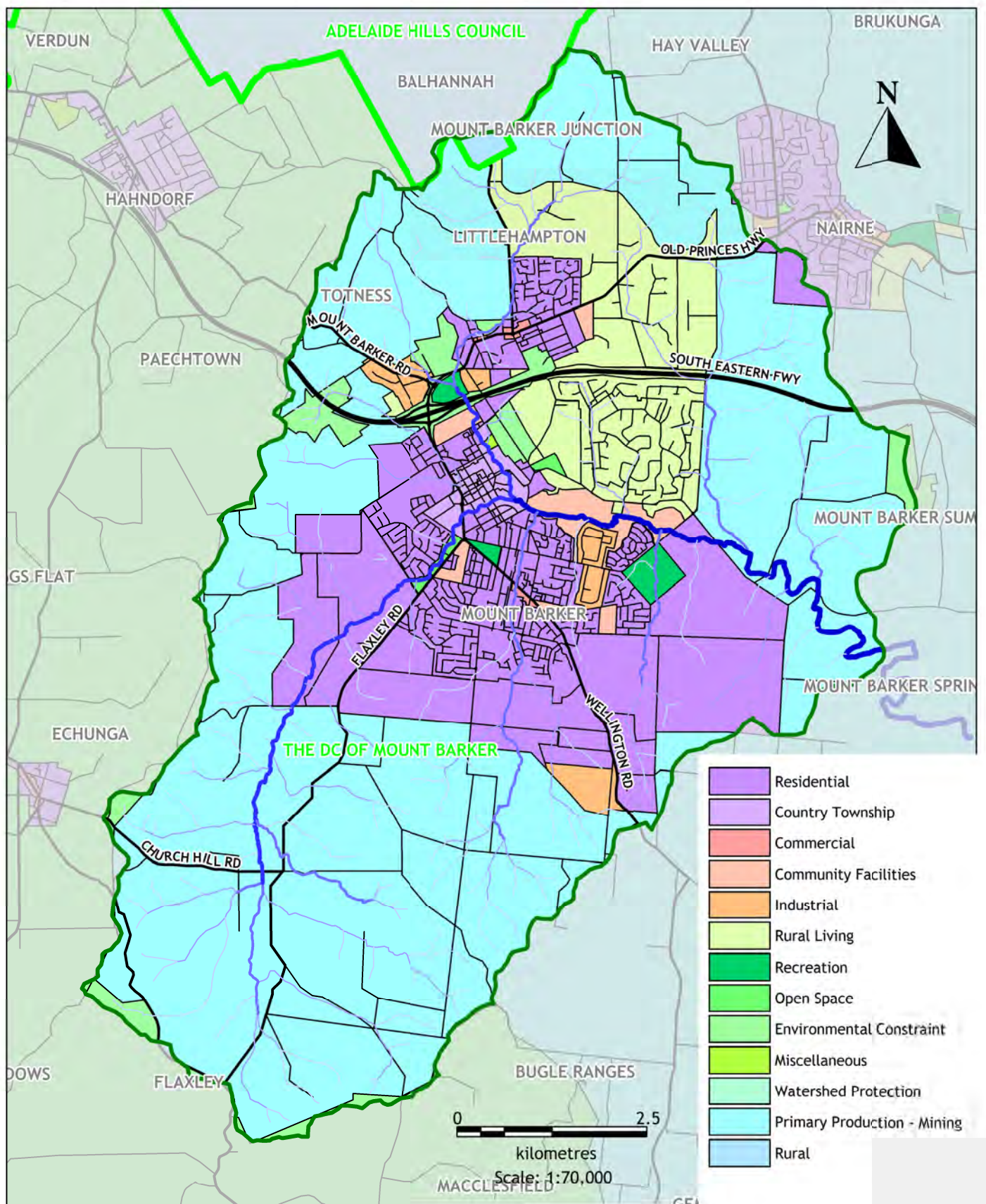


Copyright Southfront 2014

Data Sources:
 District Council of Mount Barker (Roads)
 DPTI (Land Use, Suburbs), Southfront (SMP Boundary)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

Figure 2.6
Generalised Land Use



Copyright Southfront 2014

Data Sources:
District Council of Mount Barker (Roads)
DPTI (Land Use, Suburbs), Southfront (SMP Boundary)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

Figure 2.7
Development Zone Plan

2.5 Land Development Potential

A Ministerial Mount Barker Urban Growth Development Plan Amendment (DPA) was approved in 2010, with proposed zoning changes now incorporated into the *Mount Barker Development Plan* (Department of Planning, Transport and Infrastructure, 2013).

The DPA rezoned approximately 1200 hectares of formerly rural land at Mount Barker (refer shaded areas depicted in Figure 2.8) for future residential development. Additional land south of Nairne was also rezoned but is not within this Stormwater Management Plan boundary area.

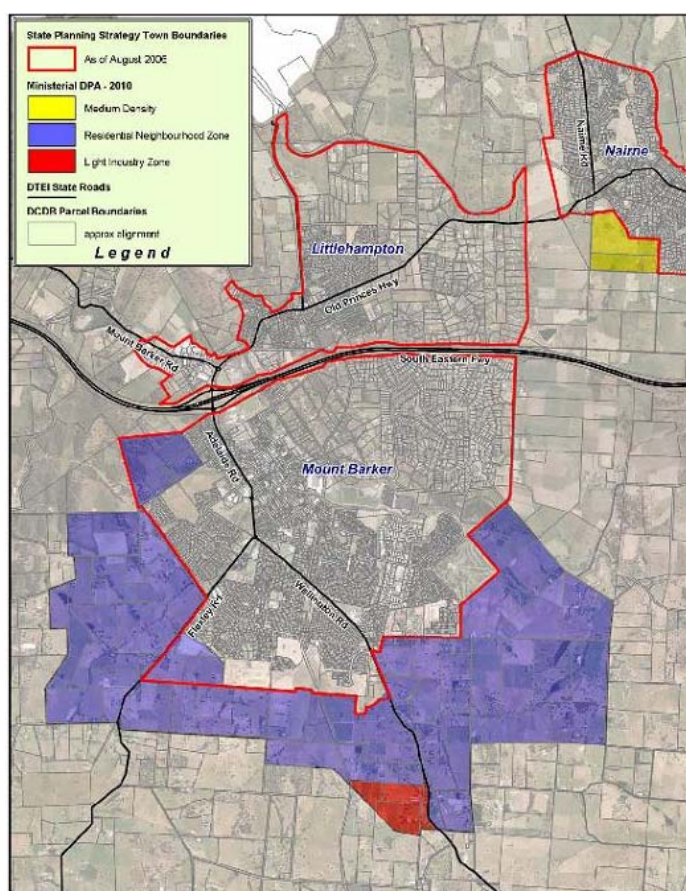


Figure 2.8 Land Zone Changes resulting from 2010 DPA

The towns of Mount Barker, Littlehampton, Nairne and near environs currently have approximately 20,000 residents. This is estimated to grow to 50,000-55,000 people by 2040 (District Council of Mount Barker, 2012b).

The District Council of Mount Barker identified that this proposed expansion of Mount Barker would introduce a number of challenges, particularly with regard to adequate provisioning of infrastructure. In response to this, a series of infrastructure planning studies have been undertaken to help guide the development process. These include:

- District Council of Mount Barker (2012b), *Mount Barker, Littlehampton and Nairne Structure Plan*

This Structure Plan was developed to provide direction for the growth as defined by the DPA to be achieved in an integrated and sustainable manner. The Plan incorporates feedback

from the local community and affected landowners. No specific stormwater infrastructure requirements are detailed in this Plan.

- District Council of Mount Barker (2015a), *Mount Barker Growth Plan (9 November 2015)*
This 'plan on a page' is a live document that is regularly updated as the layout of new land developments take shape and new information becomes available. It shows at a conceptual level the proposed connectivity across land parcels within the growth area associated with traffic, watercourses and community infrastructure. A number of stormwater detention basin locations within the Mount Barker growth area are identified. It is understood that these are indicative only (i.e. not supported by detailed investigations or analysis), but were nominated in recognition that some measures would be required to manage the increase in stormwater runoff generation associated with future development.
- Department of Planning, Transport and Infrastructure & District Council of Mount Barker (2014), *Mount Barker, Littlehampton and Nairne Strategic Infrastructure Plan*
This document provides details of the infrastructure that will be required to support the vision for urban development described in the *Mount Barker, Littlehampton and Nairne Structure Plan*. The Plan identifies the development of this Stormwater Management Plan as a priority to identify:
 - sites and approximate sizes for specific detention basins (a high level assessment is presented showing indicative locations for these basins, refer Figure 2.10, which are similarly indicative in nature to the *MDPA Area Master Plan*)
 - creek line upgrades and capacity increases, together with the identification of any structures that need augmentation or upgrades

The bulk of population growth is planned to be accommodated in the designated growth areas, with some potential infill development opportunities envisaged within established developed areas (District Council of Mount Barker, 2012b) as depicted in Figure 2.9.

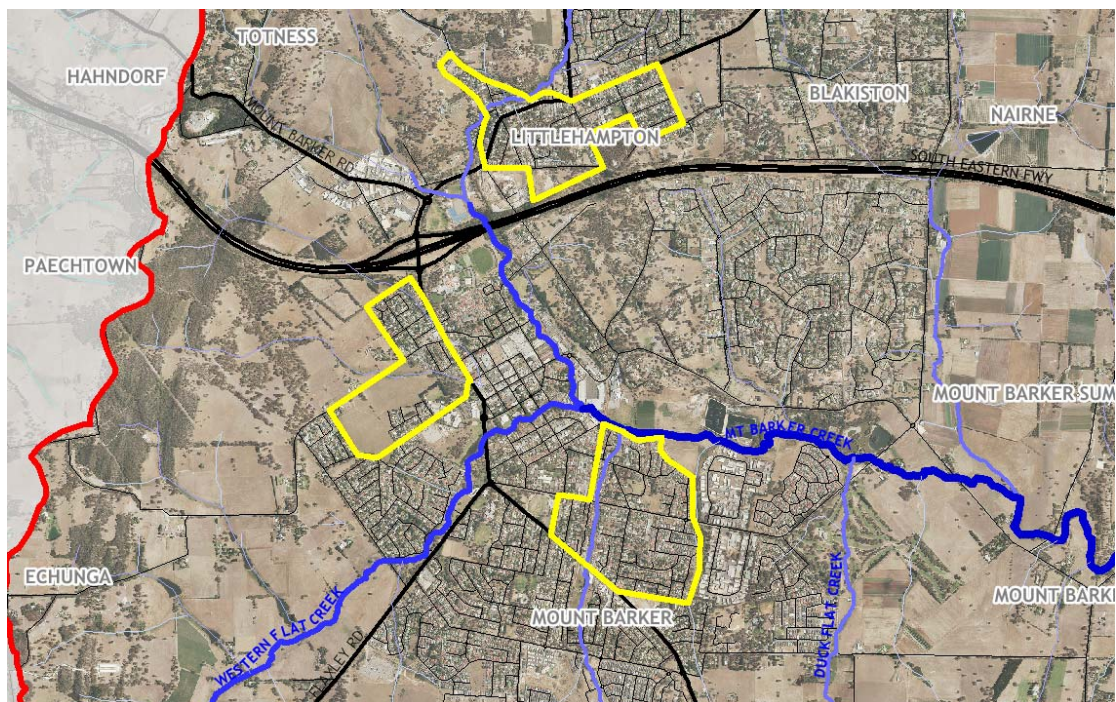


Figure 2.9 Potential Residential Infill Areas (DCMB, 2012b)

The District Council of Mount Barker currently requires new development to be undertaken in accordance with *Standards and Requirements for the Design, Construction and Development of Infrastructure Assets* (District Council of Mount Barker, 2007), which includes guidance on Council's requirements in relation to peak flow mitigation, water quality improvement, and connection to Council's drainage system.

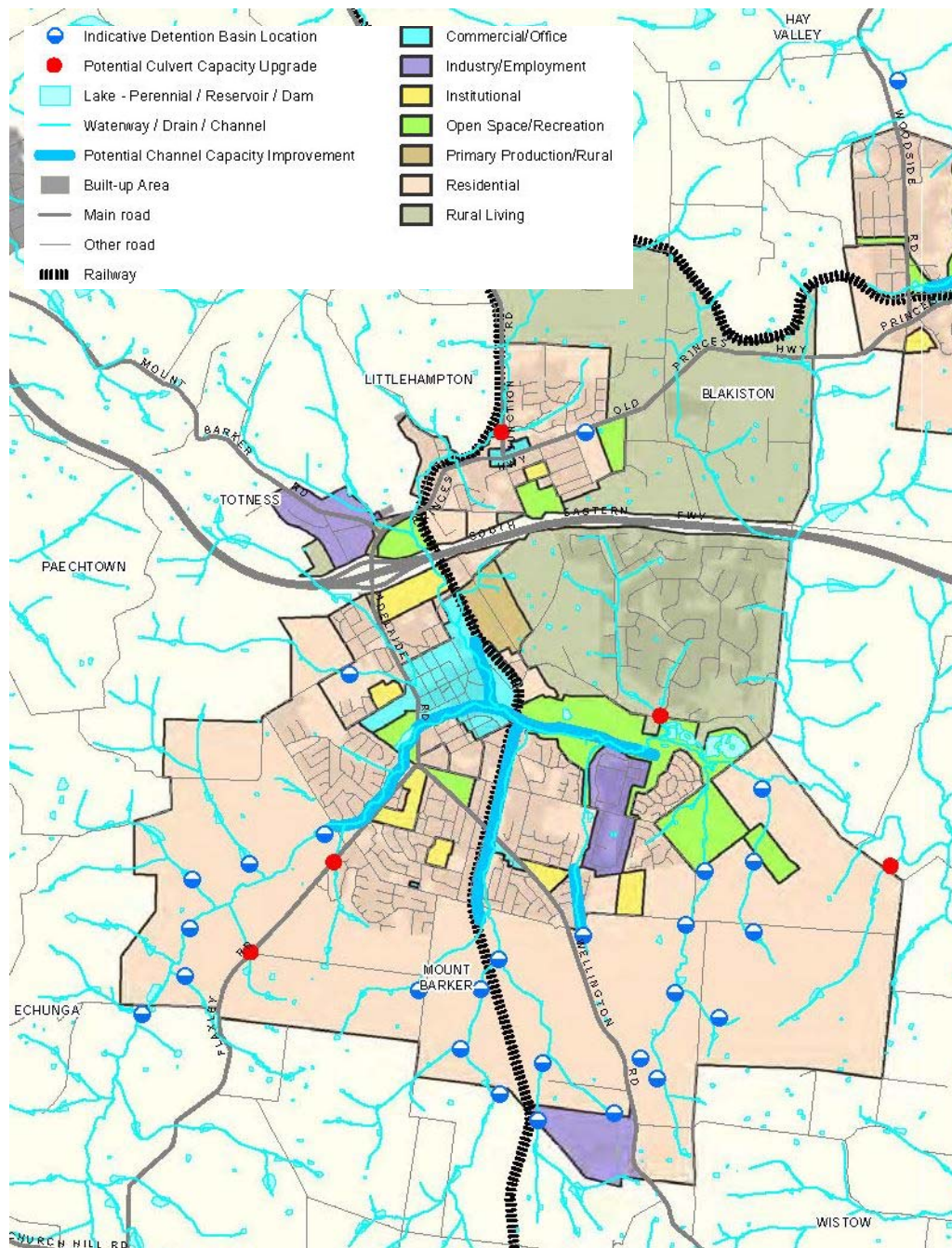


Figure 2.10 Stormwater Infrastructure Plan (DPTI & DCMB, 2014)

- District Council of Mount Barker (2015b), *Regional Town Centre DPA (For Consultation)* Council is currently in the process of updating its Development Plan to reinforce the Mount Barker town centre as the main retail, business and service centre in the greater Adelaide Hills. The DPA seeks to promote more residential development in the centre, including medium and higher density housing, and apartments built above commercial buildings.

The DPA seeks to achieve these changes without compromising the positive aspects of the character of the town and in balance with protecting historic buildings.

The policy changes in this DPA will affect the existing town centre zone and some adjacent areas, to achieve a final proposed structure as depicted in Figure 2.11.

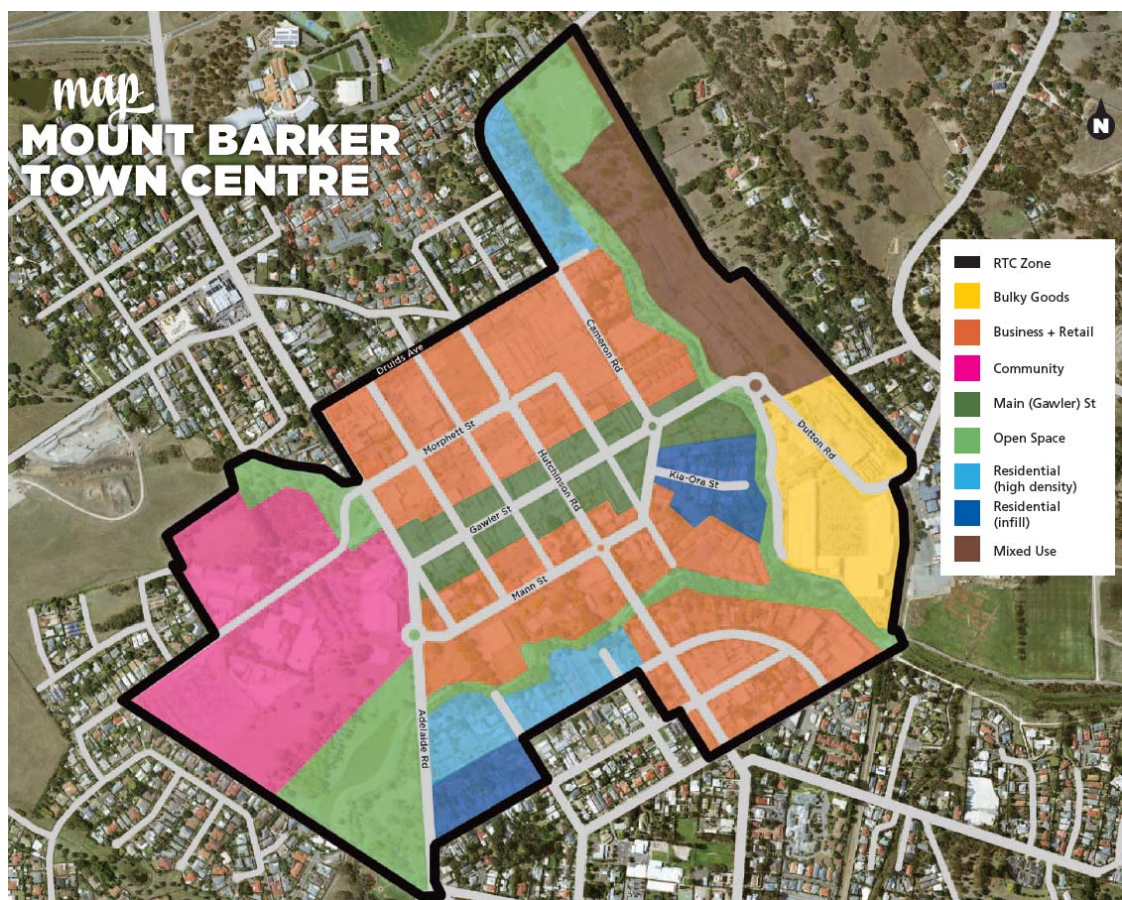


Figure 2.11 Regional Town Centre DPA Plan (DCMB, 2015b)

2.6 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 this would result in changes in levels of flood protection, stormwater drainage performance, and stormwater availability for harvesting and reuse.

A number of studies and assessments have attempted to improve the understanding of the likely changes to the South Australian climate brought about by climate change. This includes the *Resilient South Climate Change Scenarios* Report (SKM, 2013) undertaken for the southern Adelaide region and the *Climate Change in Australia* Commonwealth Government website which is maintained by the CSIRO and Bureau of Meteorology to provide updated national and regional information on how the climate may change to the end of the 21st century.

Annual average rainfall is projected to decrease throughout South Australia during the 21st century: by 2-5% by 2030 and by 5-20% by 2070. Some climate models suggest that average annual rainfall in the Adelaide region may decline by as much as 20-40% by 2070 (SKM 2013).

For the purposes of this Stormwater Management Plan, for the ultimate scenario, a 10% reduction of average annual rainfall compared to recent averages, has been assumed in the assessment of potential yield from any stormwater harvesting opportunities.

2.7 Rainfall

Average Annual Rainfall

Mount Barker has a climate that is generally cooler and wetter relative to Adelaide, due to its increased elevation.

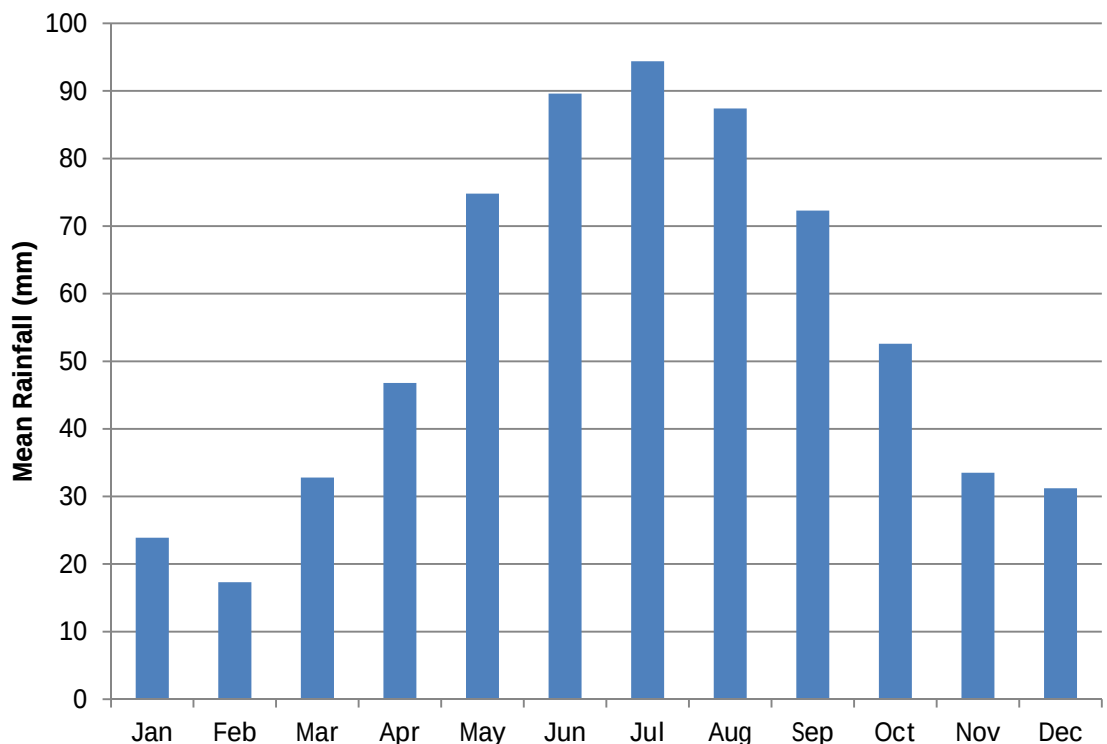


Figure 2.12 Mount Barker Monthly Rainfall Averages

Figure 2.12 displays the monthly averages for the Mount Barker rainfall gauge (No 023733) which has recorded an annual average (1861-2013) of 765mm.

Historical Rainfall Records

The Mount Barker catchment is occasionally impacted by heavy rainfall. The most significant (24 hour total) rainfall events on record (for the period 1861-2013) are summarised in Table 2.3 below.

Table 2.3 Highest Recorded 24 hr rainfall totals

Rank	Date	Rainfall ¹
1	10 April 1970	129.8
2	18 February 1946	129.3
3	9 February 1969	113.8
4	27 October 1963	97
5	25 January 1941	94.2
6	10 May 1911	81.5
7	27 April 1971	78.5
8	17 April 1938	77.7
9	16 March 1985	74.2
10	24 May 1958	73.9
11	17 April 1889	72.4
12	8 July 1993	70.2

¹ Bureau of Meteorology Data reported at the Mt Barker gauge 023733

Intensity-Frequency-Duration Data

Design Intensity Frequency Duration (IFD) data has been prepared for the Study Area at Mount Barker) utilising the (AR&R87) online procedure provided by the Bureau of Meteorology. This data is presented in Table 2.4 below.

Table 2.4 Mount Barker IFD Data (mm/hr)

Duration	Average Recurrence Interval (years)						
	1	2	5	10	20	50	100
5 mins	43.1	58.1	81	97.7	120	154	184
6 mins	40.2	54.2	75.5	90.9	112	143	171
10 mins	32.4	43.6	60.3	72.4	88.8	113	135
20 mins	22.9	30.7	42.1	50.3	61.5	78.2	92.5
30 mins	18.3	24.4	33.4	39.8	48.5	61.4	72.5
1 hour	12.2	16.3	21.9	25.9	31.3	39.4	46.2
2 hours	8.15	10.8	14.2	16.5	19.8	24.5	28.5

	Average Recurrence Interval (years)						
Duration	1	2	5	10	20	50	100
3 hours	6.46	8.46	11.0	12.7	15.1	18.5	21.4
6 hours	4.34	5.62	7.09	8.08	9.45	11.4	13.0
12 hours	2.88	3.7	4.57	5.14	5.95	7.09	8.02
24 hours	1.84	2.36	2.9	3.24	3.75	4.44	5.01
48 hours	1.12	1.44	1.78	1.99	2.3	2.73	3.09
72 hours	0.832	1.06	1.30	1.46	1.68	2.00	2.25

In early 2013, the Bureau of Meteorology released new Intensity-Frequency-Duration (IFD) design rainfalls as part of the revision of Engineers Australia's design handbook *Australian Rainfall and Runoff: A Guide to Flood Estimation*.

The new Intensity-Frequency-Duration (IFD) design rainfalls mark the first stage of this extensive revision project. While the new IFDs are derived from a longer and more extensive dataset, careful consideration is needed in relation to their application, prior to the release of further accompanying material. In particular, new temporal patterns are yet to be released that will define the distribution of these new intensity figures.

As such, this new IFD data has not been adopted for the purposes of hydrological modelling undertaken for this Stormwater Management Plan. However, the design rainfall intensities of the two datasets have been compared to assess the potential changes in flow estimates that may result from the future adoption of this emerging data.

The changes to the rainfall intensity data, by duration and ARI are shown in Table 2.5 below.

Table 2.5 Adjustment in IFD Values (Mount Barker - 1987 to 2013)

	Average Recurrence Interval (years)					
Duration	2	5	10	20	50	100
5 mins	3%	-1%	-2%	-6%	-10%	-14%
10 mins	-1%	-2%	-3%	-7%	-11%	-15%
30 mins	-5%	-6%	-6%	-9%	-13%	-15%
1 hour	-7%	-7%	-6%	-9%	-12%	-14%
2 hours	-8%	-7%	-5%	-7%	-9%	-10%
3 hours	-9%	-6%	-3%	-5%	-6%	-7%
6 hours	-10%	-5%	-1%	-1%	-1%	0%
12 hours	-10%	-3%	2%	3%	5%	6%
24 hours	-9%	-1%	5%	6%	7%	8%
48 hours	-5%	2%	7%	7%	8%	8%
72 hours	-2%	5%	9%	9%	8%	7%

These adjustments would suggest that:

- Performance standards for most drainage infrastructure (typically 5-10 year ARI, 15-30min critical duration) will improve slightly when assessed against the new IFD values
- High ARI long duration rainfall estimates (which dictate flood control dam storage requirements) are likely to increase slightly

6 minute Rainfall data

A search for historical rainfall data (with a 6-minute time step) was undertaken. This data is required for the purposes of water quality and stormwater harvesting / reuse modelling.

A suitable rainfall record is not available at Mount Barker, and hence nearby available records were sought with a similar representative annual total. The gauge record considered to be most representative of the Mount Barker area is the Macclesfield gauge (Station 023728, elevation 311mAHD). This gauge record has a long term annual average of 736mm.

The dataset spans from February 2004 to March 2010.

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

In recent years, 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 downstream receiving environmental impacts (Engineers Australia, 2006) and to mandate Water Sensitive Urban Design principles in new development (Department of Environment, Water and Natural Resources, 2013).

The State Government recently released its WSUD policy in *WSUD – Creating more liveable & water sensitive cities in South Australia* (DEWNR, 2013). The water quality improvement targets outlined in this document are:

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

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

3.3 SA MDB NRM Plan

The *Natural Resources Management Plan, Volume A | Strategic Plan* (South Australian Murray-Darling Basin Natural Resources Management Board 2014a) 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. The plan refers to goals and resource condition targets (the long-term outcomes sought) that provide direction for the management of natural resources in the SA MDB NRM region for the next 10 years.

The Strategic Plan is supported by the *Natural resources management plan, Volume B | Board business and operational plan* (South Australian Murray-Darling Basin Natural Resources Management Board, 2014b) which outlines how the Board will invest the money that it raises through levies and other funding sources over a 3 year period.

The targets relevant to stormwater management in the Mount Barker region (located within the “Eastern Hills” biophysical landscape, within the “Ranges to River” district area as defined within the Plan), are summarised in Table 3.1.

Table 3.1 SA MDB NRM Resource Conditions Targets (2009-2030) extract

Asset Class	Water
Vision	Water resources that are healthy, valued and supporting of communities and thriving ecosystems
Resource Condition Targets	W1: All water resources are managed sustainably by 2030
	W2: Improve water quality to meet regional water needs by 2030
	W3: Water is available and managed to enhance and maintain the ecological function and resilience of water dependent ecosystems by 2030

It is noted that the Plan provides little commentary specifically in relation to urban stormwater, but rather focusses on the broader water resources issues associated with:

- increasing number of farm dams, that have reduced the volume of water available for downstream users, including the environment
- significant aquatic habitats (including wetlands of international significance) along the entire length of the River Murray, Lower Lakes, Coorong and Murray Mouth
- overuse of groundwater and surface water resources for irrigation, stock and domestic use, leading to degradation of these water resources including salinisation and ecosystem decline

The Plan does note that pollution from stormwater (defined in the Plan as all surface water runoff and not just runoff generated from urban areas) represents a threat to the Water Asset Class.

3.4 Eastern Mount Lofty Ranges Water Allocation Plan

The purpose of a water allocation plan (WAP) is to provide for the sustainable taking and use of prescribed water resources to meet present and future water needs of the region. The *Notice of Intent* to prescribe water resources in the Eastern Mount Lofty Ranges (which include the entire Mount Barker Stormwater Management Plan area) came into effect on 16 October 2003. The water resources in the Eastern Mount Lofty Ranges were prescribed on 8 September 2005 in accordance with the *Natural Resources Management Act 2004*.

A series of objectives were developed for this water allocation plan (South Australian Murray-Darling Basin Natural Resources Management Board, 2013) that reflect the objects of the NRM Act and the role of the water allocation plan. These objectives are:

Allocation objectives

- Encourage efficient use of water resources in a sustainable manner.*
- Maintain the quantity and quality of water resources.*

- c) Maintain and where possible restore water-dependent ecosystems by providing their water needs.*
- d) Minimise impacts of taking and using water on the environment, prescribed water resources, other water resources and water users.*

Transfer objectives

- a) Enable the transfers of water allocations in a sustainable manner.*
- b) Maintain the quantity and quality of water resources.*
- c) Maintain and where possible restore water-dependent ecosystems by providing their water needs.*
- d) Minimise impacts of taking and using water on the environment, prescribed water resources, other water resources and water users.*

Water affecting activity objectives

- a) Maintain and where possible restore water-dependent ecosystems, by providing their water needs and addressing detrimental impacts from water affecting activities.*
- b) Protect aquifer structure and geomorphology of drainage paths, watercourses, lakes and floodplains.*
- c) Provide for equitable and sustainable sharing of water resources.*
- d) Protect water quality from deterioration.*
- e) Maintain hydrological and hydrogeological systems, including natural discharge and recharge between water resources.*
- f) Minimise interference between water users.*
- g) Minimise adverse impacts of water affecting activities on the environment, water resources and water users.*

Environmental water requirements objective

- a) Maintain and/or restore self-sustaining populations of aquatic and riparian flora and fauna which are resilient in times of drought.*

With respect to potential stormwater harvesting and reuse activities that might be considered by this Stormwater Management Plan, the WAP provides specific criteria for urban runoff allocations. Key criteria (a full list of which is presented in Section 5.2.4 of the WAP) include:

- urban runoff allocations under the Plan are only available under limited circumstances for urban development that has been approved and commenced since 16 October 2003, or from particular areas
- the maximum volume of an urban runoff allocation is urban runoff minus pre-development runoff and recharge from the area of the designated urban land use development
- changes in hydrology must be managed to match pre-development hydrology, as far as reasonably practicable
- an urban runoff allocation must not compromise the provision of water requirements of water-dependent ecosystems (such as local native fish populations of mountain galaxias) and existing consumptive users
- demonstration that these criteria will be met to the satisfaction of the Minister by a suitably qualified hydrologist or engineer

These criteria highlight that there is a significant water resource opportunity arising from the ongoing urban expansion of Mount Barker.

A permit may be required for certain water affecting activities as set out under the *Natural Resources Management Act 2004*, such as dam construction or enlargement, well drilling

and repair, some works in and around watercourses, commercial forestry, and using effluent or imported water in the course of carrying on a business. A water allocation plan, and also its parent regional natural resources management plan, can set out the principles to be used to assess permit applications and to place conditions on permits. This Plan contains Water affecting activity objectives in this regard, as listed in the objectives quoted above.

Further 'activity specific policies' are outlined in the Plan that apply to some water affecting activities in addition to the general objectives and principles expressed for all water affecting activities. With respect to 'water diversion and storage', the following specific principle is noted:

204. New dam capacity in addition to the limits set out in principles 182-201 may be allowed in the case where additional runoff is generated from an area as a result of designated urban land use development. Such new dam capacity may only be allowed where:

a) the maximum volume of dam capacity for an area of designated urban land use development is urban runoff minus pre-development runoff and recharge from the area of the designated urban land use development;

b) the pre-development runoff and recharge from the site is returned to the environment:

i) as close as reasonably practical to the natural flow path;

ii) as soon as reasonably practical following precipitation, unless detained on-site for water quality remediation and/or mitigation of flooding, in which case the pre-development runoff and recharge must be returned to the environment within three days of collection or diversion;

iii) in a manner that maintains the natural flow regime and aquifer recharge; and

iv) in a manner that does not cause significant detrimental impacts to the environment, including but not limited to erosion and detrimental impacts to stream bed and bank stability, demonstrated to the satisfaction of the relevant authority by a suitably qualified environmental engineer;

c) the time to peak flow matches that of the pre-development case, as far as reasonably practical, for up to the five year average recurrence interval event, provided this does not exacerbate downstream flooding (demonstrated to the satisfaction of the relevant authority by a suitably qualified hydrologist or engineer); and

d) the time to peak flow matches that of the pre-development case for the 5 year up to the 100 year average recurrence interval events, unless catchment wide benefits can be demonstrated, provided this does not exacerbate downstream flooding (demonstrated to the satisfaction of the relevant authority by a suitably qualified hydrologist or engineer).

3.5 Mount Barker Strategic Plan

The *Strategic Plan 2012-2017* (District Council of Mount Barker, 2012a) was adopted by Council in July 2012. Importantly, this plan was developed after the rezoning of large areas of farming land for residential development and hence contains an appropriate focus on priorities and directions in relation to this.

The Strategic Plan defines six 'strategic imperatives' as the high level goals of the plan. The strategic imperatives are:

- Economic development
- Urban growth
- Ecological footprint, climate change and environmental protection
- Social infrastructure
- Character and culture
- Governance and leadership

The document identifies a range of outcomes to be achieved within each strategic imperative and the performance measures and key objectives associated with each outcome.

Outcomes, performance measures and objectives outlined in this document that are relevant to stormwater management are summarised in Table 3.2.

Table 3.2 Mt Barker Strategic Plan extract

Outcome	Objective	Performance Measure
Strategic Objective: Urban Growth		
Outcome 3: The Mount Barker District is a leader in water management	3.1 Implement actions to progress Integrated Water Management Planning including creek management across the District	10 - Volume of treated wastewater and stormwater reused for human use and for environmental benefit 11 Level to which the use of River Murray water is maintained or reduced by volume per head of population
	3.2 Require Water Sensitive Urban Design Plans to be presented as a part of all development in accordance with Council and regional policy	9 Number of developments planned and constructed that can demonstrate they meet or exceed prescribed water sensitive urban design targets
	3.3 Engage with SA Water and relevant stakeholders to achieve the best outcomes to address the management of treated effluent and stormwater in Mount Barker, Littlehampton and Nairne through a growth areas water strategy	10 - Volume of treated wastewater and stormwater reused for human use and for environmental benefit 11 Level to which the use of River Murray water is maintained or reduced by volume per head of population

Strategic Objective: Ecological footprint, climate change and environmental protection		
Outcome 7: Reduced water consumption and protection of water dependent ecosystems	7.1 Develop a 'Water Sensitive City' campaign to promote and encourage Council and community efforts to manage water resources	21 Reduced reliance on River Murray water (Litres per resident)
	7.2 Increase planning and operational effort for the protection, restoration and maintenance of local watercourses and associated revegetation areas	22 Health of local waterways

3.6 Mount Barker Stormwater Infrastructure Plans and Guidelines

As described in Section 2.5, planning and design of existing and new stormwater infrastructure is currently guided by:

- *Stormwater Drainage Asset Management Plan* (District Council of Mount Barker, 2008)
- *Mount Barker, Littlehampton and Nairne Strategic Infrastructure Plan* (Department of Planning, Transport and Infrastructure & District Council of Mount Barker, 2014)
- *Standards and Requirements for the Design, Construction and Development of Infrastructure Assets* (District Council of Mount Barker, 2007)
- *Mount Barker Development Plan* (Department of Planning, Transport and Infrastructure, 2013)

The *Stormwater Drainage Asset Management Plan* describes how Council applies management, financial, economic, engineering and other practices to its stormwater assets with the objective of providing the required level of service in the most cost effective manner. This Plan notes that a Community Satisfaction Survey (conducted by the Local Government Association) found that Mount Barker achieved a score of 6.15 (out of 10) for 'Performance in providing & maintaining storm drainage facilities', compared to a State Average score of 6.30. The below average score suggests there may be room for improvement in management of the existing stormwater system.

The *Mount Barker, Littlehampton and Nairne Strategic Infrastructure Plan* is high level in nature and makes reference to the preparation of this Stormwater Management Plan as a requirement to identify the required future stormwater actions, strategies and priorities.

The *Standards and Requirements for the Design, Construction and Development of Infrastructure Assets* provide some specific design requirements for new infrastructure, which include:

- 10 year ARI minor system and rear-of-allotment drain design standard
- 100 year ARI major system design standard
- Minimum floor levels for all building development to be a minimum of 300mm above the 100 year ARI flood level
- Minimum drain sizes and gradients and required specifications associated with structures
- On-site detention to ensure runoff does not exceed pre-development rates, with flexibility for no detention where the applicant can demonstrate it is not required
- Guidance on water quality improvement measures, when deemed required by Council

The Mount Barker Development Plan contains the Better Development Plan (BDP) module for Water Sensitive Urban Design which, among others, includes the following principles:

Water Sensitive Urban Design

10 Water discharged from a development site should:

- (a) be of a physical, chemical and biological condition equivalent to or better than its pre-developed state*
- (b) not exceed the rate of discharge from the site as it existed in pre-development conditions.*

11 Development should include stormwater management systems to protect it from damage during a minimum of a 1-in-100 year average return interval flood.

12 Development should have adequate provision to control any stormwater over-flow runoff from the site and should be sited and designed to improve the quality of stormwater and minimise pollutant transfer to receiving waters.

13 Development should include stormwater management systems to mitigate peak flows and manage the rate and duration of stormwater discharges from the site to ensure the carrying capacities of downstream systems are not overloaded.

14 Stormwater management systems should preserve natural drainage systems, including the associated environmental flows.

15 Development should include stormwater management systems to minimise the discharge of sediment, suspended solids, organic matter, nutrients, bacteria, litter and other contaminants to the stormwater system.

16 Stormwater management systems should preserve natural drainage systems, including the associated environmental flows.

17 Stormwater management systems should:

- (a) maximise the potential for stormwater harvesting and re-use, either on-site or as close as practicable to the source*
- (b) utilise, but not be limited to, one or more of the following harvesting methods:*
 - (i) the collection of roof water in tanks*
 - (ii) the discharge to open space, landscaping or garden areas, including strips adjacent to car parks*
 - (iii) the incorporation of detention and retention facilities*
 - (iv) aquifer recharge.*

18 Where it is not practicable to detain or dispose of stormwater on site, only clean stormwater runoff should enter the public stormwater drainage system.

19 Detention basins should be designed and constructed to allow sediments to settle, prior to discharge.

3.7 SMP Objectives

The consolidated objectives adopted to guide the development of this Stormwater Management Plan are summarised in Table 3.3 below. These objectives have been addressed in this Stormwater Management Plan in the corresponding Sections that follow.

Table 3.3 Mount Barker SMP Objectives

Objective (SMP Report Section)	Strategic Link	Goal
Provide an acceptable level of stormwater drainage service to the community (Section 5)	DCMB, 2008 & DCMB, 2007	Achieve Community Satisfaction Survey Level that at least equal to the State Average if not better
Provide an acceptable level of flood protection to the community (Section 6)	MB Obj 7.2, Dev Plan, DCMB 2007	Protect development from above floor inundation from all events up to and including the 100 year ARI event. Ensure any works in watercourses protect and/or restore local biodiversity
Improve the quality of runoff and reduce the impact of stormwater on the local receiving waters and downstream watercourse environment (Section 7)	MB Obj 3.2, 7.1, Dev Plan, NRM W2, W3, State WSUD Obj	Ensure measures are incorporated into new developments such that pollutant loads discharged achieve reduction levels as follows: • Suspended solids 80% • Phosphorous 60% • Nitrogen 45% • Gross Pollutants 90% Identify opportunities to retrofit measures across existing developed areas to incrementally achieve similar overall pollutant reduction levels
Make beneficial use of stormwater runoff generated by new development (Section 8)	MB Obj 3.1, 3.3, Dev Plan, WAP, NRM W1	Identify viable regional scale opportunities to harvest a large proportion of stormwater generated by new and recent development for reuse Identify site-level opportunities for beneficial on-site reuse
Sustainable management of stormwater infrastructure, including watercourse rehabilitation, protection and maintenance (Sections 6, 7, 8)	MB Obj 7.1, 7.2, NRM W3	Relevant stakeholders including District Council of Mount Barker, SA MDB NRM Board and DEWNR to be in alignment at all stages of planning, designing, constructing, managing and maintaining natural and built infrastructure along the creek corridors Stormwater infrastructure will be resilient in consideration of the likely impacts of climate change. Ensure appropriate monitoring and watercourse management plans are developed to maintain infrastructure and public safety

Achieve desirable planning outcomes associated with new development and management of open space (Sections 7, 8)	Dev Plan	Integrate enhanced water quality improvement, natural creek protection goals into Council development requirements.
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4 Catchment Hydrology

4.1 Background

The hydrology of the Mt Barker Creek catchment has previously been comprehensively investigated to support the development of the *Mt Barker Floodplain Mapping Study* (AWE, 2011), as reported separately in *Mount Barker Floodplain Mapping Hydrological Study Report* (AWE, 2010). The hydrology and the flood plain mapping presented in this previous Study (which reflects the “existing development” catchment scenario) forms part of this Stormwater Management Plan.

Since the completion of this Study, there has been a significant extension of the urban growth boundary for Mt Barker. This additional urban area was not allowed for in the 2011 floodplain mapping hydrology or associated floodplain maps. In order for this Stormwater Management Plan to provide a strategic direction to manage this future development and to evaluate the effectiveness of proposed strategies, further hydrological investigations and flood plain mapping has been undertaken to support the development of this Stormwater Management Plan.

4.2 Hydrological Model Selection

A regional hydrological model of the Mount Barker Creek catchment is required in order to:

- Provide flow hydrographs at locations of interest as inputs for flood plain modelling of additional areas (described in Section 6)
- Evaluate the effectiveness of a regional detention basin strategy, such as the one shown in Figure 2.10, which nominates approximately 20 detention basins distributed across the catchment

Further, the hydrological model needs to be sufficiently flexible so as to allow for adjustments to be made to catchment characteristics, to reflect changing proportions of rural and urban land use.

For the purposes of the previous Study, a RORB hydrological model of the catchment was developed and calibrated to a flow gauging station on Mount Barker Creek located downstream of the Mount Barker township. The calibrated model successfully produced design flow hydrographs for the purposes of flood plain mapping.

In adapting the model to reflect a future urban growth scenario, a more complex modelling approach was adopted which consisted of a RORB model representing most of the ‘static’ catchment areas and six separate DRAINS models representing various new urbanised catchment areas. These hydrological models are separate models, and consequently assessment of the combined catchment hydrology, as is now required for this Stormwater Management Plan, would require considerable additional effort. This process is considered to be inefficient, particularly for the purposes of developing and evaluating future strategies which require numerous model iterations.

A single hydrological model for the entire Mount Barker Creek catchment is now considered to be desirable, that:

- allows for a regional detention basin strategy to be considered and evaluated in a more efficient manner
- provides flow hydrograph inputs as required for floodplain modelling purposes
- provides Council with a useful tool to maintain and revise over time as land developments proceed

- is as consistent as reasonably practicable with the subcatchment delineation, subcatchment parameters and calibrated results of the previous model

The DRAINS modelling platform was selected as the hydrological model for this purpose. While DRAINS is typically regarded as an urban hydrological model, it provides the functionality to model specified subcatchments and drain reaches with other hydrological models such as RORB, which makes it suitable for modelling catchments with a mix of land uses.

4.3 DRAINS Model Establishment

4.3.1 Model Structure

The subcatchment delineation as prepared for the 2010 hydrology was adopted as the basis from which further refinement was undertaken. This refinement included:

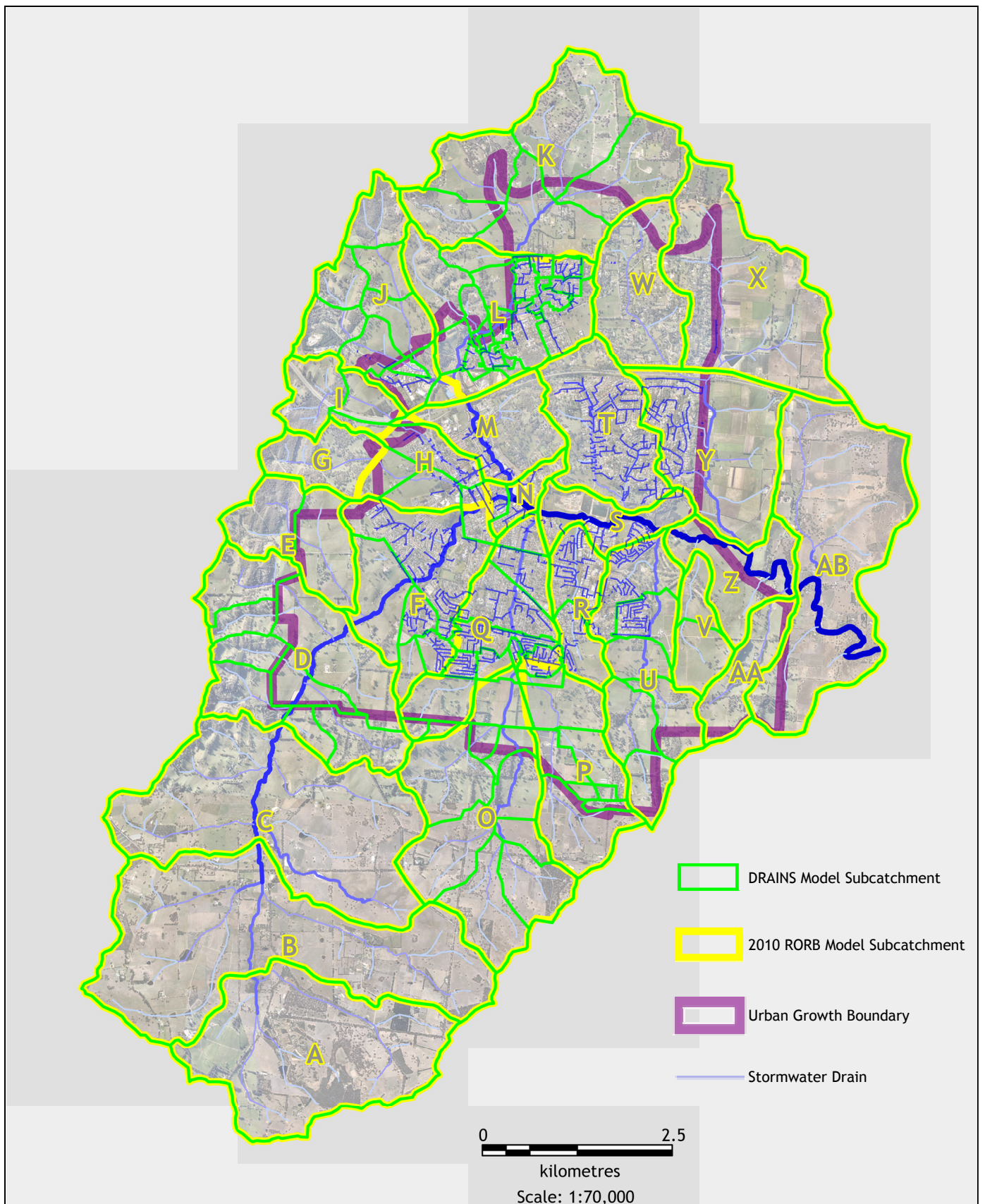
- Further delineation of some RORB subcatchments, such that at locations where flow hydrographs are to be extracted for flood plain mapping purposes, the upstream catchment is divided into at least three to four subcatchment areas
- Amendments (generally of a minor nature) of some catchment boundaries
- Division of subcatchments in a manner such that there is a delineation generally along the urban growth outer boundary, to readily facilitate changes in the model to reflect catchment land use associated with the future urban growth scenario

Hydrographs from a number of rural subcatchments were nominated within the DRAINS model to be calculated using the RORB hydrological model (with a 0% impervious fraction). These areas included the upper reaches of:

- Western Flat Creek;
- Littlehampton Creek;
- Railway Creek; and
- all of the rural living zoned area north of Mount Barker Creek

Hydrographs from the residential catchments were nominated within the DRAINS model to be calculated using the ILSAX hydrological model. Runoff coefficients (impervious fractions) were assigned according to the corresponding 2010 RORB subcatchment value where the area was largely unchanged, or via assessment of aerial photography for the more finely divided subcatchments created for this model. The model subcatchments and corresponding hydrological model applied for the existing scenario, along with the 2010 RORB model subcatchments, is shown in Figure 4.1.

All drain reaches connecting the RORB subcatchment areas were established as RORB 'natural' drain reaches. RORB 'natural' drain reaches were also specified for all main watercourse reaches downstream of these upper rural areas. The DRAINS model diagram is shown in Figure 4.2, in which the RORB drain reaches are represented as a dashed line.



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Data Sources:
District Council of Mount Barker (Drains, Aerial), DEWNR
(Watercourses), AWE (RORB Catchments), Southfront (DRAINS
Subcatchments)

Mount Barker, Littlehampton & Totness Stormwater Management Plan

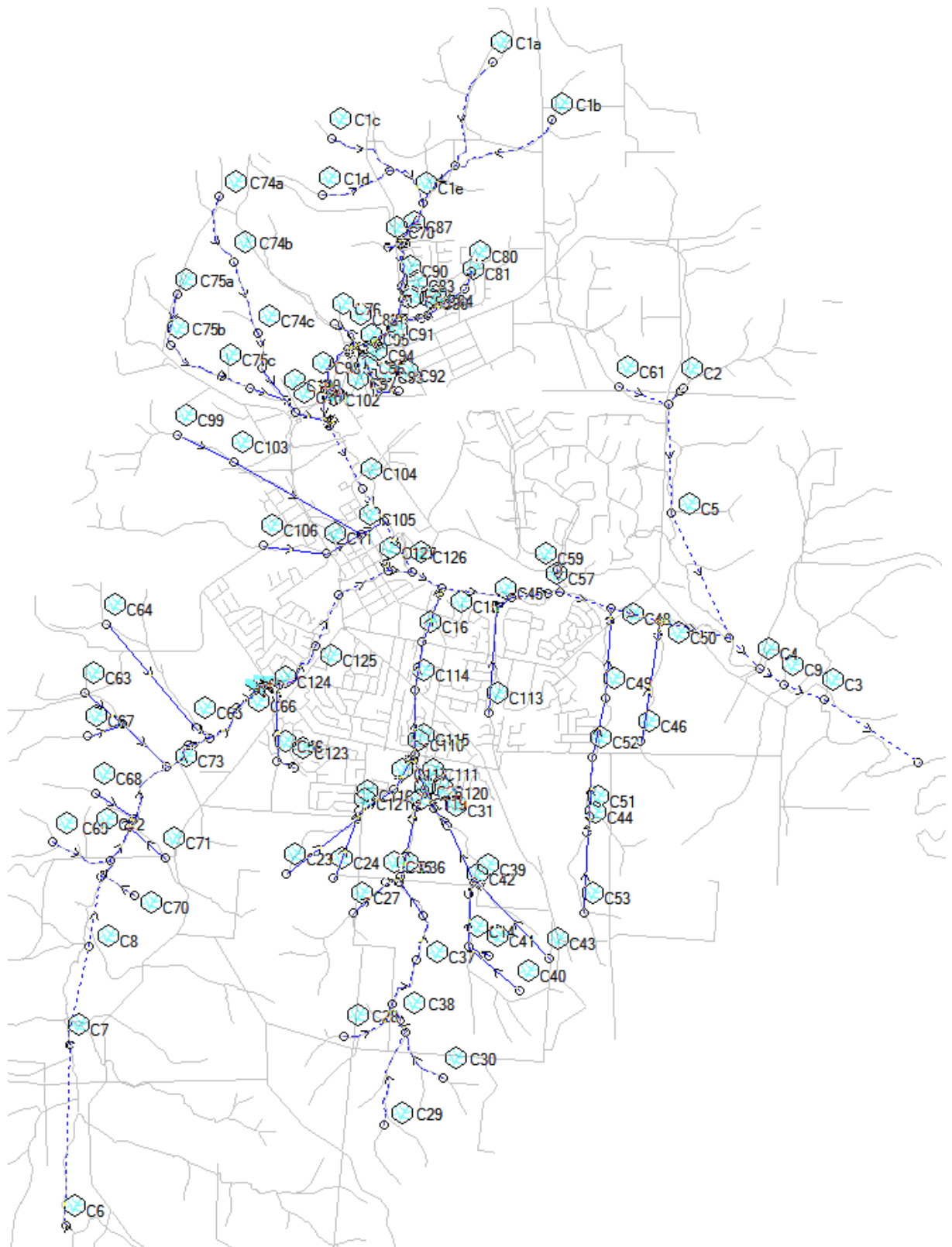


Figure 4.2 Mount Barker DRAINS Model Diagram

4.3.3 Loss Model Values

The calibration of the 2010 RORB model was achieved with the following model parameters:

- $k_c = 10.3$
- $m = 0.8$
- Initial Loss = 39.5mm (100 year ARI event)
- Continuing loss = 1.54 mm/hr

These parameters were retained for the RORB hydrological model within DRAINS. The initial loss was subsequently increased to 43mm in order to achieve a satisfactory comparison with the 2010 results, presented in Section 4.4.

The ILSAX hydrological model within DRAINS adopted the following model parameters:

- Impervious area initial loss = 1mm
- Supplementary paved area initial loss = 1mm
- Pervious Area initial loss = 45mm, Continuing Loss 2mm/hr

4.4 Existing Peak Flows

The DRAINS model developed for this Stormwater Management Plan has been executed for a range of design rainfall events. While a reasonable match (for both peak flow rate and flow volume) was achieved by adjusting the initial loss, the DRAINS model reported a 12 hour critical duration for peak flow rates for all ARI (with the exception of the 500 year ARI), instead of 9 hours as produced by the 2010 hydrological modelling. Key results from the model have been summarised at the Mount Barker Creek gauging station (DEWNR Gauge No A4260557), located downstream of Mount Barker at the downstream end of the catchment shown in Figure 4.1. These results have been compared with the corresponding results reported by the 2010 hydrology, as presented in Table 4.1 and Table 4.2 below.

Table 4.1 Mt Barker Creek Peak Design Flows, Critical Duration

ARI (years)	Peak Flow, Duration (m ³ /s)	AWE (2010) (m ³ /s)
20	61.3 (12 hr)	58.6 (9 hr)
50	86.8 (12 hr)	77.6 (9 hr)
100	123 (12 hr)	117.8 (9 hr)
500	219 (9 hr)	246.5 (9 hr)

Table 4.2 Mt Barker Creek Design Storm Event (9hr duration) Flow Volume

ARI (years)	Flow Volume (ML)	AWE (2010) (ML)
20	1580	1710
50	2240	2140
100	3050	3020
500	5240	5740

Table 4.3 Initial Loss to Match 2010 Hydrology

ARI (years)	AWE (2010) (mm)	RORB Areas (mm)	ILSAX Areas (mm)
20	29.8	38	38
50	38.1	42	45
100	39.5	43	45
500	45	45	45

4.5 Ultimate Development Peak Flows

As described in Section 2.5, there is a high likelihood that substantial development will occur within the current planning horizon that will result in land use changes in a number of areas within the area of this Stormwater Management Plan.

The DRAINS model developed for this Stormwater Management Plan has been revised to reflect these proposed changes in order to estimate the changes in peak flow rates at locations of interest.

Key hydrological modelling parameters used in these changes include:

- 55% and 10% values for directly and indirectly connected impervious fractions in future residential land development areas
- 80% directly connected impervious fractions for future industrial development areas
- Minimum 45% and 10% values for directly and indirectly connected impervious fractions in existing residential areas where infill development is anticipated to occur

The changes in 100 year ARI peak flow rates (assuming no mitigation strategies are implemented) are summarised in Table 4.4. These results show that in some catchments, the increased urbanisation is leading to a dramatic increase in peak flow rates generated by the short duration (1.5 hour) event, associated with runoff generated from these urban areas. In some locations, these short duration events will produce peak flows that exceed the long duration (6 hour) events that currently produce the peak flow rates within many of these creek systems.

Table 4.4 Existing, Ultimate Creeks 100 yr ARI Peak Flow Comparison

Location	Existing Peak Flow (m ³ /s)	(Unmitigated) Ultimate Peak Flow (m ³ /s)
Western Flat Creek (at Bollen Rd)	55.8 (6 hr)	57.7 (6 hr)
Railway Creek (at Hurling Dve)	23.4 (6 hr)	28.3 (1.5 hr)
Duck Flat Creek (outfall to Mt Barker Ck)	9.5 (6 hr)	21.7 (1.5 hr)
Railway Creek (outfall to Mt Barker Ck)	26.5 (6 hr)	34.1 (1.5 hr)
Golf Course Creek (outfall to Mt Barker Ck)	3.0 (6 hr)	8.9 (1.5 hr)
Littlehampton Creek (at Cleggett Rd)	19.2 (6 hr)	19.9 (6 hr)
Mt Barker Creek (below confluence of Western Flat Creek, Littlehampton Creek)	87.1 (6 hr)	91.5 (6 hr)
Mt Barker Creek (Gauge A4260557)	123 (12 hr)	134 (12 hr)

5 Stormwater Drainage Infrastructure

5.1 Modelling Approach

The performance of the existing stormwater drainage infrastructure was assessed using the DRAINS modelling platform.

As described in the model documentation (Watercom, 2011), DRAINS is a multi-purpose Windows program for designing and analysing urban stormwater drainage systems and catchments. DRAINS can model drainage systems of all sizes, from small to very large (up to 10 km² using subcatchments with ILSAX hydrology) and greater using storage routing model hydrology. 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. It includes two automatic design procedures for piped drainage systems and also connections to CAD and GIS programs.

The parameters developed to establish the model are described in detail below.

5.1.1 Drainage Data

The GIS based stormwater drainage data provided by Council formed the basis of the drainage data for this model. A number of modifications were made in order to prepare this data into a form that would be suitable for a DRAINS model. These changes included:

- Rationalisation of arc and polyline drain elements into single line segment elements
- Snapping end points of connecting drain segments together, and connecting nodes to drain end points
- Assignment of surface levels to all inlet / junction box nodes, using the Digital Terrain Model information
- Generation of drain invert data through the generalised assumption of 600mm cover to all drains with a positive drain grade
- Completion or confirmation of drain size data (few in number) through referral to available construction drawings
- Addition of drainage systems at the intersection of North Terrace and Junction Road through referral to construction drawings

As part of the minor drainage system assessment creeks and other waterways were omitted with only piped networks modelled.

Detention/retention basins that did not operate in line with the minor drainage system were omitted from the analysis.

5.1.2 Urban Catchment Areas

The study area is comprised of four different sub-areas:

- Littlehampton – almost exclusively residential development with some commercial land-use along North Terrace
- Totness – commercial and industrial development types
- Mt Barker Rural Living – exclusively residential
- Mt Barker Hurling Drive Developments – exclusively residential

Sample areas were selected for an assessment of impervious site coverage from each of the previously mentioned sub-areas (excluding Totness). These areas are shown in Figure 5.1. Impervious site coverage for the Totness region was estimated on an individual subcatchment basis from aerial photography.

The results of the analysis are summarised in Table 5.1.



Figure 5.1 Impervious fraction investigation – sample areas

Table 5.1 Impervious fraction investigation results

Sub-area	Percentage Impervious (%)	Percentage Pervious (%)
Mt Barker – Hurling Drive	65	35
Mt Barker – Rural Living	25	75
Littlehampton	37	63

In determining the split of this fraction between directly connected and indirectly connected impervious fractions, consideration was given to Study Area characteristics including:

- the Study area is largely comprised of recent developments, hence a higher proportion of houses can be assumed to have 'conventional' drainage systems with direct connection to the street; and
- the Study area is reasonably steep, with a reasonable proportion of rear-of-allotment drainage, which again emphasises that a higher proportion of houses can be assumed to have 'conventional' drainage systems with direct connection to the Council drainage system.

The catchment characteristics for a 'typical' residential subcatchment for each of the previously mentioned sub-areas (excluding Totness) are summarised in Table 5.2. These values have been varied on an individual subcatchment basis, where varying land uses are identified via aerial photography. Allowance has been made for future development by applying the catchment characteristics outlined below to parcels of land that were deemed to form part of future development.

Table 5.2 Typical catchment characteristics applied to each sub-area

Sub-area	Directly Connected Impervious (%)	Indirectly Connected Impervious (%)
Mt Barker – Hurling Drive	60	5
Mt Barker – Rural Living	20	10
Littlehampton	30	10

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

- paved = 1 mm
- supplementary paved = 1 mm
- grassed = 45 mm

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

5.1.3 Overflow Paths

Flow paths, defining the destination and travel time for overflow spilling from one inlet to the next, were assigned for all inlets based on digital terrain model (DTM) information.

5.1.4 IFD Rainfall Data

Design Intensity Frequency Duration (IFD) data as presented in Table 2.4 has been utilised as the design rainfall data for the DRAINS model.

5.2 Existing Drainage Performance

5.2.1 'Area A' and Area 'C' Assessment

Existing drainage performance assessments have been completed for some portions of the study area and the associated reports and mapping that was produced by these assignments (Tonkin Consulting, 2013 and SMEC, 2013) form part of this Stormwater Management Plan.

The balance of the urban drainage network was assessed as part of this study, as illustrated in Figure 5.2 along with 'Area A' (Tonkin Consulting, 2013) and 'Area C' (SMEC, 2013).

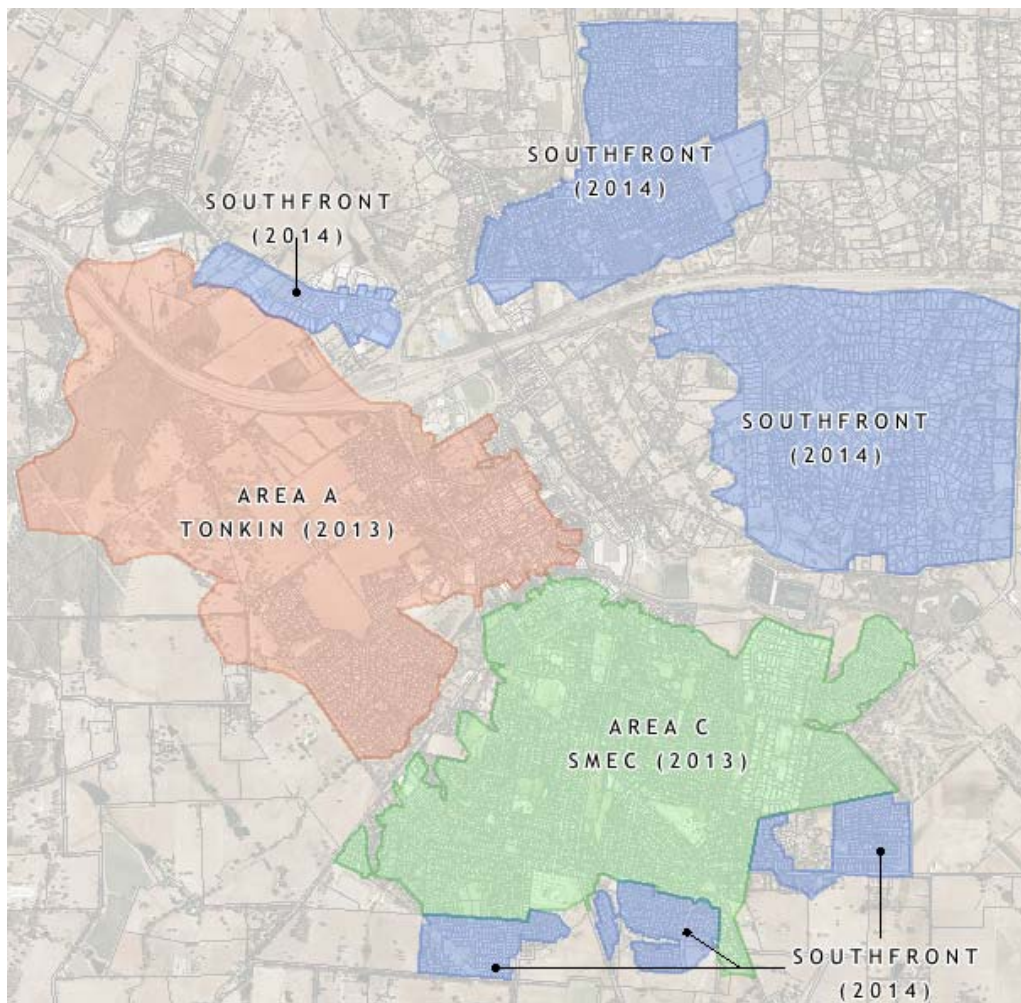


Figure 5.2 Minor Network Assessment Extents

5.2.2 Remaining Areas Assessment

A DRAINS model of the existing drainage system of the remaining areas (the blue areas highlighted in Figure 5.2) was executed for the 1, 2, 5, 10, 20, 50 and 100 year ARI storm events. Drainage system 'failure' was defined as occurring whenever the hydraulic grade line level results in a free board within the upstream pit of less than 150 mm. It should be noted that it is generally desirable for underground drainage networks to achieve performance standards of a 5 year ARI.

5.2.3 Minor Network Performance Summary

The DRAINS model of the existing drainage system has been executed for the 1, 2, 5, 10, 20, 50 and 100 year ARI storm events.

The performance standard (i.e. the corresponding ARI beyond which exceedance of the pipe reach is reported to occur) is illustrated in the plans presented in Appendix A. These plans also include the drainage performance standard data arising the SMEC and Tonkin studies to provide a performance summary across the entire network.

The capture capacity of the existing side entry pits was also assessed by analysing the magnitude of the 2 year ARI and 5 year ARI approach flows to individual pits. Overland flood flow paths within the urban network were also analysed for the 10 and 100 year ARI events. Plans in Appendix B (for the 'remaining areas' Southfront model area as depicted in Figure 5.2) show:

- Stormwater inlets with varying 2 / 5 year ARI approach flows, categorised according to multiples of 75 L/s, which is equivalent to the maximum flow rate at which a standard double side-entry pit (on a road with 1% longitudinal grade) will achieve 100% capture
- Overland flood flow paths (categorised according to nominal flow rate bands) in the urban areas

Table 5.3 lists the stormwater network issues arising from all of the assessments undertaken across the urban area. The reference 'ID' number corresponds to the upgrade works item 'ID' number in subsequent sections.

The consequences of low capacity systems with a design standard lower than the desirable 5 year standard, will not necessarily result in the flooding of property. It may only result in nuisance flooding of roadways in certain ARI events. Of the drains shown with insufficient performance standard, many will likely only result in higher and wider gutter flows, potentially leading to short-term localised flooding of roads and nature strips. However, there is particular concern for systems that when the drainage capacity is exceeded, have overland flow paths through private property.

A number of overland flow paths were identified as not being ideal for the safe conveyance of overflows when the drain or pit inlet capacity are exceeded (i.e. pit overflows or bypasses pass through residential properties or other unsuitable areas). These overland flow paths occurred when pits were located within a depression or at the end of a cul de sac and were identified using the digital terrain model. These locations are also combined in the list presented in Table 5.3.

Table 5.3 Minor Drainage Network, Low Performance Issues

ID	Project / Activity	Issue
	Totness	
1	Crompton Road/Follett Close/Mt Barker Road	Pipe Capacity, Overland Flow Path through Commercial

ID	Project / Activity	Issue
		Development
	Littlehampton	
2	North Terrace	Pipe Capacity
3	West Terrace/Junction Road	Pipe Capacity/Inlet Capacity/Lack of Drainage
4	Fulford Terrace to Benjamin Gray Drive	Pipe Capacity/Inlet Capacity
5	Baker Street	Pipe Capacity/Inlet Capacity
6	Spring Park Drive	Inlet Capacity
7	Saint James Drive/Edson Court/Gum Tree Drive	Pipe Capacity/Inlet Capacity
44	Junction Road Culvert	Pipe Capacity
45	Clems Road	Lack of Drainage
46	North Terrace	Lack of Drainage
	Mount Barker (Area A)	
14	Wilkinson Court	Inlet Capacity
15	Cook Court	Inlet Capacity
16	Apollo Street	Inlet Capacity
17	Hill Street	Inlet Capacity
18	Hawthorn Road/Adelaide Road	Inlet Capacity
19	Pridmore Terrace/Hutchinson Street	Pipe Capacity/Inlet Capacity
20	Cameron Road/Gollan Circuit	Inlet Capacity/Lack of Drainage/Pipe Capacity
21	Walker Street/Gawler Street/Mann Street	Pipe Capacity/Inlet Capacity
22	Hutchinson Street	Inlet Capacity
23	Morphett Street/McLaren Street	Inlet Capacity
24	Gawler Street	Inlet Capacity
25	Maurice Road/Wuttke Road/Allen Avenue/Bollen Road	Pipe Capacity
26	Cameron Street/Druids Avenue	Inlet Capacity/Pipe Capacity
49	Hawthorn Road Culvert	Creek Culvert Capacity
	Mount Barker (Area C)	
27	Light Crescent/Secker Road	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve
28	Daw Avenue/Netley Street/Howard Close/Grivell Street/Craig Terrace	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve
29	Phillip Street/Princes Road/Edward Street/Hughes Street	Pipe Capacity/Inlet Capacity/Lack of Drainage

ID	Project / Activity	Issue
		Reserve
30	Wunderley Drive/Victoria Road/Wiland Street	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve
31	Albert Road (between Alexandrina Road & Wellington Road)	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve
32	Oborn Road	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve
34	Sims Road	Inlet Capacity/Lack of Drainage Reserve
35	Hack Street	Inlet Capacity/Pipe Capacity
36	Newland Street	Inlet Capacity/Pipe Capacity
37	Hutchinson Street/Victoria Crescent	Inlet Capacity/Pipe Capacity/High River Level
38	Alexandrina Road	Pipe Capacity/Inlet Capacity
39	Exhibition Road/Fletcher Road	Inlet Capacity
40	Madion Street/Wellington Road/Alexandrina Road	Inlet Capacity/Pipe Capacity
41	Stephenson Street	Inlet Capacity/Pipe Capacity
42	Lewis Avenue/Barton Circuit	Inlet Capacity/Pipe Capacity
43	Albert Road	Pipe Capacity
47	Wellington Road (North Railway Terrace)	Lack of Drainage
48	Wellington Road (South Railway Terrace)	Lack of Drainage
50	Bernhardt Court	Backflow from creek
	Mount Barker (Other)	
8	Barrow Court/Durham Court	Pipe Capacity
9	Pontiac Road	Pipe Capacity/Inlet Capacity
10	Sheridan Court	Pipe Capacity
11	Claret Ash Parade	Inlet Capacity
12	East Parkway/Lawson Street/Majestic Drive	Pipe Capacity/Inlet Capacity
13	Hallmark Road	Inlet Capacity

5.4 Target Performance Standard

The following performance standards have been adopted in scoping stormwater infrastructure upgrade works:

- 10 year ARI minor drainage standard in the 'Regional Town Centre' Development zone area, and all future urban growth areas, including recently completed residential development stages south of Hurling Drive
- 5 year ARI minor drainage standard in all other urban areas
- 100 year ARI major drainage standard to all areas. In the absence of an overland flow path of sufficient capacity, this may be achieved through an increased capacity underground drainage system with suitable allowance for blockages

5.5 Action Summary

A consolidated summary of stormwater infrastructure deficiencies across the study area as identified by the assessments described in Section 5.2 (including those identified in Tonkin Consulting, 2013 and SMEC, 2013) and nuisance hotspots reported by Council staff is presented in Table 5.4.

Each issue has been prioritised, broadly as follows:

- High priority – Existing deficiency gives rise to risk of property inundation for events up to and including a 100 year ARI event (i.e. there is not a suitable overland flow path to protect existing development)
- Medium priority – Existing deficiency gives rise to excessive nuisance flows that are likely to result in disruption of traffic activity / complaints to Council
- Low priority – Existing minor drainage deficiency where current performance is less than target standard as nominated in Section 5.3

The scope of the proposed infrastructure works is also described and is further illustrated in plans presented in Appendix C. It is noted that none of these identified works packages are of a sufficient scale to meet eligibility criteria for Stormwater Management Authority funding support.

Table 5.4 Stormwater Infrastructure Action Summary

ID	Project / Activity	Suburb	Issue	Priority	Budget Estimate	Design ARI, Description
1A	Follett Close to Mt Barker Road (App C Sht 2)	Totness	Pipe Capacity/Overland Flow Path through Commercial Development	H	\$330,000	100 year ARI – High capacity drain from Follett Close discharging to Mount Barker Road.
1B	Mount Barker Road (App C Sht 2)	Totness	Pipe Capacity/Lack of Drainage	L	\$140,000	5 year ARI – Extend existing drain up Mount Barker Road to meet outfall of high capacity drain, provide drainage of Mt Barker Road.
2	North Terrace (App C Sht 3)	Littlehampton	Pipe Capacity	M	\$60,000	5 year ARI - Increase drain capacity through to creek outfall.
3A	Junction Road (App C Sht 3)	Littlehampton	Pipe Capacity/Inlet Capacity/Lack of Drainage	M	\$400,000	5 year ARI - Install K&G and upgrade existing drainage along Junction Road to outlet.
3B	West Terrace (App C Sht 3)	Littlehampton	Pipe Capacity/Inlet Capacity/Lack of Drainage	L	\$180,000	5 year ARI - Extend existing drainage along West Terrace and Blundy Way to reduce gutter flows.
4A	North Terrace to Benjamin Gray Drive (App C Sht 1)	Littlehampton	Pipe Capacity/Inlet Capacity	H	\$390,000	100 yr ARI – Duplicate existing drain, upgrade easement drain draining area east of Gum Tree Drive.
4B	Fulford Terrace to North Terrace (App C Sht 3)	Littlehampton	Pipe Capacity/Inlet Capacity / Lack of Flow Path	L	\$760,000	100 yr ARI - Provide new inlet pits and upgrade existing easement drain as opportunities are identified
5	Baker Street (App C Sht 3)	Littlehampton	Pipe Capacity/Inlet Capacity	H	\$50,000	100 yr ARI - Construct new inlets at existing low point.
6	Spring Park Drive (App C Sht 1)	Littlehampton	Inlet Capacity	L	\$40,000	5 year ARI - Construct new inlets.
7	Saint James Drive/Edson Court/Gum Tree Drive (App C Sht 1)	Littlehampton	Pipe Capacity/Inlet Capacity	L	\$110,000	5 year ARI - Upgrade existing drain from Saint James Drive to Gum Tree Drive.

ID	Project / Activity	Suburb	Issue	Priority	Budget Estimate	Design ARI, Description
8	Barrow Court/Durham Court (App C Sht 3)	Mt Barker	Pipe Capacity	L	\$120,000	5 year ARI - Upgrade existing drain from Barrow Court to Atlantic Road.
9	Pontiac Road (App C Sht 4)	Mt Barker	Pipe Capacity/Inlet Capacity	L	\$50,000	5 year ARI - Upgrade existing drain crossing Pontiac Road.
10	Sheridan Court (App C Sht 7)	Mt Barker	Pipe Capacity	L	\$90,000	5 year ARI - Upgrade existing from Dalmeny Drive
11	Claret Ash Parade (App C Sht 3)	Mt Barker	Inlet Capacity	H	\$10,000	100 year ARI - Construct new inlet.
13	Hallmark Road (App C Sht 12)	Mt Barker	Inlet Capacity	H	\$20,000	100 year ARI - Construct new inlets.
14	Wilkinson Court (App C Sht 8)	Mt Barker	Inlet Capacity	L	\$15,000	5 year ARI - Construct new inlet.
15	Cook Court (App C Sht 8)	Mt Barker	Inlet Capacity	L	\$10,000	5 year ARI - Construct new inlet.
16	Apollo Street (App C Sht 5)	Mt Barker	Inlet Capacity	M	\$10,000	5 year ARI - Construct new inlet.
17	Hill Street (App C Sht 5)	Mt Barker	Inlet Capacity	L	\$10,000	5 year ARI - Construct new inlet.
18	Hawthorn Road/Adelaide Road (App C Sht 5)	Mt Barker	Inlet Capacity	L	\$180,000	5 year ARI - Extend drain to south west along Hawthorn road and construct new inlets.
19	Pridmore Terrace/Hutchinson Street (App C Sht 5, 6)	Mt Barker	Pipe Capacity/Inlet Capacity	M	\$240,000	10 year ARI - Proposed upgrades to be reviewed as part of Pridmore Terrace/Druids Avenue flood mitigation options assessment.
20	Cameron Road/Gollan Circuit (App C Sht 6)	Mt Barker	Inlet Capacity/Lack of Drainage/Pipe Capacity	L	\$10,000	5 year ARI - Construct new inlet.
21	Walker Street/Gawler Street/Mann Street (App C Sht 6)	Mt Barker	Pipe Capacity/Inlet Capacity	M	\$260,000	100 year ARI - Extend drain north east and south west along Mann Street and construct new inlets. Install new inlets and upgrade existing single side entry pits to double side entry pits.
22	Hutchinson Street (App C Sht 6)	Mt Barker	Inlet Capacity	L	\$10,000	5 year ARI - Construct new inlet.

ID	Project / Activity	Suburb	Issue	Priority	Budget Estimate	Design ARI, Description
23	Morphett Street/McLaren Street (App C Sht 6)	Mt Barker	Inlet Capacity	L	\$10,000	5 year ARI - Construct new inlet.
24	Gawler Street (App C Sht 6)	Mt Barker	Inlet Capacity	L	\$10,000	5 year ARI - Construct new inlet.
25	Maurice Road/Wuttke Road/Allen Avenue (App C Sht 8)	Mt Barker	Pipe Capacity	M	\$360,000	Existing system found to provide 5 year ARI drainage standard assuming free flowing outfall. Performance diminished as a result of high creek level – Cutoff drain intercepting these systems and discharging downstream of Kay Road proposed to enable design performance during times of high creek water level.
26	Cameron Street/Druids Avenue (App C Sht 6)	Mt Barker	Inlet Capacity/Pipe Capacity	L	\$15,000	5 year ARI - Construct new inlets.
27A	Light Crescent (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity	H	\$130,000	100 year ARI - Construct new easement drain and inlets at low point along Light Crescent.
27B	Secker Road (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	L	\$140,000	5 year ARI - Upgrade existing drain along Light Crescent to Secker Road.
28A	Netley Street/Howard Close/Grivell Street/Craig Terrace (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	H	\$430,000	100 year ARI - Upgrade existing easement drain to achieve 100 year standard.
28B	Daw Avenue (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	L	\$340,000	100 year ARI - Extend existing west along Daw Avenue to Jubilee Crescent and construct new inlets.
29	Phillip Street/Princes Road/Edward Street/Hughes Street (App C Sht 8)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	H	\$580,000	100 year ARI - Extend existing Princes Road drainage to north west and construct new inlets. Upgrade drainage from James Street low point along Edward Street to outfall to provide 100 year ARI drainage standard.

ID	Project / Activity	Suburb	Issue	Priority	Budget Estimate	Design ARI, Description
30A	Wunderley Drive/Victoria Road/Wiland Street (App C Sht 9)	Mt Barker	Pipe Capacity	M	\$410,000	100 year ARI - Drainage upgrade required along Wiland Street to outfall
30B	Wunderley Drive/Victoria Road/Wiland Street (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	H	\$170,000	100 year ARI -. Upgrade existing drainage within road reserve and easement at Victoria Road low point to achieve 100 year standard.
30C	Wunderley Drive / Victoria Road (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity	L	\$370,000	5 year ARI - Extend existing drain east along Wunderley Drive to Barratt Avenue and north along Victoria Road to Ramsay Street.
31	Albert Road (between Alexandrina Road & Wellington Road) (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	H	\$20,000	100 year ARI - Construct new pits at Albert Road low point. Upgrade drain crossing Albert Road.
32	Oborn Road (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity/Lack of Drainage Reserve	H	\$670,000	100 year ARI - Construct new drain from Enterprise Court along Oborn Road to Alexandrina Road and continue to outlet to service Oborn Road low point.
34	Sims Road (App C Sht 12)	Mt Barker	Inlet Capacity/Lack of Drainage Reserve	H	\$15,000	Detailed assessment of creek capacity downstream of existing culvert to be undertaken and used to inform detention requirement to manage increased runoff arising from future development to the east and south of Sims Road.
35	Hack Street (App C Sht 9)	Mt Barker	Inlet Capacity/Pipe Capacity	L	\$430,000	5 year ARI - Extend drainage system and construct new inlets. Upgrade existing drainage.
36	Newland Street (App C Sht 9)		Inlet Capacity/Pipe Capacity	L	\$85,000	5 year ARI - Extend drainage system and construct new inlets. Upgrade existing drainage.
37	Hutchinson Street/Victoria Crescent (App C Sht 6, 9)		Inlet Capacity/Pipe Capacity/High River Level	L	\$320,000	5 year ARI - Extend drainage system and construct new inlets. Upgrade existing drainage.

ID	Project / Activity	Suburb	Issue	Priority	Budget Estimate	Design ARI, Description
38	Alexandrina Road (App C Sht 9)	Mt Barker	Pipe Capacity/Inlet Capacity	L	\$270,000	Upgrade existing drainage from Howard Lane to outfall. Construct new inlets.
39	Exhibition Road/Fletcher Road (App C Sht 9)	Mt Barker	Inlet Capacity	M	\$610,000	5 year ARI – Extend new Fletcher Road drain west to Exhibition Road. Upgrade existing.
40	Maldon Street/Wellington Road/Alexandrina Road (App C Sht 9)	Mt Barker	Inlet Capacity/Pipe Capacity	L	\$580,000	5 year ARI – Extend existing drainage along Maldon Street to the south and along Wellington Road/Pope Street. Construct new swale/drain to detention basin within Council reserve (approx. capacity 800 m ³) to the north of Wellington Road.
41	Stephenson Street (App C Sht 8)	Mt Barker	Inlet Capacity/Pipe Capacity	L	\$15,000	Construct new inlet.
42	Lewis Avenue/Barton Circuit (App C Sht 9)	Mt Barker	Inlet Capacity/Pipe Capacity	L	\$270,000	5 year ARI – Extend existing drain along Deer Avenue to Williams Street. Upgrade existing drainage from Deer Avenue along Lewis Avenue/Barton Circuit to new outlet prior to Collett Avenue.
43	Albert Road (App C Sht 12)	Mt Barker	Pipe Capacity	L	\$150,000	5 year ARI – Upgrade existing drainage from Alexander Drive along Albert Road and through to Craig Terrace.
44	Junction Road Culvert (App C Sht 1)	Littlehampton	Pipe Capacity	M	\$70,000	20 year ARI – Upgrade existing culvert
45	Clems Road (App C Sht 2)	Littlehampton	Lack of Drainage	L	-	Upgrades produced as part of creek upgrades assessment.
46	North Terrace (App C Sht 1)	Littlehampton	Lack of Drainage	M	\$20,000	Detailed assessment of existing drainage infrastructure required to identify required drainage standard and confirm objectives with DCMB.
47	Wellington Road (North Railway Terrace) (App C Sht 9)	Mt Barker	Lack of Drainage	L	\$490,000	5 year ARI – Wellington Road drainage upgrades to be done in conjunction with road upgrade/kerbing.

ID	Project / Activity	Suburb	Issue	Priority	Budget Estimate	Design ARI, Description
48	Wellington Road (South Railway Terrace) (App C Sht 9, 12)	Mt Barker	Lack of Drainage	L	\$840,000	5 year ARI – Wellington Road drainage upgrades to be done in conjunction with road upgrade/kerbing.
49	Hawthorn Road Culvert (App C Sht 5)	Mt Barker	Pipe Capacity	M	\$70,000	20 year ARI – Upgrade existing culvert
50	Bernhardt Court (App C Sht 9)	Mt Barker	Backflow from creek	M	\$370,000	Construction of new drainage to new pump station, pump to enable minimum 1 year ARI flow during times of high creek flow when gravity drains cease discharge.

6 Flood Protection

6.1 Previously Completed Flood Plain Mapping

Floodplain mapping has previously been completed for most of the study area (AWE, 2010) and the mapping that was produced forms part of this Stormwater Management Plan.

Since completion of this study, there has been a significant extension of the urban growth boundary for Mt Barker. This additional urban area was not allowed for in the floodplain mapping hydrology or associated floodplain maps.

6.2 Additional Flood Plain Mapping Scope

Additional flood plain mapping of the Mt Barker Study Area has been undertaken as part of the development of this Stormwater Management Plan to define the existing level of flood risk, as follows:

- Littlehampton & Totness – to identify existing flood risk in this urban area that has not previously been comprehensively assessed
- Mt Barker Town Centre – to review the flood plain behaviour in this area in greater detail. These maps supersede the previous mapping of this area.
- Urban growth area south of Hurling Drive, Mt Barker – to account for recent development activity. These maps supersede the previous AWE mapping of this area.

These flood models have been established as separate model domains. The separation of domains has allowed the models to be run with a finer grid size (improving accuracy and resolution) than would be possible using a single model domain.

The additional floodplain model boundaries are shown in Figure 6.1.

6.3 Flood Plain Modelling Approach

6.3.1 Software Selection

Hydraulic floodplain modelling was carried out using the TUFLOW (and ESTRY) computer program jointly funded and developed by BMT WBM and The University of Queensland in 1990. 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 2D in nature and cannot or would be awkward to represent using a 1D model (BMT WBM, 2010).

A powerful feature of TUFLOW is its ability to dynamically link to 1D networks using the hydrodynamic solutions of ESTRY. The user sets up a model as a combination of 1D network domains linked to 2D domains.

The TUFLOW and ESTRY computational engines use third party software as their interface. These software are typically a text editor (eg. Wordpad), a GIS platform (eg. MapInfo), 3D surface modelling software (eg. Vertical Mapper) and result viewing (eg. SMS).

The TUFLOW model is based on the Stelling (1984) solution scheme, which is a finite difference, alternating direction implicit (ADI) 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, 2010).

The model area is divided into fixed rectangular 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.

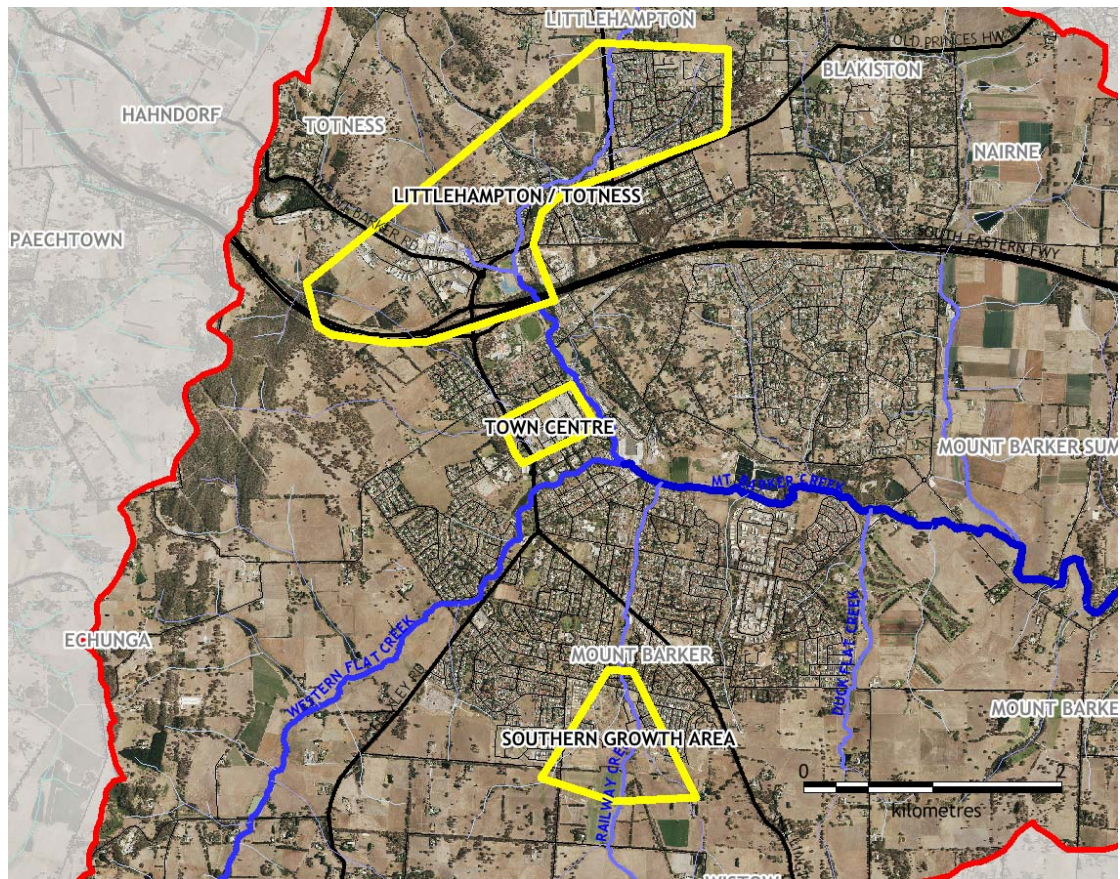


Figure 6.1 Mt Barker Floodplain Model Boundaries

6.3.2 1D/2D Hydraulic Model Domains

The models were developed so that culvert crossings and the underground stormwater drains were modelled in 1 dimension (1D) using ESTRY, while the floodplain on the surface was modelled in 2 dimensions (2D) using TUFLOW. Selected reaches of creek in Littlehampton that were too heavily vegetated to be accurately represented within the DTM were modelled in 1D by using cross-section generated from supplementary ground survey. The 1D and 2D domains within each model were hydro-dynamically linked, allowing flows in both domains to interact.

6.3.3 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.

The cell size used within each model is shown in Table 6.1.

Table 6.1 Flood Model 2D Cell Size

TUFLOW and ESTRY Model	2D Cell Size	Number of Cells
Mt Barker Town Centre	1 metre	252,000
Littlehampton & Totness	3 metres	373,000
Southern Growth Area	1 metre	1,374,000

It is recommended in the TUFLOW and ESTRY User Manual (BMT WBM, 2010) that when modelling channels in 2D, the selected cell sizes should allow for at least 4-5 cells to fit within the banks to provide an accurate representation of the channel profile. The 1 metre grid used in the Southern Growth Area model allowed for all open channels to be modelled in 2D. Within the Littlehampton & Totness model, the majority of channels were modelled in 1D using cross-sections generated from supplementary ground survey.

6.3.4 Time Step

Selection of an appropriate time step in the 2D domain is an important aspect of TUFLOW modelling as it is directly proportional to the running time of a model. A small time step will create more accurate results and is less likely to cause instabilities, however the simulation time can often stretch to days for long duration storm events. On the other hand, a large time step will shorten simulation times but increases the risk of inaccurate results.

A general rule for TUFLOW models (although this is not a necessity) is to use a time step (in seconds) equal to approximately half the cell size (in metres). For all models, the time steps used are shown in Table 6.2.

Table 6.2 Flood Model Time Step

TUFLOW and ESTRY Model	2D Time Step	1D Time Step
Mt Barker Town Centre	0.5 seconds	0.5 seconds
Littlehampton & Totness	0.5 seconds	0.5 seconds
Southern Growth Area	0.25 seconds	0.25 seconds

The vast majority of the modelling computational effort is in solving the 2D surface flow equations and hence the impact of the time step on simulation times is negligible in the 1D domain.

6.3.5 Topography

A digital terrain model (DTM) of each of the model domain areas was acquired to define the existing flood plain topography.

The DTM for the Littlehampton / Totness area and the Southern Growth Area is based on imagery obtained in December 2013. It provides a vertical accuracy of 0.25m at the 95% confidence interval. The Town Centre DTM was obtained through new data acquired specifically for this assignment (via a flight undertaken on 28 August 2014) and was provided at a vertical accuracy of 0.10m at the 95% confidence interval.

The DTM was used to assign elevations to individual cells within the 2D domain. These elevations are assigned at the cell centres, corners and mid-sides to enable interaction with surrounding cells.

On inspection of the DTM, it was apparent that certain heavily vegetated areas of creek line did not allow for accurate photogrammetric pickup. Supplementary ground survey data was undertaken to produce cross sections of the creek channel in these locations.

6.3.6 1D Domain Pipe Network

The 1D domain was constructed from drainage construction plans, as-constructed surveys as well as ground survey of stormwater pits within the Town Centre and additional survey of creek culvert crossings. Drain diameters and inverts were extracted from the data provided.

The existing floodway consisting of three separate 2.4m wide x 0.75m high culverts at the base of the shopping centre between McLaren Street and Cameron Road has been incorporated into the model as a 1D element. This floodway is controlled by flap gates at the entrance and exit which have a maximum opening of approximately 400 mm high across the full width of each culvert. This aperture restriction has been accounted for within the modelling. There has been no allowance for any blockage to the floodway opening which would be expected to significantly increase the depth of flooding at the floodway entrance and shopping centre carpark in events greater than a 50 year ARI event.



Flood gates under Mt Barker Central Shopping Centre

6.3.7 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 n value described in the Materials File. This approach allows for a relatively quick and simple adjustment of Manning's n values, especially if model calibration is possible.

The bed resistance values used in the modelling are specified in Table 6.3

Table 6.3 Bed Resistance Parameters

Type of Land Use	Manning's Roughness Coefficient
Residential / Commercial Development	0.200
Roads	0.030
Sparsely Vegetated Open Space	0.040
Railway	0.040
Densely Vegetated Open Space	0.070
Dam, ponds	0.025
Densely Vegetated Creek	0.080
Moderately Vegetated Creek	0.050
Sparsely Vegetated Creek	0.030

It should be noted that relatively high values of Manning's n are used for residential and commercial development to compensate for the lack of building envelopes in the Littlehampton / Totness and Southern Urban Area DTMs. Building envelopes were defined for the Town Centre model.

The Manning's n value used for modelling of underground drains was 0.012.

6.3.8 2D Breaklines

Town Centre Model

The photogrammetry obtained for the town centre contained information regarding the spatial location of breaklines within the area. These breaklines included the following:

- Building outlines
- Fences and retaining walls
- Road crowns
- Kerbs, islands
- Surface features (e.g. edges of channels, embankments)

The elevation of each breakline was not provided as part of the aerial survey. Therefore those breaklines that were assumed to provide a solid barrier to surface flows were automatically assigned a height as shown in Table 6.4.

Table 6.4 2D Breakline Heights

Breakline Type	Assigned Height
Building Outline (Single Storey)	2 metres
Building Outline (Multiple Storey)	5 metres
Fence / Retaining Wall	1 metre
Kerbs / Islands	150 mm

6.3.9 Boundary Conditions

As part of the modelling, consideration was given to the boundary conditions within the 1D and 2D domains.

1D Boundary Conditions

The 1D boundary conditions within the Town Centre and Littlehampton/Totness models consist of the inflows to stormwater pits or channel reaches. The model is set up to allow flows to travel freely between the 1D domain (underground drainage system or open channel) and the 2D domain (ground surface defined by the DTM) as governed by hydraulic conditions that vary over the course of a design storm event.

At the downstream end of the Morphett Street drain in the Town Centre, the hydraulic performance is influenced by receiving water levels in Littlehampton Creek. The receiving water levels used in the model are shown in Table 6.5.

Table 6.5 Town Centre Downstream Boundary Conditions

Boundary Condition	100 Year ARI Event	50 Year ARI Event
Main Town Centre Drain Outlet	319.0 m AHD (Littlehampton Creek Receiving Water Level)*	318.6 m AHD (Littlehampton Creek Receiving Water Level)*

* Values obtained from Mount Barker Floodplain Mapping Study (AWE, 2010)

2D Boundary Conditions

Within the 2D domain, the boundary condition is the edge of the model around the Town Centre perimeter or for the creek models it is the downstream end of each reach. The boundary condition adopted in the 2D domain was a "HQ" (stage-discharge) type boundary with a water surface slope of 2%.

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.

6.3.10 Inflows

Town Centre Model

The inflow hydrographs at each inlet were derived from existing DRAINS modelling previously undertaken for the Town Centre catchment (Tonkin Consulting, 2014). This existing DRAINS model was modified so that the sub-catchment boundaries were representative of the layout of the TUFLOW model. In cases where a particular sub-catchment had more than one inlet point (such as the bank of nine side entry pits on Walker Street), the inflows were distributed evenly between each inlet.

Rural catchment rainfall losses within the DRAINS model (which used an ILSAX hydrological model) were modified to match those used in the Mount Barker Floodplain Mapping Study (AWE, 2010). The losses used within the model are shown in Table 6.6.

The hydrographs for each storm event were applied as either point inflows at the inverts of each pit within the 1D domain or in the case of Adelaide Road near Druids Avenue where no pits are present, as surface flows directly onto the 2D domain.

Table 6.6 Town Centre DRAINS Model Loss Model Values

Catchment	100 Year ARI	50 Year ARI
Rural Catchment Initial Loss	39.5 mm	38.1 mm
Rural Catchment Continuing Loss	1.54 mm/hr	1.54 mm/hr
Urban Catchment Initial Loss	30 mm	30 mm
Urban Catchment Continuing Loss	3 mm/hr	3 mm/hr

Due to the hydro-dynamic links between the 1D and 2D domains, this arrangement allowed for flows equal to or smaller than the pipe capacity to travel within the underground network, while flows exceeding the pipe capacity spilled onto the surface and travelled overland within the 2D domain.

Littlehampton & Totness / Southern Growth Models

The inflow hydrographs for the creek-based models were generated using the output from the DRAINS model developed as part of this Study. A description of the model including the approach and adopted parameters can be found in Section 4.3. For the Southern Growth Area, all inflow hydrographs were applied on the surface within each channel reach. For the Littlehampton and Totness area, flows were applied as either surface inflows or as point inflows at the invert of each pit or channel reach depending on the spatial distribution of sub-catchment boundaries.

Probable Maximum Flood (PMF) Flows

The Estimation of Probable Maximum Precipitation in Australia: Generalised Short Duration Method (GSDM) (Bureau of Meteorology, 2003) offers guidance to those engaged in estimating the probable maximum precipitation for durations up to three or six hours in Australia.

Probable Maximum Precipitation (PMP) values were calculated at Mount Barker for a range of durations in accordance with the procedure outlined in the guideline document. These rainfall depths were applied to the respective DRAINS hydrological models to produce a set of PMF hydrographs. These hydrographs were applied to the flood model in the same manner and location as per the 20 / 50 / 100 / 500 year ARI models.

6.4 Flood Plain Mapping Results, Existing Scenario

6.4.1 Flood Plain Maps

A1 format flood plain maps for each ARI have been prepared and are presented in Appendix D.

6.4.2 Design Event Runs

The scope of this Study involved floodplain mapping of the 20 year, 50 year, 100 year, 500 year ARI and the Probable Maximum Flood (PMF) events for areas not previously mapped. The Town Centre, which had previously been assessed as part of previous mapping work (Australian Water Environments, 2011) was undertaken for the 50 and 100 year ARI events only. Various storm durations were modelled within each ARI 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. Therefore, the results presented in the floodplain maps are based on a combination of critical events and can be assumed to represent the

worst case scenario or flood envelope for each ARI. The critical storm durations for each ARI are shown in Table 6.7.

Table 6.7 Critical Storm Durations for each ARI

TUFLOW and ESTRY Model	Average Recurrence Interval	Critical Storm Durations
Mt Barker Town Centre	50 years	20 min, 3 hrs
	100 years	20 min, 3 hrs
Littlehampton & Totness	20 years	90 min, 12 hrs
	50 years	90 min, 6 hrs
	100 years	90 min, 6 hrs
	500 years	90 min, 9 hrs
	PMF	90 min
Southern Urban Growth Area	20 years	12 hrs
	50 years	6 hrs
	100 years	6 hrs
	500 years	9 hrs
	PMF	90 min

6.4.3 Town Centre Mapping Commentary

50 Year ARI

The 50 year ARI flood plain map shows areas of shallow flooding that is mostly contained within the road network throughout the town centre. The flooding is mainly evident along Morphett Street (which contains the main trunk drain for the town centre), Walker Street, Hutchinson Street, McLaren Street, Cameron Road and Druids Avenue.

Ponding up to 1.5 metres deep is evident at the entrance to the main drain upstream of Adelaide Road. This would suggest hydraulic capacity of the main drain is driven by inlet control at the drain entrance in the 50 year ARI event.

Flows from Pridmore Terrace are spilling into Druids Avenue and overtopping the kerb and gutter at the intersection with Hutchinson Street. These overflows (>100mm) are shown to enter private property at the south-eastern corner of the intersection, the building floor level of which is set lower than that of the adjacent intersection. This may result in stormwater ingress to this business. These flows are shown to pass into the adjacent undercroft car park area south of Druids Avenue, with ponding against the shopping centre of over 250mm, potentially entering the shopping centre itself. Modelling indicates the shopping centre forms a trapped low spot, with solid barriers on the downstream end preventing flows from travelling through to Cameron Road.

The capacity of the main drain in Morphett Street is shown to be exceeded east of Walker Street. Overflows within Morphett Street are shown to be as deep as 300mm within the roadway, overtopping the kerb and gutter and potentially above floor level of a number of businesses on either side of Morphett Street (between Stephen Street and Hutchinson Street). The parcel of mostly vacant land between Stephen Street and Hutchinson Street to the north of Morphett Street is inundated with depths up to 0.5 metres which is also affected by overflows from Stephen Street.

Morphett Street overflows, and those spilling from the vacant parcel of land, are shown to enter Hutchinson Street (between Morphett Street and Druids Avenue) and overtop the kerb and gutter on the eastern side. Flood depths of up to 250mm are shown alongside businesses on the eastern side of Hutchinson Street, which may also result in above floor flooding.

These flows from Hutchinson Street are shown to enter the undercroft shopping centre carpark bounded by Morphett Street, Hutchinson Street and McLaren Street. It is then conveyed across the carpark at depths of less than 100mm towards McLaren Street and through to the designated floodway.

At the downstream end of the model, flood flows are shown to bypass the undercroft carpark between Cameron Road and Littlehampton Creek and flow around both the northern and southern perimeters of this complex. Areas to the north and south of this parking complex are residential housing. Although the flooding through these properties is shown to be shallow (<100mm) they may experience property damage as stormwater flows make their way through the properties to the downstream creek.

100 Year ARI

The 100 year ARI flood plain map shows greater depths and extents of flooding when compared to the 50 year ARI mapping.

Ponding up to 2.5 metres deep is evident in the channel at the entrance to the main drain upstream of Adelaide Road. Floodwaters are shown to overtop Adelaide Road to the south of Morphett Street and enter adjacent properties with flood depths of over 500mm.

Modelling indicates Side Entry Pits (SEP's) of the Morphett Street main drain will surcharge at the intersections with Stephen Street and Walker Street in the 100 year ARI event

The flood depths have increased along Morphett Street, Walker Street, Hutchinson Street, McLaren Street, Cameron Road and Druids Avenue compared to the 50 year ARI mapping, with several areas now shown to be inundated with depths in the range of 250mm – 500mm. Modelling indicates several drains, as well as the Morphett Street main drain, will surcharge at pit inlet locations, particularly at the intersections with Stephen Street and Walker Street. Above floor flooding is likely in many of the businesses along these roads. Shallow flooding in the range of 100mm – 250mm is also apparent on Stephen Street, which was absent during the 50 year ARI simulation.

The parcel of land between Stephen Street and Hutchinson Street to the north of Morphett Street is inundated with depths up to 1 metre.

The trapped low point in Druids Avenue between Hutchinson Street and Cameron Road is shown to result in roadway ponding across the full width of Druids Avenue, with flood depths of up to 500mm within the roadway. An increase of flow spilling from Druids Avenue in to the south-east corner of the Hutchinson Road intersection is also observed.

The undercroft carpark area bounded by Morphett Street, Hutchinson Street and McLaren Street is shown to be inundated with flooding between 100mm and 250mm deep, with the corner near McLaren Street shown to be inundated up to 1 metre deep.

At the downstream end of the model, flood flows travel through the underground carpark between Cameron Road and Littlehampton Creek with flooding up to 250 mm deep. An increase in flooding through adjacent residential properties is also observed.

6.4.4 Littlehampton / Totness Mapping Commentary

20 Year ARI

The section of creek between Kym Avenue and Junction Road in Littlehampton shows that the 20 year ARI flow is contained in the upstream reaches, with shallow overtopping of the banks evident downstream of O'Donnell Drive. At the eastern side of Littlehampton the creek flows are well contained between Lloyd Crescent and Benjamin Gray Drive. The maps show that the detention basin adjacent to Gum Tree Drive has a shallow overflow in the 20 year ARI event. The pond adjacent to Miels Avenue does not overtop during the 20 year ARI event.

The Junction Road culvert crossings are overtopped during a 20 year ARI event, however downstream of this point where the creek tributaries merge the flows are shown to be contained within the confines of the creek channel.

Creek overtopping with flood depths of up to 250mm is shown in the reach adjacent to Cleggett Road, particularly in the vicinity of Rosella Court.

Downstream of Cleggett Road, flooding can be seen within the Clems Lane properties with the majority shown to have a maximum depth of 250mm. Selected pockets of deeper flooding (up to 500 mm) are also evident in this area. The section of creek from North Terrace to the Freeway is shown to contain the peak 20 year ARI flows.

Within Totness, floodwaters from the channel on the northern boundary of the commercial precinct are shown to enter the precinct via overflows from the adjacent upstream dam wall (south side). Floodwaters are shown to be mostly shallow depths of up to 100mm.

The large diameter (1200 – 1800 mm) underground drain located beneath the commercial precinct does not surcharge in the 20 year ARI event.

At the southern end of Totness, flood flows are shown to travel at depths of up to 250 mm within the natural valley between the dam and the entrance to the orifice plate fitted 1500mm diameter pipe under the South Eastern Freeway.

50 Year ARI

The Kym Avenue culvert is overtopped and there is a slight increase in flood plain extents between Kym Avenue and Junction Road when compared to the 20 year ARI flood maps. At the eastern side of Littlehampton the creek flows are well contained between Lloyd Crescent and Benjamin Gray Drive, although a slight increase in inundation depths and extents is evident.

As for the 20 year ARI event, although the Junction Road culvert crossings are overtopped during a 50 year ARI event, the flows are shown to be contained within the embankments downstream of this point.

Creek overtopping with flood depths of up to 500 mm is shown in the reach adjacent to Cleggett Road, particularly in the vicinity of Rosella Court.

Downstream of Cleggett Road, flooding can be seen within the Clems Lane properties with the majority shown to have a maximum depth of 250 mm – 500 mm.

Within Totness, floodwaters from the channel on the northern boundary of the commercial precinct are shown to enter the precinct with mostly shallow flooding with a peak depth of 250 mm or less.

The large diameter (1200 – 1800 mm) underground drain located beneath the commercial precinct does not surcharge in the 50 year ARI event.

At the southern end of Totness, flood flows are shown to travel at depths of up to 250 mm within the natural valley between the dam and the entrance to the orifice plate fitted 1500 mm diameter pipe under the South Eastern Freeway.

100 Year ARI

The entire creek reach between Kym Avenue and Junction Road appears to flood in the 100 year ARI event. However the flood flows do not enter private properties and are contained in the creek reserve. At the eastern side of Littlehampton greater flood plain extents and depths are noted compared to more frequent events, particularly downstream of Benjamin Gray Drive.

Creek overtopping and flooding of properties with depths of up to 500mm is shown in the reach adjacent to Cleggett Road, particularly in the vicinity of Rosella Court.

Downstream of Cleggett Road, flooding can be seen within the Clems Lane properties with the majority shown to have a maximum flood depth of 500 mm but with isolated pockets of inundation with depths of up to 1 metre also evident.

Within Totness, floodwaters from the channel on the northern boundary of the commercial precinct inundate the precinct to a greater degree compared to more frequent events.

A noticeable increase in flooding is also evident downstream of the commercial precinct from Kookaburra Lane where floodwaters overtop North Terrace and travel to the eastern tributary.

At the southern end of Totness, flood flows are shown to travel at depths of up to 500mm within the natural valley between the dam and the entrance to the orifice plate fitted 1500 mm diameter pipe under the South Eastern Freeway. The ponding upstream of the orifice is noticeably deeper when compared to the 50 year ARI event.

500 Year ARI

The creek reaches upstream of Junction Road are shown to overtop and flow at greater depth when compared to the 100 year ARI event, however there appears to be minimal risk to properties along these reaches with the exception of those on the corner of Benjamin Gray Drive and Junction Road.

Creek overtopping and flooding of properties with depths of up to 1 metre is shown in the reach adjacent to Cleggett Road, particularly in the vicinity of Rosella Court.

Downstream of Cleggett Road, flooding can be seen within the Clems Lane properties with the majority shown to have a maximum flood depth of 500mm – 1 metre. The floodplain extents upstream of North Terrace are also noticeably wider when compared to the 100 year ARI event.

Within Totness, the commercial precinct is shown to be inundated significantly more than what was observed during the 100 year ARI event, with the large diameter underground drain shown to surcharge within the precinct.

Significantly more ponding is observed at the upstream of the South Eastern Freeway culvert crossings in both Littlehampton and Totness.

6.4.5 Southern Urban Growth Area Mapping Commentary

20 Year ARI

There are three creek tributaries in this area that merge into a single creek (Railway Creek) upstream of Hurling Drive. The western tributary is shown to be mostly contained in the 20 year ARI event. The central and eastern creek tributaries spill during this event, especially at the upstream reaches to the south of Bradford Street.

50 Year ARI

The western tributary is shown to spill in the vicinity of the railway crossing, with shallow flows (less than 250mm deep) travelling towards Hurling Drive. The central tributary also ponds and spills in the vicinity of the railway crossing. The eastern tributary shows greater flood extents when compared to the 20 year ARI event with a wide band of shallow floodwaters between the creek and railway.

Shallow flooding with a maximum depth of 100mm can be seen on Siding and Kennebec Courts.

100 Year ARI

The flood plain shown for the 100 year ARI event has a very similar pattern to that of the 50 year ARI event. Incremental increases in flood depths and extents are evident in the previously described flood prone areas.

500 Year ARI

The western tributary is shown to spill in various locations including Barker Road, West Parkway and in the vicinity of the railway crossing, with flows up to 500mm deep travelling towards Hurling Drive. The central and eastern tributaries appear to merge due to floodwaters connecting the two reaches with depths of up to 1 metre.

Flooding with a maximum depth of 500mm can be seen on Siding and Kennebec Courts.

6.4.6 Hazard Mapping

The criteria adopted for determining the flood hazard rating at a particular location is shown in Figure 6.2. The flood hazard is dependent on both flow velocity and flood depth. These hazard classes can be found in the SCARM Report 73 (CSIRO, 2000).

Flood hazard maps are shown in Appendix D. In general, most of the built up areas that are inundated by the various flood events fall into the “low hazard” category due to the shallow (less than 0.35 m) depths of flooding and low (less than 0.3 m/s) velocities in these areas. Conversely, creek channels are likely to experience high flow velocities (greater than 1.5 m/s) and large depths (greater than 1.2 m) which place them in the “extreme hazard” category. Streets and other defined flow paths often fall into the “medium” or “high” hazard categories with flow depths and velocities in between the “low” and “extreme” hazard category limits.

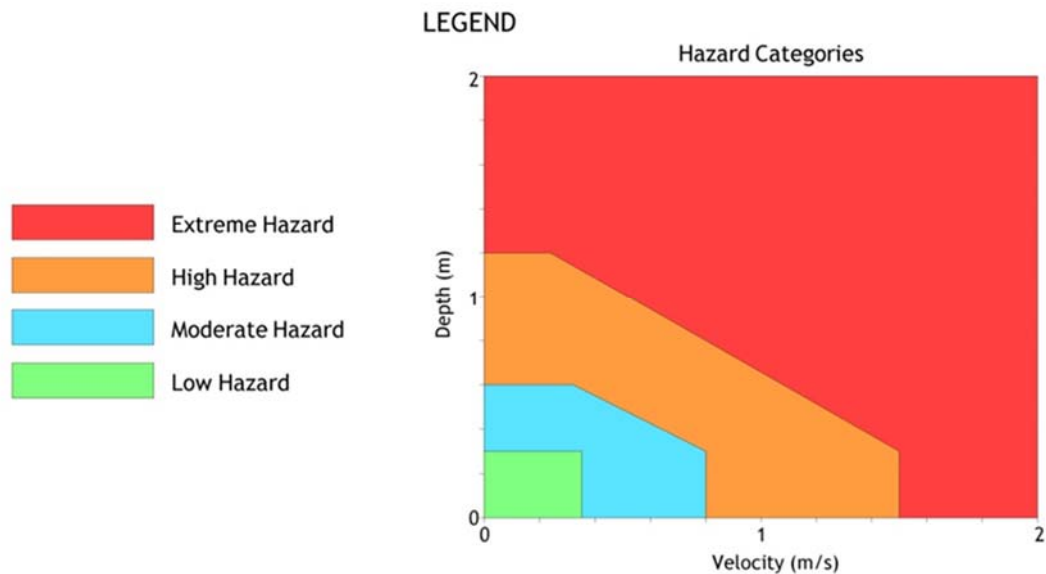


Figure 6.2 Flood Hazard Classification

6.5 Existing Flood Damages Evaluation

6.5.1 Evaluation Approach

Overview

Estimates of flood damages provide important information that can be used to prioritise flood mitigation or flood prevention works. They indicate the magnitude of damages caused by a design flood event of a given Average Recurrence Interval (ARI).

The magnitudes of flood damages are dependent upon a number of factors including property values, property size 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.

The first step was to overlay the zoning boundaries on the cadastral layer in order to identify residential areas separately from the commercial / industrial areas as well as other areas such as reserves that are not factored into the damages calculations.

The floodplain extents were then overlaid the residential and commercial/industrial areas, respectively. The flood depth at the centroid of each property was determined for each ARI.

For residential buildings, the flood depths for each ARI were broken up into the following ranges as recommended in the RAM Report (NRE, 2000):

- Inundation depths from 0.15 - 0.6m
- Inundation depths from 0.6 - 1.5m
- Inundation depths from 1.5 - 2.0m
- Inundation depths over 2.0m

For commercial / industrial buildings, the flood depths for each ARI were broken up into the following ranges (also taken from the RAM report):

- Inundation depths from 0 - 0.25m
- Inundation depths from 0.25 - 0.75m
- Inundation depths from 0.75 - 1.25m
- Inundation depths from 1.25 - 1.75m
- Inundation depths from 1.75 - 2m
- Inundation depths from 2 - 10m

In the absence of floor level data, an estimate has been made of the typical floor level (relative to the ground level as reported by the DTM). This is required to ensure that a suitable allowance has been made for reduced damages associated with building floor levels that can be at variance with ground levels reported by the DTM. These estimates are:

- Residential – Floor level 150mm above the property centroid DTM level
- Commercial / Industrial – Floor level at the property centroid DTM level

The RAM report provides a range of values to be applied to building damages based on the size and condition of the building. For this assessment it is assumed that all buildings are in "fair" condition, and that all buildings (residential / commercial / industrial) are "medium" in size.

Damage values taken from the RAM report have been indexed to 2015 units using appropriate CPI factors sourced from Bureau of Statistics (December 2014 Quarter). These values were then applied to each inundation range for each type of property that was shown to be flooded. This process was repeated for all ARI's as well as for both the existing and future scenarios.

The building damages estimates (classified as direct, tangible losses) were then summed to allow the calculation of indirect tangible losses which are directly proportional to the direct losses.

These damages estimates do not consider the following items:

- Damage to public infrastructure
- Damage to crops and stock losses
- Losses to vehicles
- Intangible losses.

Direct Tangible Losses and Stage-Damage values

Losses to buildings including their contents (split between residential and commercial / industrial buildings) were considered in this analysis. Stage-damage curves were developed for this flood damage assessment. These curves were sourced from NRE (2000) and modified to represent 2015 dollar values. The stage-damage data used in this analysis is presented in Table 6.8 and 6.9.

The value ranges documented in the reference literature have a minimum and maximum value that can be applied. This evaluation of damages has adopted the maximum values shown in each table in order to provide the most conservative flood damage estimates.

Table 6.8 Stage Damage Value Ranges, Residential Buildings

Inundation Depth Range	Minimum	Maximum (these values were adopted)
0.15 - 0.6m	\$12,890	\$32,320
0.6 - 1.5m	\$32,320	\$48,480
1.5 - 2m	\$48,480	\$51,750
> 2m	\$51,750	\$51,750

Table 6.9 Stage Damage Value Ranges, Commercial / Industrial Buildings

Inundation Depth Range	Minimum	Maximum (these values were adopted)
0 - 0.25m	\$0	\$81,000
0.25 - 0.75m	\$81,000	\$195,950
0.75 - 1.25m	\$195,950	\$298,220
1.25 - 1.75m	\$298,220	\$330,130
1.75 - 2m	\$330,130	\$351,410
2 - 10m	\$351,410	\$351,410

Adjustment Factors

The Rapid Appraisal Method (RAM) for Floodplain Management suggests that the stage damage curves (originally sourced from Smith, 1994) underestimate flood damages. To address this issue, the RAM report recommends increases of 60% be applied to both the residential and non-residential curves. Section 3.1 of the RAM report provides a detailed explanation for the increase, but essentially the increase to the stage-damage curves is required as the original curves are based primarily on relatively old data.

Damages to property that actually occur (actual damages) are normally less than those that could occur (potential damages) if residents took no action to reduce damages during a flood, eg, lift furniture. Ratios to convert Potential damages to Actual damages were used in accordance with the recommendations from the RAM. That is, for a community that is generally unaware of the flood risk and have a warning time of between 2 and 12 hours, a factor (ratio) of 0.8 is used to reduce the potential damages to actual damages. This factor also applies to communities who regularly experience floods who have a warning time of less than 2 hours.

Both of these factors have been applied to the values shown in Table 6.8 and 6.9.

6.5.2 Damages Precincts

The flood damages estimates have been segmented into seven separate precincts which are based on areas within which flood mitigation options are being assessed and presented as part of the overall Stormwater Management Plan. The breakdown will enable a comparison between current and future damages on a 'per precinct' basis which will then be assessed against the costs of any proposed flood mitigation upgrades within each precinct. A map of the seven precincts is shown in Figure 6.3.

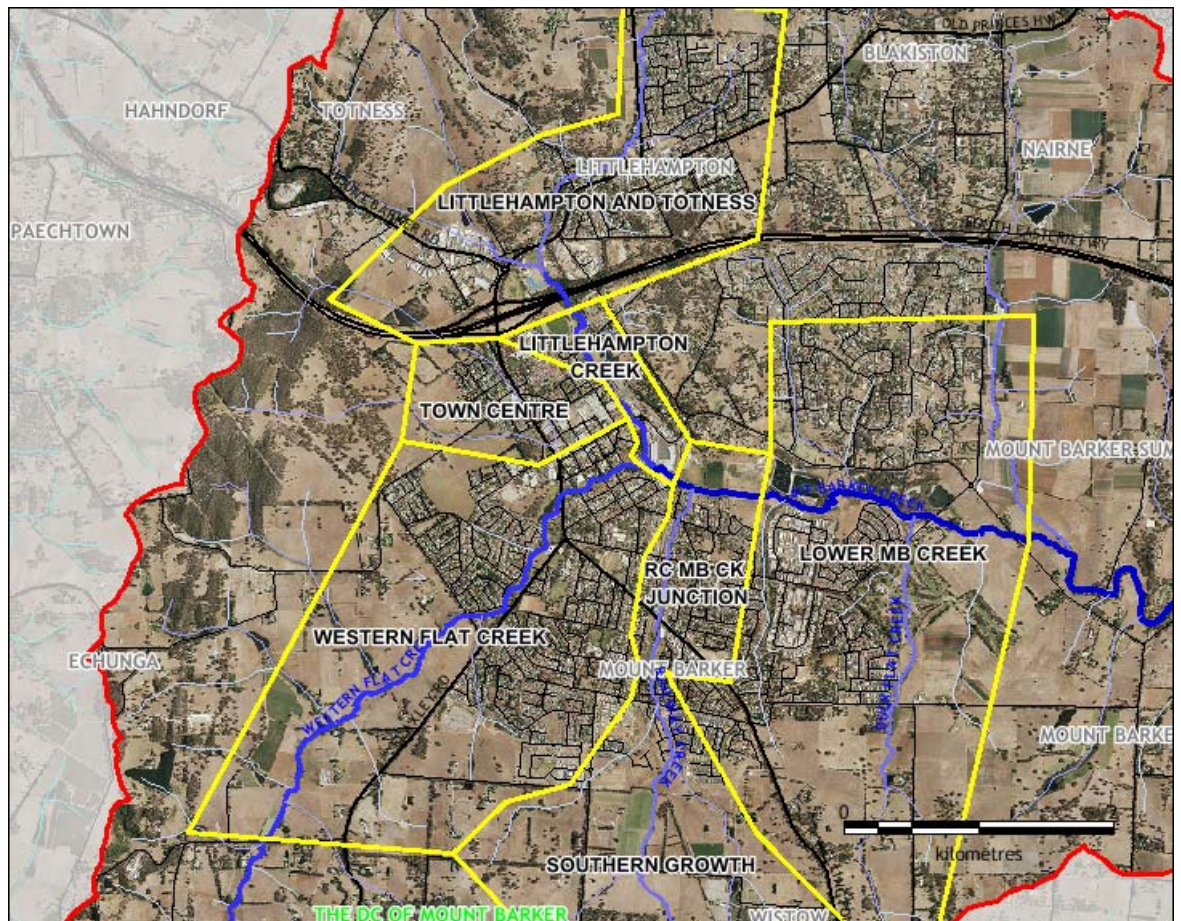


Figure 6.3 Mt Barker Damages Precincts

6.5.3 Damages to Residential Buildings

The number of residential buildings 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 the aerial photography.

It was assumed that there were no damages to residential buildings if the flood heights were below 150 mm, as described in Section 6.5.1.

The results of the analysis of the number of inundated properties for each ARI and depth range are shown in Table 6.10.

Table 6.10 Residential Properties and Damage Estimates, Existing Scenario

Precinct	ARI (yrs)	No. of Properties Inundated at each Depth Range				Damage Estimate
		0.15 - 0.6m	0.6 - 1.5m	1.5 - 2m	Over 2m	
LH & Totness	20	4	0	0	0	\$129,300
S. Growth	20	1	0	0	0	\$32,300
Town Centre	20	6	0	0	0	\$193,900
WF Creek	20	2	1	0	0	\$113,100
L Creek	20	5	0	0	0	\$161,600
Lower MBC	20	6	0	0	0	\$193,900
MB RC Junct.	20	7	2	0	0	\$323,200
LH & Totness	50	7	0	0	0	\$226,200
S. Growth	50	1	1	0	0	\$80,800
Town Centre	50	11	2	0	0	\$452,500
WF Creek	50	3	1	0	0	\$145,400
L Creek	50	10	0	0	0	\$323,200
Lower MBC	50	6	1	0	0	\$242,400
MB RC Junct.	50	20	2	0	0	\$743,300
LH & Totness	100	12	1	0	0	\$436,300
S. Growth	100	4	1	0	0	\$177,700
Town Centre	100	12	3	0	0	\$533,200
WF Creek	100	16	1	0	0	\$565,600
L Creek	100	13	0	0	0	\$420,100
Lower MBC	100	7	1	0	0	\$274,700
MB RC Junct.	100	40	3	0	0	\$1,438,100
LH & Totness	500	12	4	0	0	\$581,700
S. Growth	500	4	1	0	0	\$177,700
Town Centre	500	26	4	1	0	\$1,085,900
WF Creek	500	97	48	0	0	\$5,461,700
L Creek	500	17	6	0	0	\$840,300
Lower MBC	500	9	2	0	0	\$387,800
MB RC Junct.	500	37	34	2	0	\$2,947,500

6.5.4 Damages to Commercial and Industrial Buildings

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 the aerial photography.

The results of the analysis of the number of inundated commercial / industrial properties for each ARI and depth range are shown in Table 6.11.

6.5.5 Outside Buildings

Damages to equipment in outside buildings are not included in the standard stage-damage curves used. Such damages may include damage to fences, driveways, lower level laundries and outdoor equipment. To account for this \$2,000 was applied to each property that was inundated as shown in Table 6.12.

6.5.6 Indirect Damages

Indirect damages refer to the costs incurred to a community during a flood and include emergency response and disruptions to employment, commerce, tourism, transport and communication. The RAM report suggests that these costs are approximately 30% of direct damages.

6.5.7 Summary of Total Damages

The total damages for each ARI were determined by simply summing the various types of damages calculated previously.

The total damages for the existing scenario are shown in Table 6.13.

Table 6.11 Commercial / Industrial Properties and Damages, Existing Scenario

Precinct	ARI (yrs)	No. of Properties Inundated at each Depth Range						Damage Estimate
		0 - 0.25m	0.25 - 0.75m	0.75 - 1.25m	1.25 - 1.75m	1.75 - 2m	2 - 10m	
LH & Totness	20	4	0	0	0	0	0	\$324,000
S. Growth	20	1	0	0	0	0	0	\$81,000
Town Centre	20	14	0	0	0	0	0	\$1,134,000
WF Creek	20	5	0	0	0	0	0	\$405,000
L Creek	20	4	1	0	0	0	0	\$519,900
Lower MBC	20	4	4	0	0	0	0	\$1,107,800
MB RC Junct.	20	3	1	0	0	0	0	\$439,000
LH & Totness	50	5	0	1	0	0	0	\$703,200
S. Growth	50	1	0	0	0	0	0	\$81,000
Town Centre	50	16	2	0	0	0	0	\$1,687,900
WF Creek	50	9	0	0	0	0	0	\$729,000
L Creek	50	9	2	0	0	0	0	\$1,120,900
Lower MBC	50	3	6	0	0	0	0	\$1,418,700
MB RC Junct.	50	1	4	0	0	0	0	\$864,800
LH & Totness	100	4	1	0	1	0	0	\$850,100
S. Growth	100	1	0	0	0	0	0	\$81,000
Town Centre	100	27	0	0	0	0	0	\$2,187,000
WF Creek	100	16	3	0	0	0	0	\$1,883,800
L Creek	100	5	5	1	0	0	0	\$1,683,000
Lower MBC	100	3	5	2	0	0	0	\$1,819,200
MB RC Junct.	100	2	5	0	0	0	0	\$1,141,800
LH & Totness	500	5	2	0	0	1	0	\$1,148,300
S. Growth	500	2	0	0	0	0	0	\$162,000
Town Centre	500	16	41	10	0	0	0	\$12,312,300
WF Creek	500	11	33	3	0	0	0	\$8,252,100
L Creek	500	5	6	5	0	0	0	\$3,071,800
Lower MBC	500	5	4	5	1	0	0	\$3,010,100
MB RC Junct.	500	11	4	1	2	0	0	\$2,633,300

Table 6.12 Outside Building Damage Estimates - Existing Scenario

Precinct	ARI (years)	Number of Outside Buildings	Outside Damages
LH & Totness	20	8	\$16,000
S. Growth	20	2	\$4,000
Town Centre	20	20	\$40,000
WF Creek	20	8	\$16,000
L Creek	20	10	\$20,000
Lower MBC	20	14	\$28,000
MB RC Junct.	20	13	\$26,000
LH & Totness	50	13	\$26,000
S. Growth	50	3	\$6,000
Town Centre	50	31	\$62,000
WF Creek	50	13	\$26,000
L Creek	50	21	\$42,000
Lower MBC	50	16	\$32,000
MB RC Junct.	50	27	\$54,000
LH & Totness	100	19	\$38,000
S. Growth	100	6	\$12,000
Town Centre	100	42	\$84,000
WF Creek	100	36	\$72,000
L Creek	100	24	\$48,000
Lower MBC	100	18	\$36,000
MB RC Junction	100	50	\$100,000
LH & Totness	500	24	\$48,000
S. Growth	500	7	\$14,000
Town Centre	500	98	\$196,000
WF Creek	500	196	\$384,000
L Creek	500	39	\$78,000
Lower MBC	500	26	\$52,000
MB RC Junction	500	91	\$182,000

Table 6.13 Total Damage Estimates - Existing Scenario

Precinct	ARI (yrs)	Residential Damages	Commercial / Industrial Damages	Outside Building Damages	Indirect Damages	Total Damages
LH & Totness	20	\$129,300	\$324,000	\$16,000	\$140,700	\$0.61m
S. Growth	20	\$32,300	\$81,000	\$4,000	\$35,100	\$0.15m
Town Centre	20	\$193,900	\$1,134,000	\$40,000	\$410,300	\$1.79m
WF Creek	20	\$113,100	\$405,000	\$16,000	\$160,200	\$0.69m
L Creek	20	\$161,600	\$519,900	\$20,000	\$210,400	\$0.91m
Lower MBC	20	\$193,900	\$1,107,800	\$28,000	\$398,900	\$1.73m
MB RC Junct.	20	\$323,200	\$439,000	\$26,000	\$236,400	\$1.02m
					Total	\$6.9m
LH & Totness	50	\$226,200	\$703,200	\$26,000	\$286,600	\$1.24m
S. Growth	50	\$80,800	\$81,000	\$6,000	\$50,300	\$0.22m
Town Centre	50	\$452,500	\$1,687,900	\$62,000	\$660,700	\$2.86m
WF Creek	50	\$145,400	\$729,000	\$26,000	\$270,100	\$1.17m
L Creek	50	\$323,200	\$1,120,900	\$42,000	\$445,800	\$1.93m
Lower MBC	50	\$242,400	\$1,418,700	\$32,000	\$507,900	\$2.20m
MB RC Junct.	50	\$743,300	\$864,800	\$54,000	\$498,600	\$2.16m
					Total	\$11.79m
LH & Totness	100	\$436,300	\$850,100	\$38,000	\$397,300	\$1.72m
S. Growth	100	\$177,700	\$81,000	\$12,000	\$81,200	\$0.35m
Town Centre	100	\$533,200	\$2,187,000	\$84,000	\$841,300	\$3.65m
WF Creek	100	\$565,600	\$1,883,800	\$72,000	\$756,400	\$3.28m
L Creek	100	\$420,100	\$1,683,000	\$48,000	\$645,300	\$2.80m
Lower MBC	100	\$274,700	\$1,819,200	\$36,000	\$639,000	\$2.77m
MB RC Junct.	100	\$1,438,100	\$1,141,800	\$100,000	\$804,000	\$3.48m
					Total	\$18.05m
LH & Totness	500	\$581,700	\$1,148,300	\$48,000	\$533,400	\$2.31m
S. Growth	500	\$177,700	\$162,000	\$14,000	\$106,100	\$0.46m
Town Centre	500	\$1,085,900	\$12,312,300	\$196,000	\$4,078,300	\$17.67m
WF Creek	500	\$5,461,700	\$8,252,100	\$384,000	\$4,229,300	\$18.33m
L Creek	500	\$840,300	\$3,071,800	\$78,000	\$1,197,000	\$5.19m
Lower MBC	500	\$387,800	\$3,010,100	\$52,000	\$1,035,000	\$4.49m
MB RC Junct.	500	\$2,947,500	\$2,633,300	\$182,000	\$1,728,800	\$7.49m
					Total	\$55.93m

6.6 Structural Flood Mitigation Strategies

6.6.1 Littlehampton and Totness

Clems Lane Flood Flow Path

The flood plain modelling has indicated that properties along Clems Lane downstream of Cleggett Road in Littlehampton are at risk of flooding. The existing creek corridor in this area meanders between the front and back yards of various properties, passing under several driveway crossings and footbridges, before flowing through a less restrictive drainage corridor upstream of North Terrace.

The restricted capacity of the creek in this area forces flood flows to spill onto Clems Lane at the upstream end, and then travel south before flowing back into the creek at the downstream end of Clems Lane. Discussion with property owners has confirmed that this overbank flow of flood waters has occurred several times in the past, and as recently as 2011.



Clems Lane Flow Diversion Works

The proposed solution involves diverting a portion of creek flows through the land bounded by Clems Lane to the west and the railway corridor to the east. The proposed diversion consists of an 1800 x 750 box culvert located at the first driveway crossing downstream of Cleggett Road, which would be constructed under Clems Lane, and then discharge into a 4 metre wide x 800 mm deep open earth channel in the general alignment as shown on the figure below.

New headwalls would be constructed at both the inlet and outlet ends of the culvert. Scour protection measures in the form of rock pitching would be required at the discharge points of both the culvert and channel.

The alignment of the channel is shown to meander within the reserve with an objective to minimise the requirement for tree removal, and then connect to and enlarge the existing informal swales within the reserve to minimise the earthworks volumes required. The proposed alignment has also been selected to avoid clashes with other physical site constraints such as stobie poles, fences, gates, existing water supply infrastructure and a proposed wastewater main upgrade.

The top of bank elevation will sit below the edge of road elevation of the eastern side of Clems Lane to allow local catchment runoff to sheet off the unkerbed road directly into the proposed channel.

The diversion has been sized to provide a 20 year ARI standard of protection against flooding, however the flood plain mapping (refer Section 6.8, Appendix E) shows significant reductions in flood water depths and extents when compared to the Existing Scenario mapping for larger events including the 100 year ARI.

6.6.2 Southern Growth Area

Southern Growth Area Detention Storages

The ongoing changes in land use of the Southern Growth area is resulting in an increase in peak flow rates, as described in Section 4.5, and downstream flood risk.

The opportunity is available to consider stormwater detention storages within this area, in order to mitigate against this increase in flows conveyed by Railway Creek, particularly in areas not yet developed. The *MDPA Area Master Plan (Working Draft) (District Council of Mount Barker, 2014)* illustrates the extent of approved land developments within the urban growth boundary, which with respect to the Railway Creek catchment, indicates the following:

- A western tributary subcatchment, of which the urban zoned portion is largely held in a single land parcel. A stormwater drainage strategy for the creation of 550 allotments within this parcel (known as the 'Springlake' development) was recently approved by Council in association with the first stage of this development proceeding. A permanent water body with surcharge detention storage within the north eastern corner of this land parcel forms part of this first stage of works.
- A central tributary subcatchment, which is predominantly rural. The urban growth area portion of this catchment includes the Adelaide Polo Club grounds (nominated to become the Mount Barker South Sports and Community Hub), and 3-4 other land parcels.
- An eastern tributary subcatchment, which is predominantly within the urban growth area. A light industrial zone is nominated to be accommodated within this catchment. There are 10 land parcels within the urban growth area.



- Additional detention storage within the future stages of the Spinglake development
- Modification to the basin constructed as part of the first stage of the Springlake development
- Diversion of flows to the 'Railway Central' basin and associated incremental increase in sizing of this basin



Springlake development basin (Nearmap aerial photo, March 2015)

The Springlake development stormwater management measures ultimately need to achieve a maximum 100 year ARI discharge of 2.3 m³/s in order to not increase flood risk to the downstream Railway Creek catchment.

Central Tributary

The opportunity to utilise the Adelaide Polo Club grounds as detention storage (as an outcome associated with the proposed transfer of this land to Council ownership and establishment of a Sports and Community Hub at this site) has previously been broadly scoped (Australian Water Environments, 2013).

The opportunity to achieve a single detention storage at this site has been assessed such that the peak 'ultimate development' 100 year ARI flow immediately downstream of the basin is reduced to a level below that is below the existing 100 year ARI peak flow. This flow reduction was maximised, to the extent that this can be reasonably achieved with respect to the active recreation use that is also proposed for this site. A greater flow reduction requirement is considered appropriate for this site, as it is the only Railway Creek detention storage site where such a requirement would not have a direct commercial impact (i.e. impact on land usage and allotment creation).

The opportunity to establish a 'high early discharge' outlet arrangement has been adopted for the purposes of the concept design, in order to optimise the performance of the available flood storage. This is achieved via the establishment of a 'spill bank' aligned between the creek channel and flood storage area. This will also serve to reduce the frequency of inundation of the active recreation area. A concept design drawing for this arrangement is presented in Appendix G.

Eastern Tributary

The opportunity to achieve a single detention basin within the Eastern subcatchment has been scoped such that the peak 'ultimate development' 100 year ARI flow immediately downstream of the basin matches the existing 100 year ARI peak flow. The site of an existing lined dam has been selected for this purpose, as it is the most downstream point of this catchment, receiving flows from both the main tributary and a lateral creek line.

The opportunity to establish a 'high early discharge' outlet arrangement has been adopted for the purposes of the concept design, in order to optimise the performance of the available flood storage. This is achieved via the establishment of a 'spill bank' aligned between the creek channel and flood storage area. Some realignment of the two watercourse lines that enter this site are proposed in order to achieve this in an effective manner.

Residential allotments are proposed to be located immediately north of this detention storage. It is anticipated that an excessively high levee along the interface would create undesirable overlooking issues, and in response to this the concept design relies on excavation to achieve the proposed storage volume.

It is noted that it may be practically difficult (particularly within the eastern tributary subcatchment) for Council to administer and deliver a stormwater strategy where agreement would be required among up to 10 landowners in order to:

- Contribute to a cost sharing funding model for infrastructure and land costs
- Schedule land development and infrastructure delivery in an orderly manner (i.e. downstream to upstream)

A more flexible approach in this instance would be for Council to impose a detention requirement for all land development applications, requiring that the post development peak 100 year ARI flow match the pre-development 100 year ARI 1 hour duration peak ARI flow. Under this approach, Council should wherever possible facilitate collaboration between applicants to rationalise the number of basins that Council will ultimately own and maintain in this area.

Hydrological modelling of the conceptual basin arrangements has demonstrated that the overall outcome of this approach is a 100 year ARI peak flow at Hurling Drive of 22.4 m³/s, which compares favourably against the existing development scenario peak flow estimate of 23.4 m³/s.

6.6.3 Town Centre

The Town Centre is shown to be subjected to excessive surface flows for events in excess of a 50 year ARI. There is also a significant amount of future development to occur above Adelaide Road that will increase peak flows to the Morphett Street drain, such that the 100 year ARI peak flow exceeds the capacity of various reaches of this system between Adelaide Road and the creek outfall by 2 to 3 m³/s.

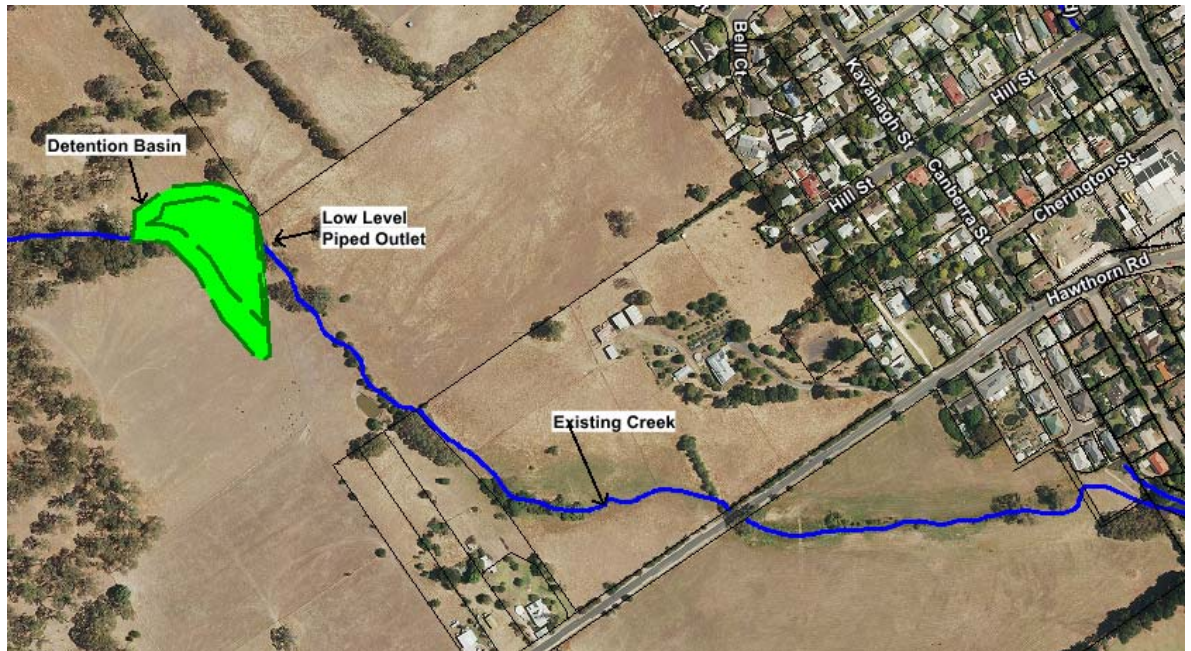
Upgrading the Morphett Street drain is not considered to be a feasible option due to the significant previous works undertaken, that have largely delivered an underground drainage system with a hydraulic capacity that is at the upper limit of what can reasonably be achieved, amongst the underground services and conflicting infrastructure in this corridor. The downstream end of the drain also passes underneath a multi-level shopping centre which also represents a constraint to any further capacity upgrade.

Options have been explored with the aim of improving the performance standard within the main trunk drain at Morphett Street. These options have been developed with a focus on reducing peak flows within the Morphett Street drain, which has a capacity at Adelaide Road of approximately 7 m³/s.

Detention Storage above Adelaide Road

The opportunity to provide a detention basin within private property upstream of Hawthorn Road has been assessed with the aim of reducing the peak flow rates generated by the rural catchment above Adelaide Road, in an area immediately outside of the urban growth boundary.

The figure below shows the inundation footprint associated with an inline basin with a 2.5 metre high bank with a low level piped outlet through the eastern side. The construction of the basin may necessitate the removal of some remnant vegetation.



Potential Hawthorn Road Basin Site

A basin of these extents would achieve a flood storage volume of approximately 2,500 m³. Hydrological modelling of this arrangement indicated that this would reduce the peak 100 year ARI flow upstream of Adelaide Road from approximately 9 m³/s to 8.7 m³/s which is considered to be insufficient to provide a significant improvement to the performance of the main trunk drain down Morphett Street.

Further modelling indicates that a detention basin volume in excess of 10,000 m³ would be required to reduce the peak flow rates upstream of Adelaide Road from 9 m³/s to 7 m³/s in order to provide a sufficient improvement in performance. This is broadly consistent with the results of a previous similar assessment (Tonkin Consulting, 2014). Achieving such a storage at this site would require the basin bank height to exceed 5 metres which increases the difficulties associated with community acceptance and risk assessment considerations. Appropriate consideration of risk posed to downstream development would tend to suggest that such a dam would need to be fortified against damage from a range of events through to extremely rare events, substantially increasing the cost of the dam. It is noted that a previous proposal for a regional detention basin, located downstream of Hawthorn Road, was recently rejected by Council on similar grounds.

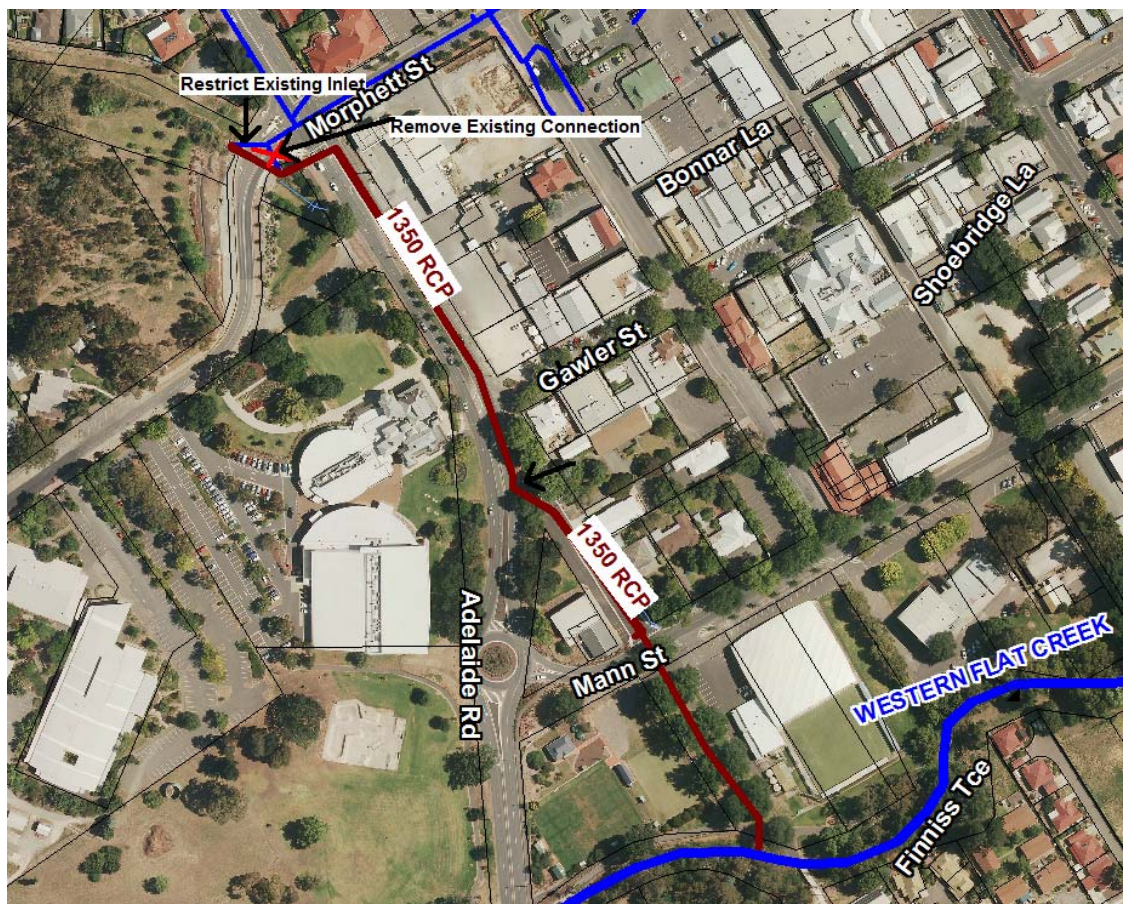
This option has not been adopted as a flood mitigation measure for this Stormwater Management Plan.

Town Centre Diversion Drain

A diversion drain has been proposed from the headwall at the entrance to the 1650 mm diameter Morphett Street trunk drain from Dumas Street to Western Flat Creek. As with the detention basin option, the diversion has been proposed to reduce the peak flows down the Morphett Street drain.

The proposed diversion drain has been sized to reduce the peak flows at the upstream end of Morphett Street by up to $3\text{m}^3/\text{s}$ in the 100 year ARI event, which is sufficient to provide a significant improvement to the performance of the Morphett Street drain. The improvement is such that the 100 year ARI Ultimate Upgrade Scenario map shows lesser inundation extents and depths than those shown during a 50 year ARI event under the Existing Scenario.

The diversion consists of an express drain, taking the form of a gravity (0.3% – 0.5%) 1350 mm diameter drain aligned in Adelaide Road between Morphett Street and Hack Street, and then a steeper alignment from Hack Street to Western Flat Creek adjacent to the Bowling Club.



Proposed Town Centre Drain Diversion

The proposed drain passes under a high point in Adelaide Road, before entering Hack Street which drops off sharply. The peak depth to invert under the high point is estimated to be 4 metres.

A headwall outlet is proposed at Western Flat Creek which would require scour protection measures such as rock pitching to be installed.

The addition of up to 3m³/s of peak flow to Western Flat Creek is assessed to have a tolerable impact on peak flow rates within the creek. This is due to:

- the shorter response time of the Town Centre catchment relative to the Western Flat Creek Catchment; and
- the flood mitigation measures proposed for Western Flat Creek (refer Section 0) ensuring that the creek reach downstream of Adelaide Road will have sufficient capacity to receive these flows.

This works package would be eligible for Stormwater Management Authority funding.

Cameron Road Overflow

A flood flow path from Cameron Road to Littlehampton Creek is proposed to prevent flooding of nearby residential dwellings. The proposed overflow path is to be contained within a driveway adjacent to the existing open channel on the northern side of the Cameron Road car park. The flood flow path is to be constructed to allow up to 0.5 m³/s in the 100 year ARI event to pass through to the creek channel at the downstream end.

Additional supplementary works required within Cameron Road also required, include:

- Roadway shape modification (including existing raised pedestrian crossing) to direct overflows within Cameron Road to spill into the driveway flood flow path.
- Raising footpath levels on eastern side of Cameron Road up to 200mm (on southern side of carpark) to prevent floodwaters entering residential dwellings. This may require driveway level modifications extending into private property.



Proposed Cameron Road Overflow Concept

6.6.4 Western Flat Creek

Detention Storages - above Bollen Road

The flood plain mapping of Western Flat Creek as depicted below has demonstrated that there is a flood risk, below Bollen Road and the Littlehampton Creek confluence, attributable to flows exceeding the capacity of the existing creek channel.



Western Flat Creek 100 year ARI Floodplain, from Australian Water Environments (2011)

Further, as a result of the Mount Barker Urban Growth DPA, a vast area to the south west of Mount Barker, that drains to Western Flat Creek, has been rezoned to allow future residential development. As presented in Table 4.4, this future development scenario has the potential to marginally increase peak flow rates and associated downstream flood risk.

The *MDPA Area Master Plan (Working Draft)* (District Council of Mount Barker, 2014) illustrates that a large area of open space is envisaged to be established in private property immediately upstream of Bollen Road. This open space is largely subject to inundation associated with the 100 year ARI floodplain, and in part also contains the alignment of overhead electricity transmission lines. The site is currently nominated in the *MDPA Area Master Plan* to be the location of the 'Mount Barker South West Sports and Community Hub', as part of a residential land development elsewhere on this land parcel.



Western Flat Creek and adjacent land upstream of Bollen Road

The opportunity is available to integrate stormwater management infrastructure elements into this location in order to achieve flood mitigation storage, and thereby reduce downstream peak flows and flood risk. A general arrangement is presented in Appendix G that illustrates one way that this could be achieved.

A summary of the key features and performance aspects associated with this concept are as follows:

- Detention storage to be divided across 2 areas, an upper storage and a lower storage immediately adjacent to Bollen Road
- Both storages are proposed to be achieved via the 'airspace' above off-line constructed wetlands. The wetlands would be design to receive low flows (via gravity) from the creek / adjoining development in order to provide a water quality improvement function to cater for the future urban development.
- Flood spill banks would be established between the creek and the flood storage areas, in order to achieve a 'high early discharge' scenario through the culverts and connecting creek channels. This ensures that the flood storages are utilised in a hydrologically efficient manner, reducing the amount of detention storage required. During flood event conditions, flood flows would enter the flood storages by building up within the creek channel to the bank threshold level, above which flow would spill over these banks.
- The intention of the concept is for the storage capacities within the confines of the constructed wetlands areas to be engaged preferentially, with the broader areas (which are likely to be established as playing fields / sportsgrounds) to be engaged on a more infrequent basis.
- Culverts within the creek channel draining both storages are shown to be sized to a 100 year ARI standard, such that the storages do not overtop the embankment / roadway for all events up to and including the 100 year ARI event. A spillway is nominated for both embankments to provide a path for overflows resulting from events greater than a 100 year ARI.
- Hydrological modelling of this concept indicates that the peak 100 year ARI flow would be reduced from 58 m³/s to 44 m³/s, with a total utilisation of 70,000 m³ of detention storage.

These works would be partially eligible for Stormwater Management Authority funding. A component of these works would be undertaken in order for the proponent of the land development to meet their stormwater management obligations, and it is only the incremental costs associated with expanding on these site development requirements in order to fulfil the regional strategy that would be eligible for Council and Stormwater Management Authority funding support. The priority for these works must be aligned with the timing of the associated stage of the land development during which other works would occur at this location. Further design development is required in order to refine the initial estimate of Council / Stormwater Management Authority funding contributions nominated in this Stormwater Management Plan.

Channel Capacity Improvements - Adelaide Road to Mt Barker Creek

Western Flat Creek has limited capacity to cater for peak flows generated by the upstream catchment during large rainfall events and is shown in flood plain mapping to overtop its banks and inundate adjoining property. While the proposed detention storage above Bollen Road will reduce peak flow rates, there remains a capacity deficiency within the existing creek channel that fails to provide adequate flood protection during the 100 year ARI event.

Two options were developed with an objective of increasing the capacity of this creek reach. To inform the development of these options, a site analysis was undertaken utilising available engineering survey and site observations to identify key issues and constraints within the corridor, including:

- Large River redgum trees
- Large exotic (shady) trees
- Important native vegetation (where identified by Council staff / supplied reports)

- Major underground services

This information is summarised on a plan presented in Appendix F.



Western Flat Creek, above Hutchinson Street



Western Flat Creek, Hack Street footbridge

The importance of minimising disruption to the existing creek bed was identified, in order to protect local native fish populations of *Mountain Galaxias*, and to preserve some examples of local native riparian vegetation that have largely been lost from the region. In order to avoid issues arising from interfering with these local values, a constraint was adopted in the development of options requiring that no works be undertaken that interfered with the channel invert (to a point that is no less than 500mm above the natural creek invert).

This led to the identification of 2 approaches to achieving greater channel capacity:

- Levee bank on the southern boundary to contain flows within the creek corridor
- Laying back of the upper channel banks to increase overall bank-full channel capacity

These approaches were applied to formulate two options. The performance of the upgrade options was confirmed through modification and execution of the flood plain model. Concept design drawings for these options are shown in Appendix F and are described in more detail below.

Option 1 - Levee Bank

This option consists of a levee bank on the southern side that typically ranges from 500 – 800 mm in height, incorporating a freeboard to the 100 year ARI flood level of 300mm. This levee bank starts between Adelaide Road and Hack Street and continues to the southern Railway Line embankment along Mt Barker Creek. The levee bank is continuous in between each of the three road crossings (Hack Street, Newland Street and Hutchinson Street) and transitions to the existing road levels at the interface of each road. The levee between

Newland Street and Hutchinson Street is partly located within the adjoining private properties, between the top of creek bank and a line of very large pine trees. It is considered likely that future development of these properties will provide Council with the opportunity to obtain easements and achieve an integrated design outcome in this regard.

The proposed levee banks are based on a clay fill construction, with a narrow top width and general side slopes (V:H) of 1:2. In some areas the side slopes may need to be increased to 1:1.5 to enable the levees to fit within the confines of the available corridor. The levees are not proposed to be trafficable and only serve as flood mitigation measures.

Option 2 – Levee Bank, Lay backed Creek Banks

This option is similar to Option 1 in that there is a levee bank proposed from upstream of Hack Street to the Railway Line embankment. However, between Hack Street and Hutchinson Street, the existing path would be relocated and creek bank laid back from 500mm above the invert on a gentler gradient, thereby increasing the cross-sectional area of the creek.

With these proposed reconstruction works in place, it was found that the height of the proposed levee bank directly opposite the works could be reduced by an average of 150mm. This negated the requirement for a levee within a 60 metre section of the bank downstream of Hack Street. More extensive bank laybacks were not incorporated into this option due to the constraints, primarily associated with larger exotic trees in doing so. While it would be beneficial from a natural resource management perspective to remove these exotic trees and establish native vegetation through this process, many of these trees are extremely large and hence represent a high amenity value to the local community. This issue is understood to have resulted in the failure of a similar previous proposal to lay back creek banks in the early 2000's. Bank layback on the southern embankment is not considered technically feasible due to the limited space available along most of the alignment.

Option 1 was assessed to have a lower cost, lower level of impact to regulated trees, and higher anticipated level of community support relative to Option 2. This Stormwater Management Plan has adopted Option 1 as the proposed flood mitigation strategy for this reach of Western Flat Creek. This works package would be eligible for Stormwater Management Authority funding.

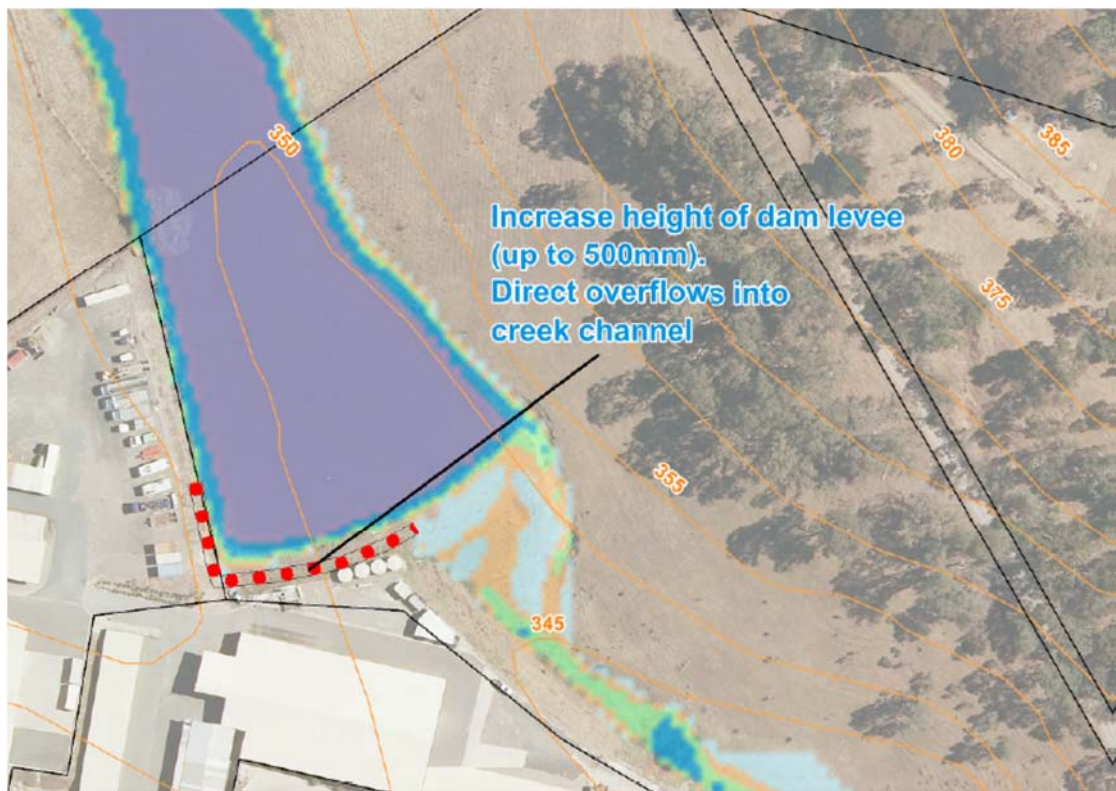
6.6.5 Littlehampton Creek

Totness Tributary Industrial Estate

A potential flood risk was identified with respect to overflow from a large dam located immediately north of an industrial precinct on the northern side of Mount Barker Road in Totness.

Raising of the bank around the dam is recommended to ensure that dam overflows are directed in a controlled manner to the downstream creek channel, rather than spilling through the industrial estate.

Given that the dam and affected land is entirely within private ownership, it is recommended that Council notify the affected landowners of the issue and provide logistical support in the design and development of remedial works.



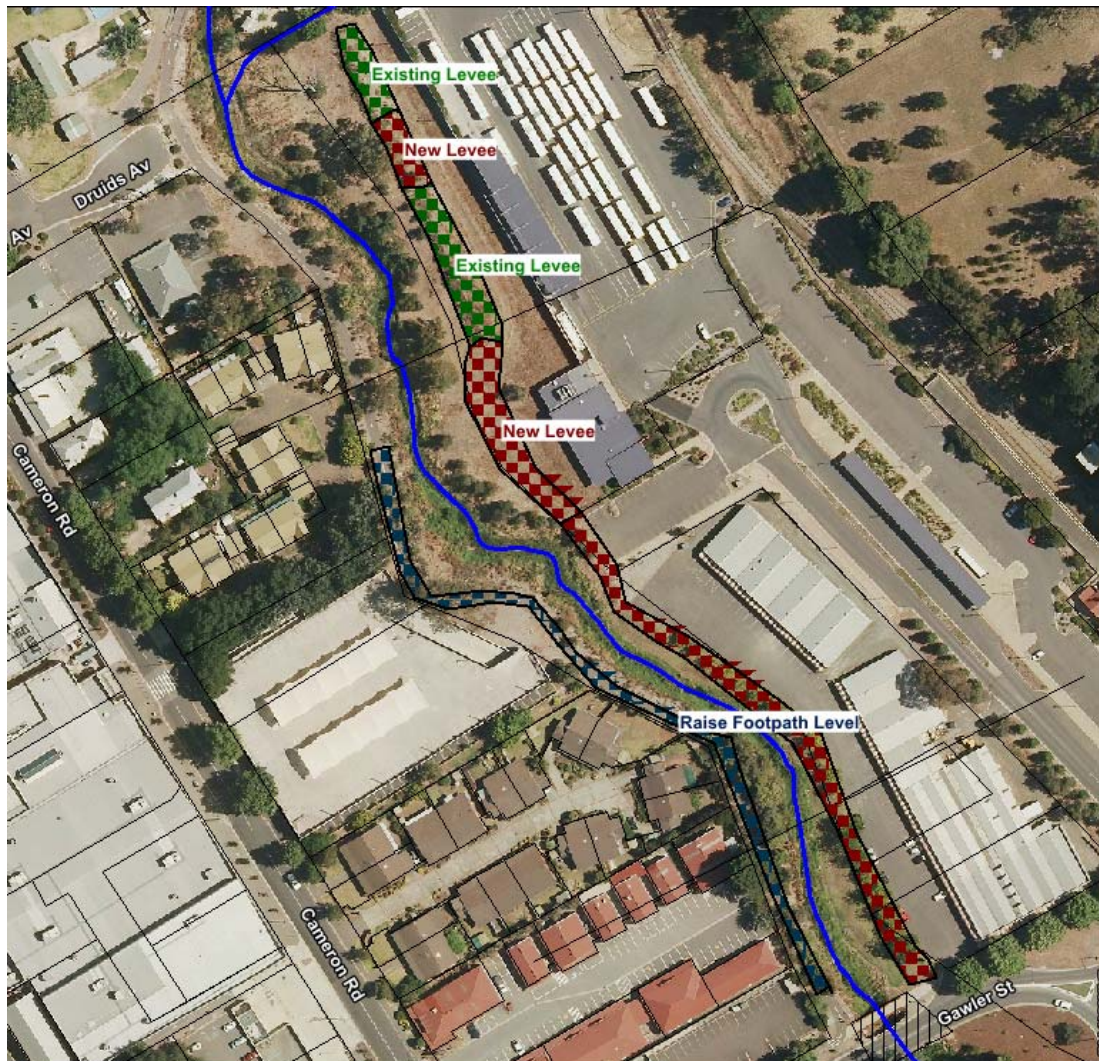
Totness Industrial Estate Dam Overflow Concept

Proposed Levee Banks, Druids Avenue to Gawler Street

The flood mapping indicates an existing flood risk for the commercial district between Druids Avenue and Gawler Street.

On the eastern side, there are some short sections of existing earth bank levees currently in place, with an approximate height of 2 metres. A new levee is proposed to fill in the area between the two existing levees and extend further south to Gawler Street. The new levee between the existing banks does not need match the existing levee height. The proposed levee bank has a maximum height of 800 mm. Flap gates would need to be installed on any existing local drains draining under the levee into the creek.

On the western bank, it is proposed to raise the shared path level as a means of providing flood protection whilst maintaining the current functionality. The new footpath does not extend all the way to Druids Avenue as it does not appear that existing dwellings in the area are at risk of inundation, although this should be reviewed as part of any future detailed design.



Druids Avenue to Gawler Street Levees

Eastern Bank Levee, Gawler Street to Home Maker Centre

The floodplain mapping shows the potential for flows to break out downstream of Gawler Street, and travel south to the industrial precinct and the Home Maker Centre which has the potential to incur significant damages.

The section of Littlehampton Creek downstream of Gawler Street is confined to a tight corridor that leaves little room for creek capacity improvement.

Therefore it is proposed to construct a levee (concrete) wall alongside MacFarlane Terrace that would be aligned on the outside of the eastern bank.

The proposed levee would be approximately 700mm high (incorporating 300mm freeboard) and would extend to the section of road opposite the footbridge from Kia Ora Street. Downstream of this point, the creek depths increase and the floor levels are elevated significantly (typically over 0.5 metres) above the top of creek.



Druids Avenue to Home Maker Centre Levee

6.6.7 Railway Creek / Mt Barker Creek Junction

Creek Capacity Improvements - Hurling Road to Wellington Road

A concept design for the reconstruction of this creek reach was recently completed (Wallbridge & Gilbert, 2011). The design development process for the 'Bluestone' residential land development, under construction at that time, clarified that the creek and culverts downstream of the development did not have sufficient capacity to convey the 100 year ARI flow.

Works to upgrade the culvert crossing at Hurling Drive and Faehrmann Drive, and the intervening creek channel have since been completed. The hydraulic design of this completed reach was based on an assumption that further works will be undertaken in the downstream reach extending though to Wellington Road. The concept design prepared for this reach adopted an integrated approach to achieve the following objectives:

- Flood protection of existing properties, through increasing the creek capacity.
- Minimise risks to public safety by adopting stable bank grades where achievable and considering barrier fencing on a merit basis where excessive grades are encountered.
- Cost efficiency and sustainability in design, achieved via optimising culvert sizes and minimising the span for replacement pedestrian bridge.
- Conservation of native vegetation where possible by managing the creek alignment and flood plain with particular attention to significant trees.
- Maintained amenity through the provision of large open flat space, maintaining established native trees and providing for pathways allowing connection adjacent public open space.
- Improved visual amenity through the introduction of meanders to the creek and excavation lines, habitat ponds, riparian and ephemeral zones and ultimately landscaping across the works.
- Water quality improvements through reduced low-flow bed grades (created by meanders) and shallow ponds together reducing flow velocity.
- Environmental improvements including restoring native vegetation and in turn habitat to return to a more natural ecosystem.

The concept design adopted a design flow rate of 33.4 m³/s, which is well in excess of the 100 year ARI peak flow estimate of 24.1 m³/s that the hydrological modelling prepared for this Stormwater Management Plan indicates would be achieved, in association with proposed Southern Growth Area detention storages and ultimate development catchment conditions.

The existing creek channel is estimated to have a (bank full) channel capacity of approximately 25 m³/s, which suggests that these upgrade works are not of importance when assessed on flood protection criteria. Despite this, the 2011 concept design is adopted as a recommendation of this Stormwater Management Plan due to the following:

- The concept delivers on a broad range of desirable environmental and watercourse management objectives that are consistent with the objectives of this Stormwater Management Plan
- The feasibility of being able to pass a slightly higher channel flow capacity through this reach provides Council with some flexibility in the delivery of the Southern Growth area detention basin storages.

Creek Capacity Improvements - Fletcher Road to Mt Barker Creek

Downstream of Fletcher Road, Railway Creek joins with Mt Barker Creek. The flood plain maps indicate that the lower lying properties in this area are at risk of inundation during the 100 year ARI event. From the area downstream of Frame Court, there is sufficient room to provide levee banks along the Railway Creek and Mt Barker Creek banks. There is an existing gravel path on the western Railway Creek embankment that extends to the southern bank of Mt Barker Creek and continues to the walkway under the railway line embankment. There is also a footbridge at the downstream end of Railway Creek that connects to further rubble footpaths to the east of the creek.

Therefore, areas which are subject to foot traffic such as the rubble paths and footbridges are proposed to be raised to provide flood protection without compromising the current functionality of the area. In areas without a path or footbridge, earth levee banks are proposed in a similar fashion to those proposed along Western Flat Creek.

The height of the levee / raised path required is 1 metre along the boundary of Mt Barker Creek. This is reduced to approximately 500 mm along Railway Creek opposite Frame Court. It is expected that the levee banks and proposed works would transition between these two heights. Non-return flap gates would need to be installed on stormwater drain outfalls from Victoria Crescent, Hampden Road, while the drainage in Bernhardt Court is proposed to be reconfigured with a new pump station to enable this area to be drained during times of high creek flow.

Immediately downstream of Fletcher Road, the close proximity of property boundaries and fences make levee construction infeasible. Therefore in the section of creek from Fletcher Road to Frame Court, it is proposed to widen the creek to provide additional flow capacity. A diagram of the proposed works is shown below, with concept plans in Appendix F.



Railway Creek / Mt Barker Creek Junction Proposed Works

6.7 Hydrology Results, Ultimate Upgrade Scenario

The Mount Barker Creek Catchment DRAINS model as described in Section 4 was refined to include the structural flood mitigation measures described in Section 6.6.

Peak flows at key locations of interest (as reported in Table 4.4) are presented in Table 6.14. These results demonstrate that:

- The flow mitigation measures on Western Flat Creek (flood storage above Bollen Road) achieves a measurable reduction in peak flows which continue through to Mount Bark Creek below the confluence with Littlehampton Creek
- The detention storage measures proposed in the Southern Growth Area area are effective in mitigating against increases in peak flows to Hurling Drive. The slight increase in flows downstream of Hurling Drive (and the changes in hydrological response associated with the additional urban development) underlines the importance of measures to increase channel capacity below Hurling Drive and to undertake maintenance activities to remove flow obstructions.
- Future development of land draining to Golf Course Creek and Duck Flat Creek will require flood mitigation measures consistent with Council's standard requirements (not factored into this hydrological assessment) in order to maintain pre-development hydrology.

Table 6.14 Ultimate Upgrades Creeks 100 yr ARI Peak Flow Comparison

Location	Existing Peak Flow (m ³ /s)	(Unmitigated) Ultimate Peak Flow (m ³ /s)	(Mitigated) Ultimate Peak Flow (m ³ /s)
Western Flat Creek (at Bollen Rd)	55.8 (6 hr)	57.7 (6 hr)	43.6 (6 hr)
Railway Creek (at Hurling Dve)	23.4 (6 hr)	28.3 (1.5 hr)	22.4 (1.5 hr)
Duck Flat Creek (outfall to Mt Barker Ck)	9.5 (6 hr)	21.7 (1.5 hr)	21.7 (1.5 hr)
Railway Creek (outfall to Mt Barker Ck)	26.5 (6 hr)	34.1 (1.5 hr)	29.1 (1.5 hr)
Golf Course Creek (outfall to Mt Barker Ck)	3.0 (6 hr)	8.9 (1.5 hr)	8.9 (1.5 hr)
Littlehampton Creek (at Cleggett Rd)	19.2 (6 hr)	19.9 (6 hr)	19.9 (6 hr)
Mt Barker Creek (below confluence of Western Flat Creek, Littlehampton Creek)	87.1 (6 hr)	91.5 (6 hr)	80.6 (6,12 hr)
Mt Barker Creek (Gauge A4260557)	123 (12 hr)	134 (12 hr)	127 (12 hr)

6.8 Flood Plain Mapping Results, Ultimate Upgrade Scenario

6.8.1 Scope of Mapping

The flood plain mapping scope for the Ultimate Upgrade Scenario was greater than that of the Existing Scenario, with the addition of sections of Western Flat, Railway, Littlehampton and Mt Barker Creeks that are located in the most heavily developed areas of Mt Barker. This additional model was termed the Main Township Creeks model, and the extents of the mapping are depicted in Figure 6.4.

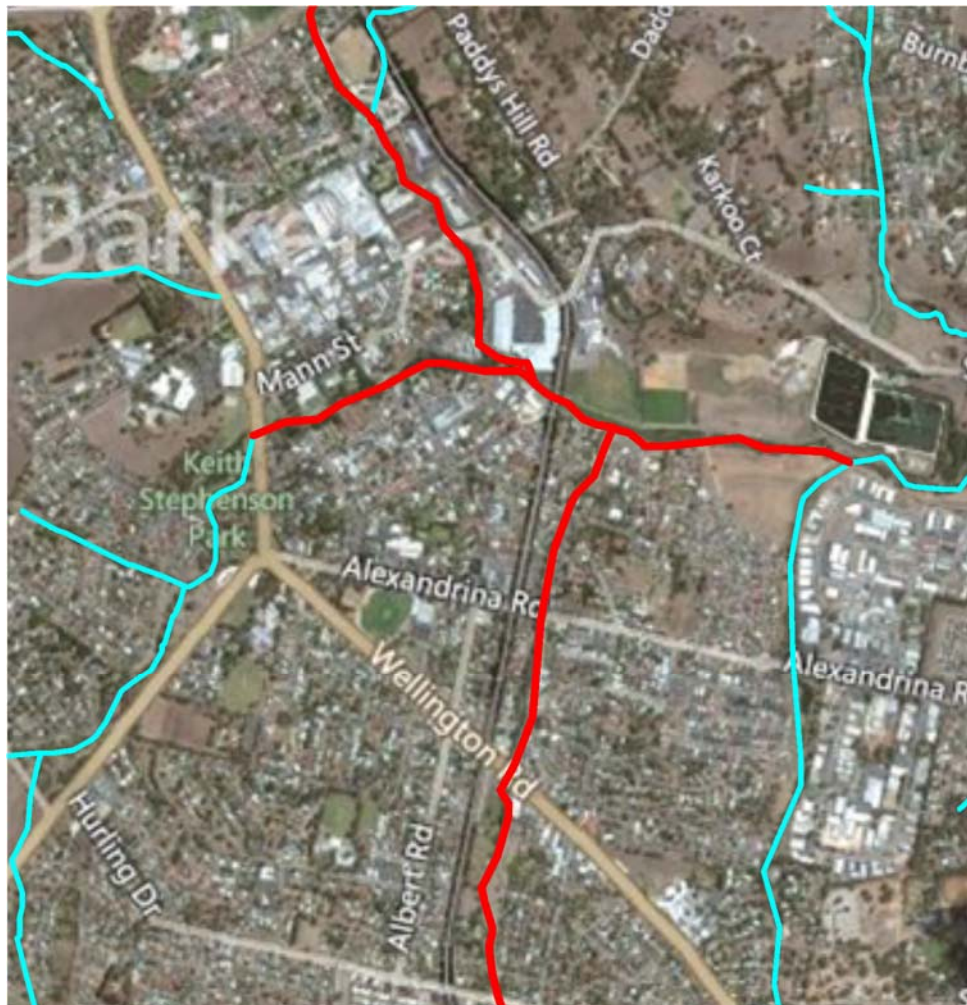


Figure 6.4 Main Township Creeks Model Extents

The TUFLOW modelling for this additional area was a 1D/2D model, in which the creeks and culvert crossings were modelled in 1D, whilst the overbank and flood plain was modelled in 2D. Existing creek and structure survey that was obtained by Council for previous investigation and design projects was made available for use within the modelling. This survey covered the majority of the watercourses that were modelled. New survey was commissioned for the section of Railway Creek between Wellington and Alexandrina Roads.

The TUFLOW modelling parameters are summarised below:

- 3 metre cell size within the 2D domain
- Downstream boundary condition was a "HQ" stage discharge curve as per the other creek models (Littlehampton & Totness, Southern Growth Area).
- Surface roughness values as used in the Existing Scenario flood plain models

- A Manning's n roughness of 0.07 for all creeks.
- Hydrological inputs generated from the DRAINS modelling undertaken for the Ultimate Upgrade Scenario which included the use of detention basins for peak flow attenuation.

6.8.2 Design Event Runs

The floodplain mapping for the major creeks was undertaken for only the major events (100 year and 500 year ARI events) whilst the Town Centre was modelled for the 50 and 100 year ARI events as per the Existing Scenario. Various storm durations were modelled within each ARI event in order to determine the critical durations for each event.

Similarly to the Existing Scenario, it was found that the flooding extents in various parts of the catchment differed based on the storm duration that was modelled. Therefore, the results presented in the floodplain maps are based on a combination of critical events and can be assumed to represent the worst case scenario or flood envelope for each ARI. The critical storm durations for each ARI are shown in Table 6.15.

Flood plain and hazard maps for each ARI and scenario have been prepared and are presented in Appendix E.

Table 6.15 Critical Storm Durations for each ARI

TUFLOW and ESTRY Model	Average Recurrence Interval	Critical Storm Durations
Mt Barker Town Centre	50 years	20 min, 3 hrs
	100 years	20 min, 3 hrs
Littlehampton & Totness	100 years	90 min, 6 hrs
	500 years	90 min, 6 hrs
Southern Urban Growth Area	100 years	90 min
	500 years	90 min
Main Township Creeks	100 years	90 min, 6 hrs
	500 years	90 min, 6 hrs

6.8.3 Main Township Creek Mapping Commentary

100 Year ARI

With all of the proposed mitigation strategies in place, there is very little flooding shown within each major creek reach. Western Flat and Littlehampton Creeks are entirely contained within the banks and their proposed levees with peak channel flood depths in the 1.5 – 2.5 metre range.

Mt Barker Creek is shown to spill mainly to the north, where there are no levee banks being proposed. There is also some spill to the south downstream of the proposed raised access paths. Peak depths in this creek are above 2.5 metres.

Within Railway Creek, the Hurling Drive and Faehrmann Avenue culverts are shown to pass the peak flow without overtopping. Downstream of Faehrmann Avenue the maps show floodwaters travelling along Separation Avenue with peak flood depths above 0.5 metres. The remainder of Railway Creek is shown to be contained within the embankments and proposed levee banks.

500 Year ARI

The 500 year ARI map shows significantly greater depths and extents of flooding when compared to the 100 year ARI event. Western Flat Creek breaks out in the vicinity of Hack Street, Newland Street and downstream of Hutchinson Street with floodwaters up to 0.5 metres deep.

Littlehampton Creek breaks out near Cameron Road as well as within the Commercial Precinct to the north of Gawler Street, where flood depths of up to 1 metre can be seen. Flood waters are also shown to enter the Home Maker Centre with inundation depths ranging from 250 – 500 mm.

Railway Creek is shown to spill across the full length from Hurling Drive to Mt Barker Creek. Peak flood depths of up to 1 metre can be seen upstream of Wellington Road as well as between Alexandrina and Fletcher Roads.

Mt Barker Creek is also shown to have significantly greater depths and extents of flooding when compared to the 100 year ARI event, however the wastewater lagoons appear to be elevated sufficiently such that they are not subjected to inundation.

6.8.4 Town Centre Mapping Commentary

50 Year ARI

The 50 year ARI flood plain map shows areas of shallow flooding (100 – 250mm) that is mostly contained within the road network throughout the town centre. The flooding is mainly evident along Morphett Street, Walker Street, Hutchinson Street, Cameron Road and Druids Avenue. Flows enter the shopping centre complex from Druids Avenue and pond with depths up to 500 mm.

Ponding up to 1.5 metre deep is evident at the entrance to the main drain upstream of Adelaide Road. The parcel of land between Stephen Street and Hutchinson Street to the north of Morphett Street is inundated with depths up to 250 mm.

The undercover shopping centre carpark bounded by Morphett Street, Hutchinson Street and McLaren Street is not shown to be inundated.

At the downstream end of the model, flood flows are shown to bypass the underground carpark between Cameron Road and Littlehampton Creek and flow around both the northern and southern perimeters of this complex.

100 Year ARI

The 100 year ARI flood plain map shows greater depths and extents of flooding when compared to the 50 year ARI mapping. The flood depths and extents have increased noticeably along Morphett Street, Walker Street and Hutchinson Street, with flood depths in the range of 250mm – 500mm. Minor increases are also evident along Cameron Road and Druids Avenue.

Ponding up to 2.5 metres deep is evident at the entrance to the main drain upstream of Adelaide Road and floodwaters up to 100mm deep are shown to overtop Adelaide Road to the south of Morphett Street, however these do not reach adjacent properties. The parcel of land between Stephen Street and Hutchinson Street to the north of Morphett Street is inundated with depths up to 0.5 metre.

The underground carpark area bounded by Morphett Street, Hutchinson Street and McLaren Street is shown to be inundated with shallow flooding mostly up to 100mm deep, with a few

discrete pockets showing depths up to 250mm. McLaren Street is mostly free from inundation.

At the downstream end of the model, flood flows travel through the underground carpark between Cameron Road and Littlehampton Creek with flooding up to 250 mm deep.

6.8.5 Littlehampton / Totness Mapping Commentary

100 Year ARI

The entire creek reach between Kym Avenue and Junction Road appears to flood in the 100 year ARI event. However the flood flows do not enter private properties and are contained in the creek reserve. At the eastern side of Littlehampton the flood plain depths and extents are similar to those in the Existing Scenario.

Creek overtopping and flooding of properties with depths of up to 500mm is shown in the reach adjacent to Cleggett Road, particularly in the vicinity of Rosella Court.

Downstream of Cleggett Road, flooding can be seen within the Clems Lane properties with the majority shown to have a maximum flood depth of 250 mm but with isolated pockets of inundation with depths of up to 500mm also evident.

Within Totness, floodwaters remain confined to the channel on the northern boundary of the commercial precinct.

Downstream of the commercial precinct floodwaters overtop Kookaburra Lane and North Terrace and travel to the eastern tributary.

At the southern end of Totness, flood flows are shown to travel at depths of up to 500mm within the natural valley between the dam and the entrance to the orifice plate fitted 1500 mm diameter pipe under the South Eastern Freeway.

500 Year ARI

The creek reaches upstream of Junction Road are shown to overtop and flow at greater depth when compared to the 100 year ARI event, however there appears to be minimal risk to properties along these reaches with the exception of those on the corner of Benjamin Gray Drive and Junction Road.

Creek overtopping and flooding of properties with depths of up to 1 metre is shown in the reach adjacent to Cleggett Road, particularly in the vicinity of Rosella Court.

Downstream of Cleggett Road, flooding can be seen within the Clems Lane properties with the majority shown to have a maximum flood depth of 500mm – 1 metre. The floodplain extents upstream of North Terrace are also noticeably wider when compared to the 100 year ARI event.

Within Totness, the commercial precinct is shown to be inundated at the upstream end with depths in the range of 250mm – 500mm.

Significantly more ponding is observed at the upstream of the South Eastern Freeway culvert crossings in both Littlehampton and Totness when compared to the 500 year ARI event.

6.8.6 Southern Urban Growth Area Mapping Commentary

100 Year ARI

The flood plain shown for the 100 year ARI event has a very similar pattern to that of the Existing Scenario, with a slight decrease in overall flood depths and extents due to the peak flow attenuation provided by the proposed detention basins.

500 Year ARI

The western tributary is shown to spill in various locations including Barker Road, West Parkway and in the vicinity of the railway crossing, with flows up to 500mm deep travelling towards Hurling Drive. The central and eastern tributaries appear to merge due to floodwaters connecting the two reaches with depths of up to 1 metre.

Flooding with a maximum depth of 500mm can be seen on Siding and Kennebec Courts.

6.9 Flood Mitigation Benefits Evaluation

The residual flood damages arising under the ultimate upgrade scenario have been evaluated, consistent with the methodology outlined in Section 6.5.1. The results are summarised in the tables below.

Table 6.16 Residential Properties and Damage Estimates, Future Scenario

Precinct	ARI (yrs)	No. of Properties Inundated at each Depth Range				Damage Estimate
		0.15 - 0.6m	0.6 - 1.5m	1.5 - 2m	Over 2m	
LH & Totness	100	6	1	0	0	\$242,400
S. Growth	100	1	1	0	0	\$80,800
Town Centre	100	14	3	0	0	\$597,900
WF Creek	100	6	1	0	0	\$242,400
L Creek	100	0	0	0	0	\$ -
Lower MBC	100	7	1	0	0	\$274,700
MB RC Junct.	100	1	2	0	0	\$129,300
LH & Totness	500	13	3	0	0	\$565,600
S. Growth	500	4	1	0	0	\$177,700
Town Centre	500	26	4	1	0	\$1,085,900
WF Creek	500	29	14	0	0	\$1,615,900
L Creek	500	2	6	0	0	\$355,500
Lower MBC	500	9	2	0	0	\$387,800
MB RC Junct.	500	28	1	1	0	\$1,005,100

Table 6.17 Commercial / Industrial Properties and Damages, Future Scenario

Precinct	ARI (yrs)	No. of Properties Inundated at each Depth Range						Damage Estimate
		0 - 0.25m	0.25 - 0.75m	0.75 - 1.25m	1.25 - 1.75m	1.75 - 2m	2 - 10m	
LH & Totness	100	3	0	0	1	0	0	\$573,100
S. Growth	100	0	0	0	0	0	0	\$ -
Town Centre	100	11	2	0	0	0	0	\$1,282,900
WF Creek	100	0	0	0	0	0	0	\$ -
L Creek	100	3	0	0	0	0	0	\$243,000
Lower MBC	100	3	5	2	0	0	0	\$1,819,200
MB RC Junct.	100	0	2	0	0	0	0	\$391,900
LH & Totness	500	2	2	0	0	1	0	\$905,300
S. Growth	500	2	0	0	0	0	0	\$162,000
Town Centre	500	16	42	9	0	0	0	\$12,210,000
WF Creek	500	1	0	0	0	0	0	\$81,000
L Creek	500	5	5	5	0	0	0	\$2,875,900
Lower MBC	500	5	4	5	1	0	0	\$3,010,100
MB RC Junct.	500	0	3	2	0	0	0	\$1,184,300

Table 6.18 Outside Building Damage Estimates - Future Scenario

Precinct	ARI (years)	Number of Outside Buildings	Outside Damages
LH & Totness	100	11	\$22,000
S. Growth	100	2	\$4,000
Town Centre	100	30	\$60,000
WF Creek	100	7	\$14,000
L Creek	100	3	\$6,000
Lower MBC	100	18	\$36,000
MB RC Junct.	100	5	\$10,000
LH & Totness	500	21	\$42,000
S. Growth	500	7	\$14,000
Town Centre	500	98	\$196,000
WF Creek	500	44	\$88,000
L Creek	500	23	\$46,000
Lower MBC	500	26	\$52,000
MB RC Junct.	500	35	\$70,000

Table 6.19 Total Damage Estimates - Future Scenario

Precinct	ARI (yrs)	Residential Damages	Commercial / Industrial Damages	Outside Building Damages	Indirect Damages	Total Damages
LH & Totness	100	\$242,400	\$573,100	\$22,000	\$251,250	\$1,089,000
S. Growth	100	\$80,800	\$ -	\$4,000	\$25,440	\$110,000
Town Centre	100	\$597,900	\$1,282,900	\$60,000	\$582,240	\$2,523,000
WF Creek	100	\$242,400	\$ -	\$14,000	\$76,920	\$333,000
L Creek	100	\$ -	\$243,000	\$6,000	\$74,700	\$324,000
Lower MBC	100	\$274,700	\$1,819,200	\$36,000	\$638,970	\$2,769,000
MB RC Junct.	100	\$129,300	\$391,900	\$10,000	\$159,360	\$691,000
					Total	\$7,839,000
LH & Totness	500	\$565,600	\$905,300	\$42,000	\$453,870	\$1,967,000
S. Growth	500	\$177,700	\$162,000	\$14,000	\$106,110	\$460,000
Town Centre	500	\$1,085,900	\$12,210,000	\$196,000	\$4,047,570	\$17,539,000
WF Creek	500	\$1,615,900	\$81,000	\$88,000	\$535,470	\$2,320,000
L Creek	500	\$355,500	\$2,875,900	\$46,000	\$983,220	\$4,261,000
Lower MBC	500	\$387,800	\$3,010,100	\$52,000	\$1,034,970	\$4,485,000
MB RC Junct.	500	\$1,005,100	\$1,184,300	\$70,000	\$677,820	\$2,937,000
					Total	\$33,969,000

The total reduction in direct tangible damages when comparing the future scenario to the existing scenario is shown in Table 6.20.

Table 6.20 Potential Reduction to Damages

Precinct	ARI (years)	Existing Damages	Future Damages	Reduction in Damages
LH & Totness	100	\$1.72m	\$1.09m	\$0.63m
S. Growth	100	\$0.35m	\$0.11m	\$0.24m
Town Centre	100	\$3.65m	\$2.52m	\$1.12m
WF Creek	100	\$3.28m	\$0.33m	\$2.95m
L Creek	100	\$2.80m	\$0.32m	\$2.47m
Lower MBC	100	\$2.77m	\$2.77m	\$0
MB RC Junct.	100	\$3.48m	\$0.69m	\$2.79m
	Total	\$18.05m	\$7.84m	\$10.21m
LH & Totness	500	\$2.31m	\$1.97m	\$0.34m
S. Growth	500	\$0.46m	\$0.46m	\$0
Town Centre	500	\$17.67m	\$ 17.54m	\$0.13m
WF Creek	500	\$18.33m	\$2.32m	\$16.01m
L Creek	500	\$5.19m	\$4.26m	\$0.93m
Lower MBC	500	\$4.49m	\$4.49m	\$0
MB RC Junct.	500	\$7.49m	\$2.94m	\$4.56m
	Total	\$55.93m	\$33.97m	\$21.96m

6.10 Non-structural Flood Mitigation Strategies

To complement the proposed structural options, a number of non-structural flood mitigation options are also proposed. 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.

Development Controls

Floor Levels

It is recommended that Council continue to ensure that all new development within the catchment have a floor level that is at least 300mm above the 100 year ARI flood plain, as depicted on the flood plain maps of the area, consistent with the provisions contained within the current Development Plan.

The potential future construction of levees and flood storages will reduce the flood risk of the area. However, it should be noted that levees have an inherent risk of failure, and can be overtopped by events greater than the design flood, and hence it is recommended that wherever possible floor levels within those areas shown to be at risk should be elevated to provide a greater resilience to the area.

Community Flood Response and Preparedness

SES Community FloodSafe Program

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
- 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
- How to call for SES response

Since its inception in 2009, many metropolitan and regional South Australian councils have joined the FloodSafe program. With the flood plain mapping of Mount Barker already publicly available via Council's website, along with advice to residents on measures they can take to reduce their flood risk and steps to preparing a Personal Flood Action Plan, further targeted efforts could now be made to engage with the local SES group and community.

6.11 Action Summary

A consolidated summary of flood mitigation strategies across the study area is presented in Table 6.21. Each issue has been prioritised based on a ratio of estimated reduction in damages (100 year ARI) against the budget estimate for the corresponding capital works, as follows:

- High priority – Ratio > 4
- Medium priority – Ratio between 2 and 4
- Low priority – Ratio < 2

Table 6.21 Flood Mitigation Works Action Summary

ID	Project / Activity	Region	Priority	Budget Estimate	100yr Red Damages / Budget Est	Design ARI, Description
1	Clems Lane Flow Diversion	LH & Totness	Low	\$390,000 ¹	1.6	20 year ARI, Divert portion of creek flows via culvert and open channel past properties on Clems Lane
2	Detention Basin Storages	Southern Growth	Low ²	\$610,000 ³	0.4	100 year ARI, Construct 3 detention basins on 3 separate tributaries to the south of the Bluestone Development to attenuate peak flows from redeveloped areas.
3	Pipe Diversion – Adelaide Road to Western Flat Creek	Town Centre	Low	\$1,560,000 ¹	0.7	100 year ARI, Provide a large diameter diversion drain from Morphett Street to Western Flat Creek via Adelaide Road and Hack Street.
4	Bollen Road Storage	Western Flat Creek	Medium	\$630,000 ^{1,3}	3.1	100 year ARI, Provide 70,000 m ³ of detention storage
5	Adelaide Road to Railway Line Levee Banks	Western Flat Creek	Medium	\$330,000 ¹	3.1	100 year ARI, Construct flood protection levees along southern bank from Adelaide Road to the Railway line.
6	Druids Road to Gawler Street Levees	Littlehampton Creek	Medium	\$410,000 ¹	3.0	100 year ARI, Construct levee banks, raise footpath to provide flood protection
7	Gawler Street to Home Maker Centre Levee	Littlehampton Creek	Medium	\$410,000 ¹	3.0	100 year ARI, Construct levee bank on one lane of MacFarlane Street to provide flood protection
8	Creek Reconstruction – Faehrmann Avenue to Wellington Road	Southern Growth	Low	\$1,620,000	-	100 year ARI, reconstruct creek to provide areas of increased capacity, improve amenity and water quality
9	Creek capacity works and Levee Banks – Fletcher Road to Mt Barker Creek	Railway Creek / Mt Barker Creek Junction	High	\$640,000 ¹	4.4	100 year ARI, undertake channel widening downstream of Fletcher Road and construct levee banks and raised paths near Mt Barker Creek.
10	Totness Dam Overflow	LH & Totness	Medium	\$70,000	-	100 year ARI, Construct bank to direct overflows to spillway
11	Cameron Road to Littlehampton Creek	Town Centre	Low	\$100,000	0.7	100 year ARI, Construct overland flow path for major

ID	Project / Activity	Region	Priority	Budget Estimate	100yr Red Damages / Budget Est	Design ARI, Description
	Major Flow Path					flows along existing driveway alignment
12	Floodsafe Program	-	High	\$10,000	-	Engage with local SES group to deliver program

¹ Project eligible for Stormwater Management Authority funding

² Priority dictated by timing of land developments

³ Project cost to be borne by land development applicant. A portion of the Bollen Road Storage (ID 4) to be borne by Council due to works solving a pre-development problem

7 Water Quality

7.1 Receiving Waters

Stormwater runoff generated within Mount Barker, Totness and Littlehampton is discharged into Mount Barker Creek or one of its tributaries. Mount Barker Creek is a tributary of the Bremer River which ultimately discharges into Lake Alexandrina (refer Figure 2.1).

Pollutants generated through urban runoff that impact waterway health include:

- Gross pollutants (larger objects, anthropogenic waste and green waste)
- Sediment
- Dissolved pollutants (nutrients, hydrocarbons and coloured dissolved organic matter)
- Pathogens

Water quality in Mount Barker Creek is also impacted by rural land practices, and discharges from the Mount Barker wastewater treatment plant.

The water quality of Mount Barker Creek (at Springs Road, approximately 4km east of the township) has previously been classified as 'Poor' (EPA, 2010), highlighting that management practices across the catchment (urban and rural) are not adequately protecting natural environmental habitats. Key features of the watercourse at the survey site were noted to be:

- Permanently flowing, freshwater stream in autumn and spring
- Moderately diverse macroinvertebrate community with a few rare and sensitive species
- Obvious signs of gross nutrient enrichment
- Riparian vegetation mostly comprised introduced grasses and weeds

The EPA assessment reported that the creek was given a 'Poor' rating because "the site samples showed evidence of major changes in ecosystem structure and moderate changes to the way the ecosystem functions. There was considerable evidence of human disturbance, including very high nutrient loads due to discharges from the wastewater treatment plant, fine sediment deposition and a lack of native vegetative cover in the riparian zone." A breakdown of the evaluation (EPA, 2011) showed that the 'Poor' rating was based on an even split of 'Fair' and 'Poor' ratings between the four evaluation panel members.

A summary of identified pressures and recommended management responses to improve the water quality in Mount Barker Creek was summarised (EPA, 2010) and is presented in Table 7.1.

Table 7.1 Mt Barker Creek Ecosystem Pressures, Responses (EPA, 2010)

Pressures	Management Responses
Livestock have direct access at the site and upstream, causing sediment erosion and adding excessive nutrients (which leads to habitat disturbance, algal growth and aquatic weeds).	The SA Murray-Darling Basin NRM Board acknowledges the significant impacts that livestock have on aquatic environments and seeks to provide free technical advice and incentives to land managers for fencing and other works as funding permits. Funding incentives are limited in value and extent and require land managers to volunteer to be involved.

Pressures	Management Responses
Limited riparian vegetation at the site and upstream, providing minimal buffer protection from catchment landuses (reducing habitat quality).	The SA Murray–Darling Basin NRM Board recognises that the management of riparian vegetation requires a long-term, integrated approach to achieve ecosystem benefits. The board therefore provides free technical advice on a range of topics for land managers and various incentives for works as funding permits.
Insufficient natural water flows resulting from water extraction and climate variability (reducing ecological integrity).	The SA Murray–Darling Basin NRM Board is working with the Department for Water and the community to develop a water allocation plan and licensing system which aim to balance social, economic and environmental needs for water. The objective for providing water to the environment is to maintain and/or restore self-sustaining water-dependent ecosystems which are resilient in times of drought.
Mount Barker Community Wastewater Management System discharges, adding excessive nutrients and organic matter (leading to algal growth and aquatic weeds).	The SA Murray–Darling Basin NRM Board works closely with local government and encourages the development of reclaimed water for more appropriate uses. Plans are being developed by the District Council of Mount Barker to minimise the discharge from the Community Wastewater Management System by significantly increasing reuse opportunities through expanded agricultural and reserve irrigation and the annual supply of the vast majority of effluent to the Kanmantoo mine, minimising, with the aim to eliminate, discharges to Mount Barker Creek.

It was also reported that Mount Barker Creek provides habitat for at least two sensitive types of macroinvertebrates, the mayfly (*Atalophlebia*) and gripopterygid stoneflies. They are organic feeding detritivores that are frequently found in fast-flowing, freshwater streams in the Mount Lofty Ranges. The creek also provides refuge habitats for a threatened native fish called Mountain Galaxias (*Galaxias olidus*) that was collected from the creek during 2008–09 (M. Hammer, Aquasave Consultants, 2009).

While the impacts of urban stormwater discharge from the Mt Barker, Littlehampton and Totness area are not listed in the EPA summary specifically, it is anticipated that some of the pressures (such as sediment erosion and excessive organic matter and nutrients) could be exacerbated should appropriate stormwater measures not be in place to manage increasing levels of runoff associated with future urban expansion. In particular, due to the scale of land development and house building activity across the area there is clearly an elevated risk of sediment export to receiving waters. This highlights the importance of measures to manage this issue, particularly through Soil Erosion and Drainage Management Plans (SEDMPs) which require Contractors to develop and maintain appropriate measures, and Council to review compliance.

7.2 Water Quality Modelling Approach

An estimation of the pollutant loads within stormwater discharges from the urban catchment to the receiving watercourses 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.

7.2.1 Meteorological Data

The meteorological data templates used for this project were compiled using average monthly potential evapo-transpiration (PET) values for Adelaide, and 6 minute rainfall data from a gauge at Macclesfield for the years 2004-2009. The average annual rainfall for this period was 605mm.

7.2.2 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. It should be noted that stormwater runoff volumes estimated by MUSIC are highly sensitive to this value.

For the purposes of MUSIC modelling 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 (assuming full take-up of allotments from recent land divisions)
- 0.6 to 0.8 for high density commercial and industrial developments

These values were adjusted for individual sub-catchments based on the relative proportions of urban development and open space within the sub-catchment area; hence the 'effective impervious' fractions for the MUSIC sub-catchments varied from 0.05 to 0.6.

7.2.3 Rainfall-runoff Parameters

A 'rainfall threshold' of 1mm 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 40mm and 'field capacity' of 30mm have been adopted for the pervious areas, which is consistent with MUSIC's recommended values for the Adelaide region. It should be noted that 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).

7.2.4 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).

7.3 Existing Pollutant Loads / Treatment Train Performance

7.3.1 Water Quality Improvement Measures

Existing water quality improvement measures have been included in the model include:

- Gross pollutant traps owned by Council
- Detention basins
- Retention basins (modelled as 'Pond' nodes)

Detention and retention basin volumes were estimated using the digital terrain model (to establish top of bank and floor levels) and an assumed linear batter slope of 1 in 5. Retention basins were assumed to have a 0.5m temporary extended detention depth where achievable.

Existing watercourses were assumed to provide no water quality improvement function, such as that which may occur in some heavily vegetated sections.

7.3.2 Assessed Performance

A MUSIC model was compiled for the existing Mount Barker, Totness and Littlehampton catchment using the input parameters described above. Subcatchments from the DRAINS model in Section 4 were used to determine the contributing area to the previously specified treatment devices. The model extent was limited to existing urban areas. This approach enables estimates to be obtained of the quantity and quality of runoff at specific points of interest in the drainage system. A plan of the MUSIC model layout is shown in Figure 7.1.

The results of the existing scenario MUSIC model for the Mount Barker Creek within the Mount Barker, Totness and Littlehampton catchment during the years 2004-2009 are as summarised in Table 7.2 which includes:

- 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
- Percent reduction – the percentage reduction in pollutant loadings as a result of the included treatment devices (i.e. between the Sources and Residual loadings)

Table 7.2 Pollutant Loads Summary, Existing Scenario

Parameter	Sources	Residual	% Reduction	Objective
Flow (ML/yr)	4,610	4,570	1	-
Total Suspended Solids (kg/yr)	809,000	532,000	34	80
Total Phosphorous (kg/yr)	1,740	1,330	23	60
Total Nitrogen (kg/yr)	12,800	11,700	9	45
Gross Pollutants (kg/yr)	130,000	47,400	64	90

The results demonstrate that there is currently a moderate removal of gross pollutants through the numerous gross pollutant traps across the catchment. Suspended solids removal and nutrient uptake are lower than desirable. This is predominantly due to:

- the lack of tertiary treatment devices such as bioretention treatment measures or constructed wetlands within the catchment
- the lack of water quality improvement infrastructure generally within older areas that were developed prior to the provision of such infrastructure being mandated as a condition of development

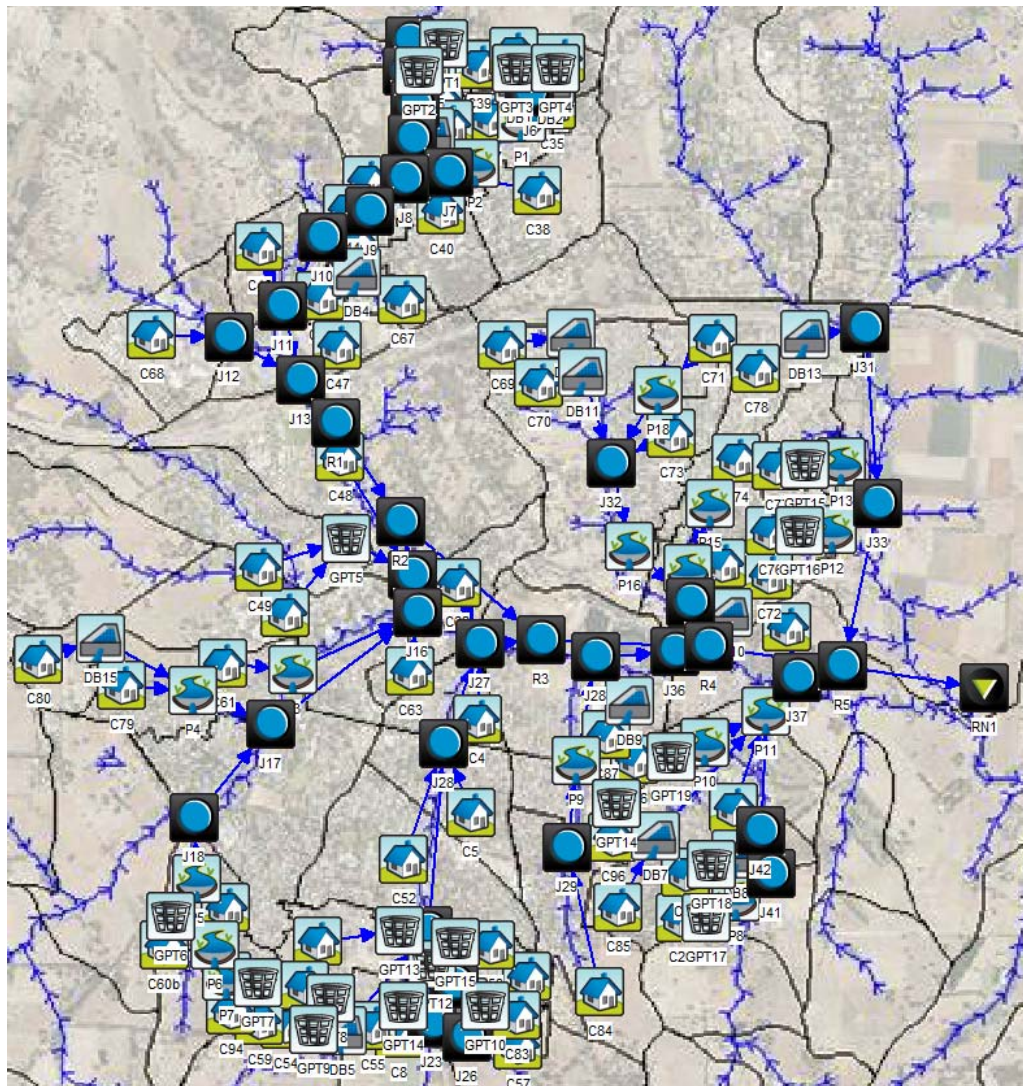
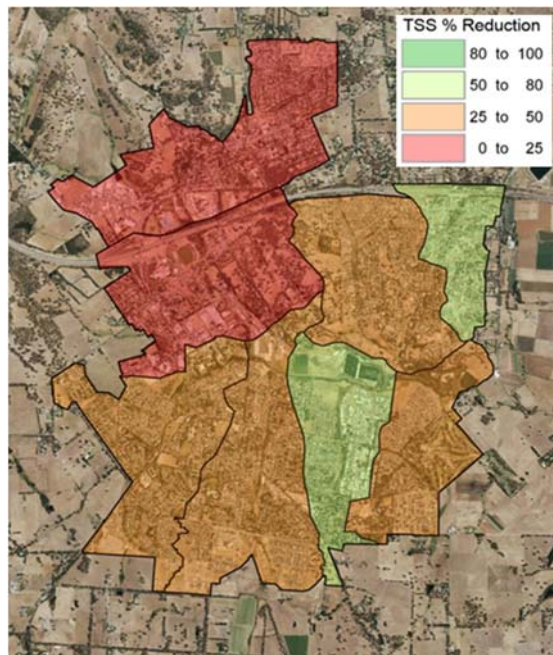


Figure 7.1 Existing Scenario MUSIC Model Layout

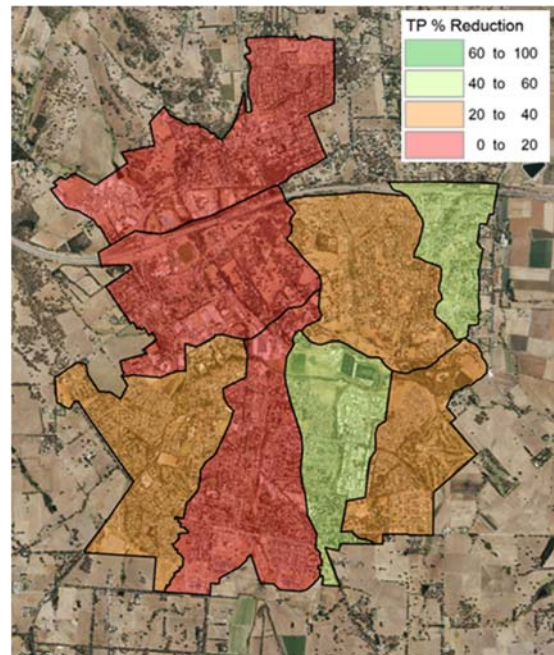
7.3.3 Subcatchment Risk Assessment

A water quality risk assessment has been undertaken to assist in identifying the relative priorities in undertaking water quality improvement measures across the catchment.

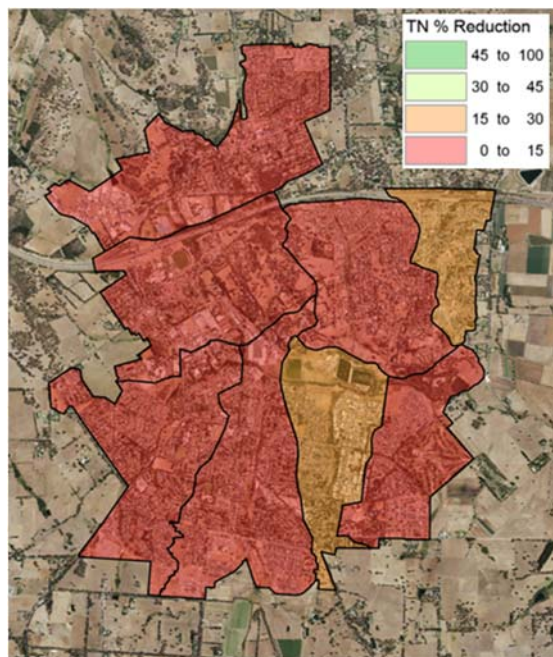
This risk assessment has been undertaken on a lumped subcatchment basis (lumped catchments shown in Figure 7.3), and is based on the existing scenario MUSIC modelling results. This provides a measure of the pollutant removal performance provided by existing infrastructure within each subcatchment area. These pollutant removal efficiencies have been utilised as an indicator of the existing risk level posed by each pollutant category, with a 'Low' level of risk assigned to those subcatchments where the SMP water quality objectives (as defined in Table 3.3) are currently achieved (refer Figure 7.2).



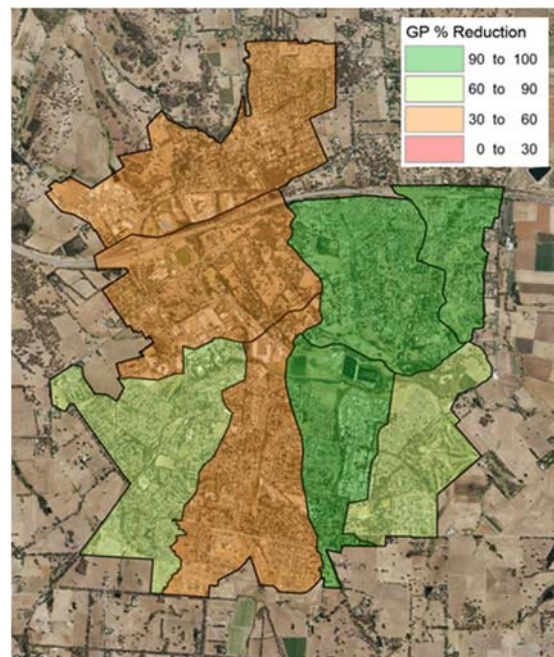
Suspended Solids



Total Phosphorous



Total Nitrogen



Gross Pollutants

Figure 7.2 Pollutant Load Reduction, Existing Scenario

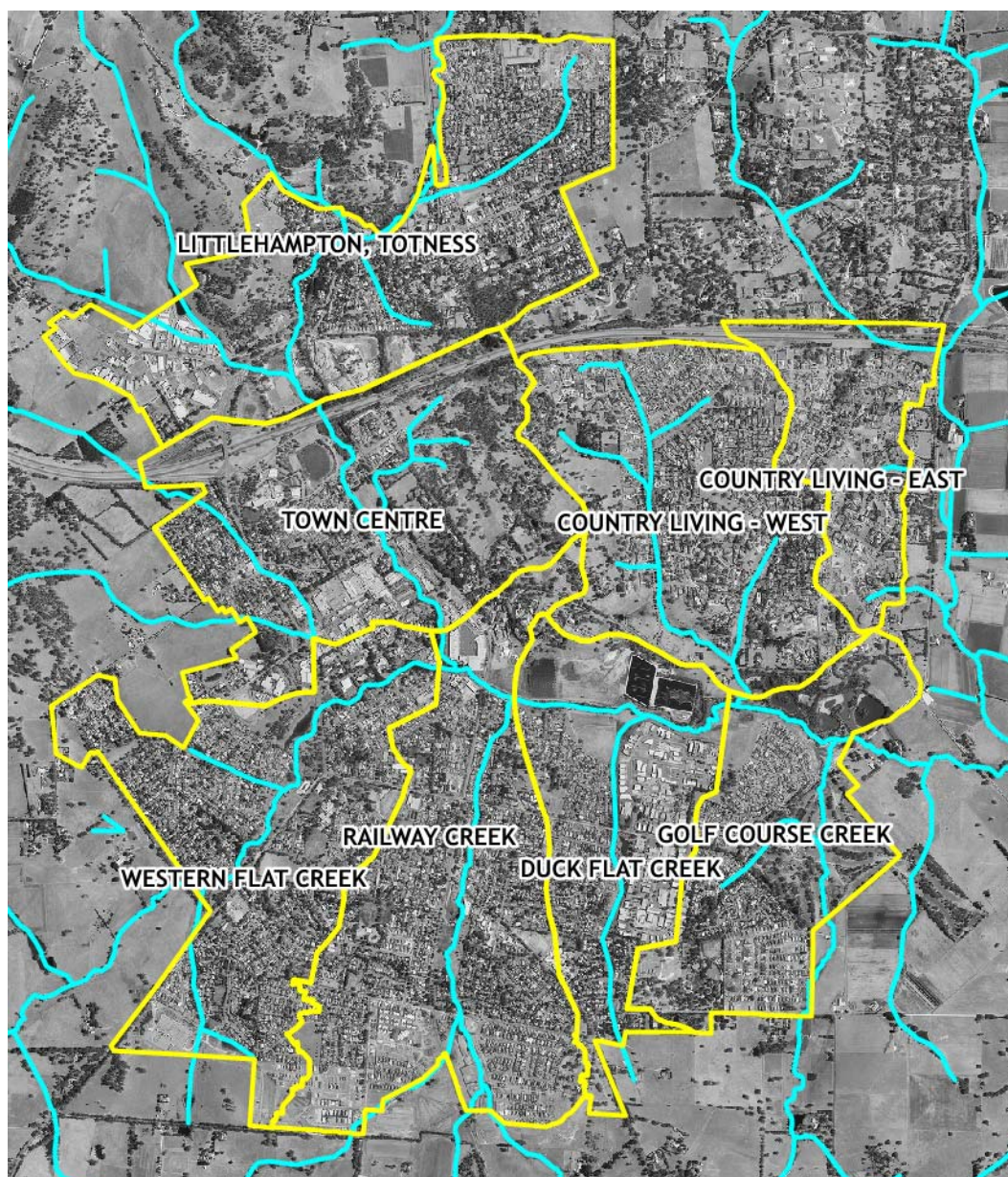


Figure 7.3 Water Quality Model Reporting Catchments

Table 7.3 Pollutant Loads (By Catchment), Existing Scenario

Parameter	Sources	Residual	% Reduction
Littlehampton, Totness			
Flow (ML/yr)	793	789	1
Total Suspended Solids (kg/yr)	141000	112000	21
Total Phosphorous (kg/yr)	304	258	15
Total Nitrogen (kg/yr)	2210	2080	6
Gross Pollutants (kg/yr)	22900	14900	35

Parameter	Sources	Residual	% Reduction
Town Centre			
Flow (ML/yr)	642	642	0
Total Suspended Solids (kg/yr)	108000	85100	21
Total Phosphorous (kg/yr)	236	218	8
Total Nitrogen (kg/yr)	1770	1770	0
Gross Pollutants (kg/yr)	14700	7750	47
Western Flat Creek			
Flow (ML/yr)	691	675	2
Total Suspended Solids (kg/yr)	123000	77700	37
Total Phosphorous (kg/yr)	262	188	28
Total Nitrogen (kg/yr)	1940	1650	15
Gross Pollutants (kg/yr)	22200	7950	64
Railway Creek			
Flow (ML/yr)	789	788	0
Total Suspended Solids (kg/yr)	141000	106000	25
Total Phosphorous (kg/yr)	301	261	14
Total Nitrogen (kg/yr)	2200	2130	3
Gross Pollutants (kg/yr)	23900	14100	41
Duck Flat Creek			
Flow (ML/yr)	487	481	1
Total Suspended Solids (kg/yr)	89000	33000	63
Total Phosphorous (kg/yr)	186	104	44
Total Nitrogen (kg/yr)	1350	1150	15
Gross Pollutants (kg/yr)	15700	0	100
Golf Course Creek			
Flow (ML/yr)	423	418	1
Total Suspended Solids (kg/yr)	73300	48700	34
Total Phosphorous (kg/yr)	158	119	25
Total Nitrogen (kg/yr)	1170	1040	11
Gross Pollutants (kg/yr)	11300	2740	76

Country Living - West			
Flow (ML/yr)	559	552	1
Total Suspended Solids (kg/yr)	93400	55600	40
Total Phosphorous (kg/yr)	205	141	31
Total Nitrogen (kg/yr)	1530	1330	14
Gross Pollutants (kg/yr)	14100	0	100
Country Living - East			
Flow (ML/yr)	226	222	2
Total Suspended Solids (kg/yr)	37000	11700	68
Total Phosphorous (kg/yr)	83	44	47
Total Nitrogen (kg/yr)	619	504	19
Gross Pollutants (kg/yr)	5230	0	100

These results indicate that the four eastern subcatchments currently have a lower level of risk, which is attributable to:

- Low density of development (2 subcatchments north of Mount Barker Creek are predominantly Country Living zoned areas)
- Existing infrastructure catering to recently established land divisions (2 subcatchments south of Mount Barker Creek)

These results have been used to influence the priorities of proposed WSUD elements.

7.4 Proposed WSUD Elements

New WSUD measures are proposed to be constructed in a number of locations to improve stormwater quality. The proposed measures are nominated in Table 7.4 and displayed on the plans presented in Appendix C.

Table 7.4 Proposed WSUD Measures Summary

Ref	Location	Type	Description
1 (App B Sht 1)	Junction Road Reserve	Bioretention basin	New low flow outlet from or retrofit of existing detention basin to new bioretention basin. High flows to either bypass existing detention basin via creek or spill from detention basin into creek. Outlet to connect into existing Benjamin Gray Drive network.
2 (App B Sht 1)	Spring Park Farm Reserve	Constructed wetland and GPT	Conversion of existing retention basin/pond to function as wetland macrophyte zone with new GPT and sedimentation basin upstream. Design flow offtake from existing channel. High flows to bypass wetland via new channel or pipe to the south of proposed wetland. Outlet to connect into existing Benjamin Gray Drive network.
3 (App B Sht 1)	Benjamin Gray Reserve	Bioretention and GPT	Construction of GPT on outlet of new pipe and establishment of vegetated swale.
4 (App B Sht 1)	Junction Road Culvert	GPT	New GPT to be placed on west of junction road on outlet of upgraded drain and existing culvert.
5 (App B Sht 2)	Mt Barker Road, Totness	GPT	New GPT servicing Totness catchment. To service existing outlet and extended Mt Barker Road drain.
6 (App B Sht 8)	Edward Street Reserve	Bioretention and GPT	Construction of GPT to service outlets from Edward Street, Gallasch Drive and Carr Street. Low flow offtake to new bioretention basin with high flows to bypass in existing channel.
7 (App B Sht 9)	Mt Barker Showgrounds	Vegetated swale and detention basin	Vegetated swale to convey flows from upgraded outlet into showgrounds reserve to a new detention basin.
8 (App B Sht 9)	Wellington Road outfall	GPT	New GPT on outlet of the proposed underground

Ref	Location	Type	Description
			stormwater drainage.
9 (App B Sht 9)	Fletcher Road outfall	GPT	New GPT on outlet of the proposed underground stormwater drainage.
10 (App B Sht 9)	Ascent Estate Reserve	GPT	New GPT at southern inlet to vegetated swale
11 (App B Sht 9)	Duck Flat Creek wetland	Constructed wetland and GPT	New large high performance wetland with new sedimentation basin and GPT upstream. System to be perched above creek level. Low flow offtake via pump. Overflow into creek or potential reuse harvesting site.
12 (App B Sht 9, 10)	Secker Road wetland	Constructed wetland and GPT	New large high performance wetland linked to Duck Flat Creek wetland by a gravity main. System to be perched above creek level. Overflow into creek or potential reuse harvesting site.
13 (App B Sht 9)	Railway Creek (Faehrmann Dve to Wellington Rd)	Creek aquatic vegetation areas, riparian revegetation	Revegetation associated with creek flood mitigation works (refer Section 6.6.6)

7.5 Assessed Performance

A MUSIC model was compiled for the Mt Barker, Totness and Littlehampton catchment to assess the combined performance of:

- Existing WSUD elements
- Proposed WSUD elements as described in Table 7.4
- Proposed stormwater harvesting scheme in Section 8

The overall performance of the proposed WSUD upgrade measures for the Mt Barker, Totness and Littlehampton catchments is summarised in Table 7.5.

Table 7.5 Pollutant Loads Summary, Proposed Scenario

Parameter	Sources	Residual	Reduction	Objective
Flow (ML/yr)	4,610	4,480	2%	-
Total Suspended Solids (kg/yr)	809,000	461,000	43%	80%
Total Phosphorous (kg/yr)	1,740	1,240	28%	60%
Total Nitrogen (kg/yr)	12,800	10,900	14%	45%
Gross Pollutants (kg/yr)	130,000	36,900	71%	90%

Table 7.6 Pollutant Loads (By Catchment), Proposed Scenario

Parameter	Sources	Residual	% Reduction
Littlehampton, Totness			
Flow (ML/yr)	793	789	1
Total Suspended Solids (kg/yr)	141000	65500	54
Total Phosphorous (kg/yr)	304	218	28
Total Nitrogen (kg/yr)	2210	1800	19
Gross Pollutants (kg/yr)	22900	4510	80
Town Centre			
Flow (ML/yr)	642	642	0
Total Suspended Solids (kg/yr)	108000	85100	21
Total Phosphorous (kg/yr)	236	218	8
Total Nitrogen (kg/yr)	1770	1770	0
Gross Pollutants (kg/yr)	14700	7750	47
Western Flat Creek			
Flow (ML/yr)	691	673	3
Total Suspended Solids (kg/yr)	123000	59400	52
Total Phosphorous (kg/yr)	262	166	37
Total Nitrogen (kg/yr)	1940	1510	22
Gross Pollutants (kg/yr)	22200	3980	82
Railway Creek			
Flow (ML/yr)	789	788	0
Total Suspended Solids (kg/yr)	141000	58700	59
Total Phosphorous (kg/yr)	301	187	38
Total Nitrogen (kg/yr)	2200	1930	13
Gross Pollutants (kg/yr)	23900	6170	75
Duck Flat Creek (Includes items 11, 12 which treat runoff from other catchments)			
Flow (ML/yr)	487	390	20
Total Suspended Solids (kg/yr)	89000	37000	58
Total Phosphorous (kg/yr)	186	87	53
Total Nitrogen (kg/yr)	1350	800	41
Gross Pollutants (kg/yr)	15700	6500	59

Golf Course Creek			
Flow (ML/yr)	423	418	1
Total Suspended Solids (kg/yr)	73300	48700	34
Total Phosphorous (kg/yr)	158	119	25
Total Nitrogen (kg/yr)	1170	1040	11
Gross Pollutants (kg/yr)	11300	2740	76
Country Living - West			
Flow (ML/yr)	559	552	1
Total Suspended Solids (kg/yr)	93400	55600	40
Total Phosphorous (kg/yr)	205	141	31
Total Nitrogen (kg/yr)	1530	1330	14
Gross Pollutants (kg/yr)	14100	0	100
Country Living - East			
Flow (ML/yr)	226	222	2
Total Suspended Solids (kg/yr)	37000	11700	68
Total Phosphorous (kg/yr)	83	44	47
Total Nitrogen (kg/yr)	619	504	19
Gross Pollutants (kg/yr)	5230	0	100

The modelling indicates that the works identified in this Plan would contribute towards the improvement in stormwater quality discharged from the catchment. However, further measures would need to be implemented in order to ultimately achieve all targets. The opportunity for further measures exist at the street level (such as WSUD measures incorporated into road reconstructions) and at the site level (such as rainwater tanks and other site-based measures incorporated into new developments). Actions have been identified in this Plan through which these additional opportunities can be identified and integrated into other capital works programs.

7.6 Natural Catchment Hydrology Flow Regime Management

The changes in peak flows as a result of additional urban development have the potential to result in a dramatic change in the hydrological regime. This is most pronounced for more frequent events.

Natural creek systems typically form an in-bank channel capable of carrying between a 1 year ARI and 2 year ARI natural catchment flow (Brisbane City Council, 2004 and Engineers Australia, 2006). Under natural catchment conditions, flows in excess of this level are sufficiently rare so as to allow the natural damage – repair cycle to occur, through which low flows carry sediments to fill scour holes, and vegetation re-establishes to stabilise exposed areas.

The changes associated with substantial urban expansion of Mount Barker could result in damaging flow events occurring on a regular basis, such that natural restoring processes are less frequently able to take place.

Management strategies that are effective in addressing the impact of urbanisation on waterway ecology and morphology is the subject of ongoing research, and as such, there is uncertainty in identifying in precise terms the required approach in this context to maintain current environmental values, and the degree to which this is practically feasible to achieve. However, it is clear that watercourses are highly sensitive to any changes in the hydrological regime and that it would be appropriate to adopt measures that would reduce the hydrological effects of urbanisation.

Relevant excerpts from reference material that provides general guidance and comments in relation to this issue are presented below.

"It is currently believed that to limit the impacts of urbanisation on creek systems, it will be necessary to design stormwater detention systems to reduce the 1 in 1 year to 1 in 2 year peak flood flows to levels significantly less than the pre-development conditions." (Brisbane City Council, 2004)

"For natural streams, the stream alignment, cross-section and grade reflects geomorphological equilibrium conditions for the less frequent 'bank full' (1 in 1.5 to 2-year ARI discharge) pre-development conditions" (Engineers Australia, 2006)

"Flow-regime stormwater management is a likely prerequisite for ecologically successful restoration and protection of streams in urban catchments. Reforming stormwater management to achieve this aim requires two challenges be addressed. First, technologies that achieve flow-regime management need to become standard tools. Second, stormwater needs to be retained in a distributed manner at small-scales.

A range of stormwater management strategies can be used to restore or retain natural hydrologic processes at smaller scales, either singly or in series. Such tools focus on retention, use and infiltration of the water. Use of water, either internally so that water ultimately leaves the catchment through the wastewater stream, or for irrigation to maximize local evapotranspiration, is a central requirement for adequately reducing runoff volume." (Burns et al, 2011)

"Drainage connections from impervious surfaces directly to the waterway efficiently translate rainfall into energy that can 'do work' on the channel. A decrease in bedload sediment supply to a channel also increases the energy available. Thus, urbanisation could be considered the 'double-edged sword' driving geomorphic change leading to channel degradation. Understanding their role highlights opportunities and the multiple activities that can address the causes of urban stream degradation.

1. Attenuate and reuse excess urban stormwater runoff to reduce channel streampower, where possible desires include:

- Implement stormwater harvesting (and use) at the house, allotment and street scale*
- Reduce drainage connection of impervious pavements through infiltration and bioretention*

- *Replace curb and gutter drainage systems with swale drainage*
 - *Provide floodplain space for floodwater attenuation*
2. *Maintain coarse-grained sediment supply to waterways, where possible desires include:*
- *Protect headwater sediment sources*
 - *Allow appropriate rates of bank erosion and channel dynamism*
 - *Provide floodplain space for channel migration*
 - *Provide sediment bypass for wetlands and online traps*
 - *Consider sediment replenishment opportunities” (Vietz, 2013)*

From the literature presented above, it is surmised that the current best practice to maintain natural watercourse values in an urban catchment is to undertake a range of measures, that are predominantly at the smaller site scale, that seek to hydrologically disconnect impervious areas from the downstream watercourse and thereby allow low ARI (1 to 2 year ARI) flow regimes to resemble the corresponding natural flow regime.

Within the Mount Barker Creek catchment, the fulfilment of a site scale based strategy is considered feasible due to the substantial proportion of future greenfield development that is yet to occur. Development currently is required to comply with the South Australian government 1kL minimum rainwater tank policy. It has previously been recommended (SKM, 2012) to increase this minimum to 10kL (5kL for firefighting, 5kL for household use) as an integrated water management strategy across Mount Barker to reduce mains water reliance, however such a strategy would also offer Council a strategy in reducing the risk of creek erosion and damage associated with future urban development.

In order to accelerate the effectiveness of this strategy, the District Council of Mount Barker could also consider the development of an incentive for property owners within the urban area to voluntarily retrofit similar measures to existing development.

7.7 Action Summary

A consolidated summary of proposed water quality improvement measures across the study area as identified in this section are presented in Table 7.7 and displayed on the plans presented in Appendix C. Actions that relate to achieving desirable planning outcomes (an SMP objective listed in Table 3.3) are highlighted.

Each action has been prioritised, broadly as follows:

- High priority – Action is required as a precursor to a range of other actions, or delivers an outcome that provides improvements on a regional basis
- Medium priority – Action addresses water quality in an area assessed to have a ‘high’ to ‘medium’ existing risk level as described in Section 7.3.3
- Low priority – Action addresses water quality in an area assessed to have a ‘medium’ to ‘low’ existing risk level as described in Section 7.3.3

Where a WSUD item is associated with other minor network or flood mitigation proposals, the priority associated with that proposal has been adopted.

Table 7.7 Water Quality Improvement Measures Actions Summary

Priority	Project / Activity	Cost (\$)
High	¹ Integrate identified WSUD opportunities within parks and reserves into relevant open space management strategies and plans	10,000
High	Update Development Plan provisions to mandate the use of 5kL rainwater tanks	20,000
Medium	¹ Integrate WSUD opportunity identification into standard practice for relevant road asset management / replacement programs	10,000
Medium	Junction Road Reserve bioretention basin (Ref 1, Sht 1)	80,000
Medium	Spring Park Farm Reserve constructed wetland and GPT (Ref 2, Sht 1)	200,000
Medium ²	Benjamin Gray Reserve vegetated swale and GPT(Ref 3, Sht 1)	100,000
Medium ²	Junction Road Culvert GPT (Ref 4, Sht 1)	100,000
Medium ²	Mt Barker Road, Totness GPT (Ref 5, Sht 2)	140,000
Low	Edward Street Reserve bioretention basin and GPT (Ref 6, Sht 8)	100,000
Medium ²	Mt Barker Showgrounds vegetated swale and detention basin (Ref 7, Sht 9)	80,000
Low ²	Wellington Road GPT (Ref 8, Sht 9)	120,000
Low ²	Fletcher Road GPT (Ref 9, Sht 9)	80,000
Low	Ascent Estate Reserve GPT (Ref 10, Sht 9)	100,000
Medium ³	Duck Flat Creek constructed wetland and	2,500,000

Priority	Project / Activity	Cost (\$)
	GPT (Ref 11, Sht 9)	
Medium ³	Secker Road constructed wetland and GPT (Ref 12, Sht 9/10)	2,000,000
Low ⁴	<i>Creek Reconstruction – Faehrmann Avenue to Wellington Road (Ref 13, Flood Action ID 8)</i>	\$1,250,000

¹ Action relating to achieving desirable planning outcomes objective

² Action and priority is dictated by a minor drainage upgrade recommended action

³ Action and priority is dictated by a stormwater harvesting recommended action

⁴ Action is listed in Table 6.21 as a flood mitigation works action

8 Stormwater Harvesting and Reuse

8.1 Existing Recycled Water Use Scheme

The District Council of Mount Barker operates the largest Council wastewater treatment plant and recycled water scheme in South Australia.

Septic tank effluent from the townships of Mt Barker, Littlehampton, Nairne and Brukunga is directed to Council's treatment plant at Springs Road, Mount Barker. The effluent is treated before being discharged to the Laratinga Wetlands, which provides a habitat for many varied flora and fauna species. The water is reused in several other ways including:

- watering of parks and gardens in nearby housing estates
- use in Council's dust suppression programme
- irrigation by market gardeners on Bald Hills Road.

Council has sought to identify other end users for recycled water that is not seasonal dependent, with a view to ultimately achieving no release of treated effluent to the Mount Barker Creek.

In 2011, Council constructed a 120ML reclaimed water storage dam to provide additional storage from the existing Mount Barker Waste Water Treatment Plant. This storage meets approximately 18-20% of current annual demand for recycled water.

A public/private partnership was established between Council and Hillgrove Resources to build a pipeline to deliver water for use as process water in the Hillgrove Kanmantoo copper mine. With the support of a State Government grant, the pipeline was extended to Callington providing an alternative water source, primarily for irrigation of the town oval. Take off points allow other properties along the pipeline route to access recycled water, achieving economic and environmental benefits.

The current scheme operation supplies over 1 GL/year of recycled water for non-potable use (Wallbridge & Gilbert, 2014).

8.2 Ongoing Scheme Development

The District Council of Mount Barker are continuing to explore and develop opportunities associated with the recycled water scheme, to achieve objectives including:

- Providing sufficient treatment capacity for increased effluent volumes associated with urban development growth
- Eliminating discharge of treated effluent to Mount Barker Creek
- Providing greater security of supply to current high volume customers
- Providing an 'environmental' flow to the Laratinga Wetlands to maintain permanent water in the wetland during summer
- Promoting economic growth in the region through secure and sustainable water supply

Ongoing activities in this regard have identified some opportunities for stormwater harvesting (Wallbridge and Gilbert, 2014). These opportunities have been identified on the basis that they have a relatively high yield, and require a relatively low stormwater harvesting infrastructure investment in order for this water source to be integrated into the existing scheme. They include harvesting of runoff from 3 catchments, each which drain through or adjacent to existing scheme infrastructure, prior to draining into Mount Barker

Creek. It is reported that the existing allocable runoff from these catchments totals 374 ML/year, which would increase to 1,015 ML/year on completion of all development in accordance with the current land zoning.

8.3 Managed Aquifer Recharge Feasibility

Managed Aquifer Recharge (MAR) is an infrastructure process through which water is intentionally placed and stored in an aquifer for later human use or to benefit the environment.

MAR schemes help replenish depleted aquifers (underground reservoirs) and are a way to store water until it is needed at a later date. In times of low rainfall, for example, water that has been stored in an aquifer can be pumped to the surface to contribute to meeting an irrigation demand. MAR schemes offer the advantage of negating the need to establish large surface storage infrastructure which is often difficult to accommodate in an urban environment.

The feasibility of MAR schemes is dependent on the properties of the local aquifer. The District Council of Mount Barker has previously commissioned an investigation to explore the MAR potential of the Mount Barker area (Australian Groundwater Technologies, 2003) with respect to storing treated effluent. This report concluded the following:

- Aquifers in the Mount Barker region are predominantly in 'fractured rock' geological conditions, which are highly variable in terms of both yield and recovery efficiency
- Wells in the area are characterised by high to very high yields (most exceed 5L/s) with salinities generally within the range suitable for drinking water
- Some wells are artesian (i.e. water table is above ground level) which in some areas may limit the potential for MAR
- Of the five areas selected for assessment, those sites considered favourable to MAR include:
 - Bald Hills Road, between Springs Road and Burbank Way
 - Area on the northern side of the Mt Barker Creek / Railway crossing
 - Adelaide Road / South-east Freeway exit Area

These results would suggest that MAR may be feasible at certain locations within the Mount Barker catchment, although further assessment (including drilling of wells) would be required at each location proposed for this purpose to inform project feasibility.

8.4 Urban Stormwater Availability

As summarised in Table 7.2, the urban component of the Mount Barker – Littlehampton - Totness catchment generates an estimated average stormwater flow volume of 4610 ML/yr.

The operation of the *Eastern Mount Lofty Ranges Water Allocation Plan* (EMLR WAP) limits the proportion of this existing flow volume that can be harvested to the incremental increase in flow volume generated by development undertaken after 2003.

Consequently, stormwater availability for harvesting purposes is currently largely limited to that which is generated by post-2003 land developments, such as Bluestone (south of Hurling Drive) and Mountain Glen (north-west of Bald Hills Road). An analysis of the stormwater harvesting potential associated with development between 2003 and 2010 has previously been undertaken (SKM, 2012) and this component was estimated to total 755 ML/year. For the purposes of an estimate for this Stormwater Management Plan, this figure has been extrapolated to 1300 ML/yr to account for development through to 2015.

Future development in accordance with the urban growth boundary will increase this allocable estimate. The average annual runoff from the future development areas has previously been estimated (Tonkin Consulting, 2013b) to total 2177 ML/year. After accounting for existing levels of runoff in accordance with the EMLR WAP, the proportion of this flow volume available for harvesting is estimated to total 1200 ML/year.

This indicates that the stormwater flow volume that is available to be harvested under 'ultimate' catchment development conditions is 2,500 ML/year.

8.5 Public Open Space Non-Potable Water Demand

The majority of other stormwater harvesting and reuse schemes developed in South Australia have been developed to supply water for irrigation of public open space. This has proven to be a successful model for these schemes as it:

- Enables Local Government to reduce its own mains water usage, of which irrigation is generally a relatively significant component
- Requires a water quality standard that the treatment measures associated with these schemes have demonstrated can be achieved, and for which Local Government is often the largest suitable customer
- Allows Local Government to irrigate open space without restrictions that are imposed on mains water use on occasion
- Allows Local Government to own, operate and supply itself with recycled water, thereby avoiding the need to engage in commercial arrangements with third parties

A desktop assessment has been made of the locations and demands for public open space non-potable water within the catchment. The locations identified are summarised in Table 8.1 and shown spatially in Figure 8.1.

Table 8.1 Open Space Non-Potable Water Demand Locations

Classification	Locations	Irrigated Area (ha)	Estimated Demand (ML/yr)
<i>Category 1</i>	Keith Stephenson Park	10	40
<i>Category 2</i>	Numerous	42	169
<i>Category 3</i>	Numerous	41	167
<i>Council Owned (not classified)</i>	Mount Barker Showgrounds, Mount Barker Tourist Park, Mount Barker Cemetery, Anembo Park, Mount Barker CFS	16	64
<i>Private Ownership</i>	Cornerstone College, St Francis de Sales College, Mt Barker High School, Mt Barker South Primary School, Mt Barker - Hahndorf Golf Club, Mt Barker Waldorf School, Littlehampton Primary School	54	219
<i>Future Demand</i>	Urban Growth Area	180	737
	Total	343	1,396

Council reserve maintenance categories were used as a basis in determining probable locations of non-potable water demand. The reserve maintenance categories are as follows:

- *Category 1 Regional Parks - Major Community Asset, have a high presentation factor and a visual objective of green appearance all year.*
- *Category 2 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.*
- *Category 3 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.*
- *Category 4 Undeveloped reserves have a low presentation factor and a visual objective of green in winter, light green in spring and brown in summer.*

Categories 1-3 were identified using Council data relating to reserves. Category 4 reserves were not considered for non-potable water demand.

In addition to the reserves nominated above aerial photography was used to identify:

- Council owned land which was not classified in the above categories, but would likely be irrigated (i.e. recreation facilities, cemetery)
- Privately owned land with non-potable water demand (i.e. school ovals)

The annual average irrigation demand has been calculated in accordance with the Code of Practice for Irrigated Public Open Space methodology. The calculated irrigation requirement of 4.1 ML/ha/yr was estimated assuming a Turf Quality Visual Standard Classification No. 3 - Local Sports Turf (SA Water, 2007).

Stormwater harvesting for the purposes of providing irrigation to areas currently not irrigated (Category 3 reserves) and providing more reliable irrigation in the summer months to currently irrigated reserves (Category 1 and 2 reserves) and other Council and privately owned facilities, would not only have a direct stormwater management benefit, but would also create indirect benefits including an enhanced recreational experience for the local community, schools and sporting organisations.

Non-potable water demand was also estimated for the urban growth area. The percentage of potentially irrigated greenspace within these new developments was estimated from recently established greenfield residential developments, with an adjustment to reflect the three 'Sports and Community Hubs' that are proposed to be established within the urban growth area (District Council of Mt Barker, 2014). An average greenspace proportion of 15% was adopted for the urban growth area that subject to rezoning in 2010.

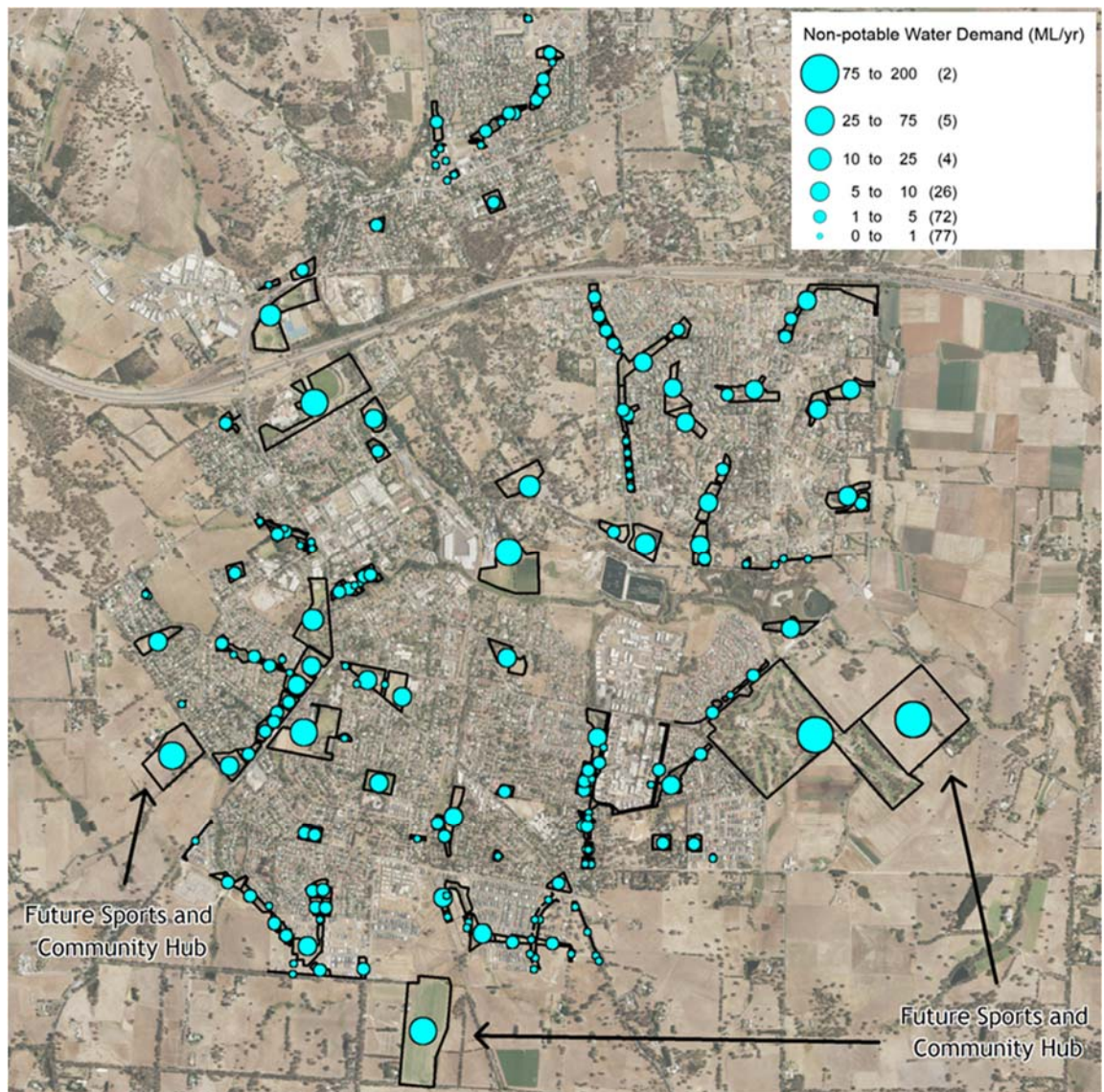


Figure 8.1 Open Space Non-Potable Water Demand

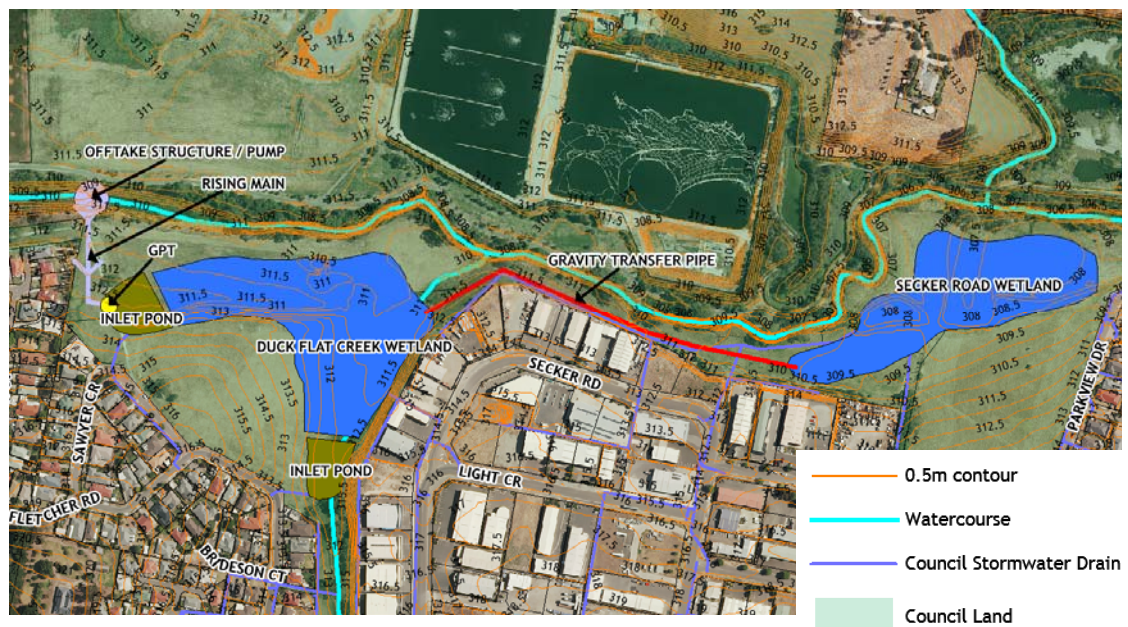
8.6 Regional Scale Harvesting

The opportunity to develop off-line wetlands on the southern bank of Mount Barker Creek, opposite the Mount Barker Waste Water Treatment Plant has been identified as an available water quality improvement measure (refer Section 0).

Subject to further feasibility assessment, an inlet pond and wetland with a total surface area of approximately 4.5ha could be achieved across the 2 vacant reserve areas.

Concept features of this arrangement include:

- An offtake structure within Mt Barker Creek, designed to permit the passage of a low threshold flow rate (in accordance EMLR WAP requirements) and the pumped offtake of excess flows
- A gross pollutant trap and inlet pond to provide primary treatment of flows (gross pollutant and sediment removal) prior to flows entering the western wetland area (labelled in the concept plan below as ‘Duck Flat Creek Wetland’)
- Potential low flow / high flow bypass of the minor tributary entering the reserve from the south
- Gravity drain link through to the eastern wetland area (labelled in the concept plan below as ‘Secker Road Wetland’)



Duck Flat Creek, Secker Road Wetlands Concept

At a preliminary level, it is estimated that a “traditional” wetland arrangement with a 3 day residence time limited to harvesting from storm events only could harvest approximately 450ML/yr. A higher yield could be achieved should the site be considered appropriate for the establishment of:

- Storage for capture and transfer only (i.e. for treatment elsewhere); or
- Alternative treatment methods such as biofilter beds



Oaklands Park wetlands (Offline, MAR)



Cooke Reserve, Royal Park Biofilter beds

Assessment of the aquifer at this location would need to be undertaken in order to assess whether MAR can provide a suitable storage function for such a scheme.

Distribution of harvested stormwater could be achieved either via supply to existing infrastructure associated with the Mount Barker Waste Water Treatment Plant, or to new distribution infrastructure to supply local non-potable demand nodes such as those listed in Table 8.1.

8.7 Site Scale Harvesting

As described in Section 7.6, it is recommended to introduce development requirements that mandate significantly greater minimum rainwater tank storage requirements.

This will both reduce mains water usage in new residential development estates, and reduce the impact of new development on downstream watercourses.

It has previously been estimated (SKM, 2012) that the estimated volume of rainwater harvested and reused within households if 5kL rainwater tanks were implemented for all new developments within Mount Barker, Littlehampton and Nairne would be 710ML.

8.8 Action Summary

Actions identified within this Section are summarised in Table 8.2, noting that the Duck Flat Creek and Secker Road wetlands opportunity is listed in Section 7, and is not repeated below. Actions that relate to achieving desirable planning outcomes associated with new development (an SMP objective listed in Table 3.3) are highlighted.

Each action has been prioritised, broadly as follows:

- High priority – Action is required as a precursor to a range of other actions, or delivers an outcome that provides improvements on a regional basis
- Medium priority – Action assists in the progression of a regional project, or delivery of a >100 ML/yr reuse project
- Low priority – Action delivers a <100 ML/yr reuse project

Table 8.2 Stormwater Harvesting Actions Summary

Priority	Project / Activity	Cost (\$)
High	¹ Review reserve management plans associated with the Duck Flat Creek and Secker Road wetland sites and ensure that the wetland concepts are appropriate and reflected in revised plans	20,000
High	Prepare a Water Resources Management Plan for the Mount Barker – Littlehampton – Totness area, that would: • Consider the scope and temporal nature of water resources (such as wastewater, stormwater) available for harvesting and reuse • Identify recycled water demand nodes including existing and planned future Council reserves and private customers • Consider stormwater harvesting compliance obligations associated with the EMLR WAP • Identify and develop a preferred harvesting, treatment, storage and distribution scheme to a sufficient level to support a business case for further development of the scheme • Investigate and scope an economically justifiable distribution and reuse network supplying recycled water to Council reserves and private customers	150,000
Medium	Undertake further feasibility assessment of the wetland and MAR concept at the Duck Flat Creek and Secker Road wetland sites and scope infrastructure associated to store harvested stormwater	150,000

¹ Action relating to achieving desirable planning outcomes objective

9 Stakeholder and Community Consultation

9.1 Project Steering Committee

The Stormwater Management Plan was undertaken under the guidance and instruction of a Steering Committee comprised of staff representing:

- District Council of Mount Barker
- South Australian Murray Darling Basin Natural Resources Management Board
- Stormwater Management Authority (represented in a technical review capacity by staff from the Department of Planning, Transport and Infrastructure)

The Steering Committee met with the Consultant team at key intervals during the preparation of the Plan to plan, review and approve the work undertaken.

9.2 General Community Engagement

The District Council of Mount Barker maintained a dedicated Stormwater Management Plan information page on its website. This page was initially established in September 2014 to provide awareness of the development of a plan, with subsequent updates providing information on opportunities to download draft material, attend information sessions and to provide input for consideration.

9.3 Land Development Industry Consultation

Given the significant scope for future greenfield urban development, approximately 100 property owners across the rezoned urban area were contacted directly via a mailout in September 2014 with the invitation to contact the Council project manager to enable the collation of any information that may potentially be relevant in the development of regional stormwater management strategies and opportunities associated with individual land parcels.

This process resulted in a number of meetings between development groups and Council / Consultant team staff. In some instances, land development designs were in progress, and the meetings were productive in both identifying opportunities to integrate regional-based strategies into these developments, and other opportunities that are aligned with objectives contained within this Stormwater Management Plan with respect to protection of natural creeks from scouring.

9.4 Draft Plan Community Consultation

Following an elected member briefing of the Draft Plan in June 2015, open house sessions were held at Council offices on 1 and 2 July 2015. Due to a very low level of attendance, a further open house was scheduled on 30 July 2015, with an invitation and feedback form posted to all local property owners located within 250m of a watercourse.

While attendance at the third session was again very low, Council received 78 feedback forms. The collated responses contained within the feedback forms is summarised in Table 9.1 and Figure 9.1 below, which indicate a very high level of agreement with the propositions.

Table 9.1 Feedback Form Written Responses

Ref	Question, Common Feedback Comment Themes
Q1	<i>Do you agree that it is important that Council identifies where there are local drainage problems and assess the risk and prioritise remedies to the highest risk areas?</i> Yes – a number of respondents highlighted local issues
Q2	<i>Do you agree that it is important that development is required to control the additional stormwater run off and extra volume so as not to erode or damage existing natural creeklines?</i> Preservation of local habitats paramount Adopt sensitive urban design techniques
Q3	<i>Do you agree that it is important for Council to identify opportunities to improve water quality in our natural waterways?</i> Numerous responses calling for rehabilitation / maintenance of degraded sections of urban creeks
Q4	<i>Do you agree that it is important that Council actively plan and prioritise to mitigate major flooding of residential and commercial development on a benefit : cost basis?</i> Benefits need to outway costs Many flood improvements have been completed in the past Council should not pay to facilitate new development – developers should pay Some responses appear to indicate that the wording of this question led to misinterpretation / misunderstanding
Q5	<i>Do you agree Council should further investigate the opportunities to harvest and reuse stormwater for irrigation or supply to primary producers and industrial users?</i> Yes, where possible at reasonable cost Fully support this Need to maintain sufficient water in wetlands for native fauna – recent drying of Laratinga wetlands cited as an undesirable outcome
Q6	<i>Do you agree that Council should encourage new development to reuse rainfall through provision in the Mt Barker Development Plan?</i> Yes – wherever possible - build for a longer term future Assign costs to developers
Q7	<i>Do you agree that it is important as part of maintaining our natural creeks and streams that water sensitive urban design is incorporated within parks and new developments even if this creates some new assets like wetlands to maintain?</i> Yes, important to maintain natural systems High proportion of comments calling for more regular creek maintenance (weeding, debris clearing) at key locations New developments need to leave the creeks alone Creeks are a major feature of the town
	<i>Other Comments?</i> Commended Council for developing a Plan to manage these issues in a progressive manner Environmental protection is paramount Incorporate recreation opportunities such as paths along creeklines where possible One comments raised concerns with safety of open drains during times of flood

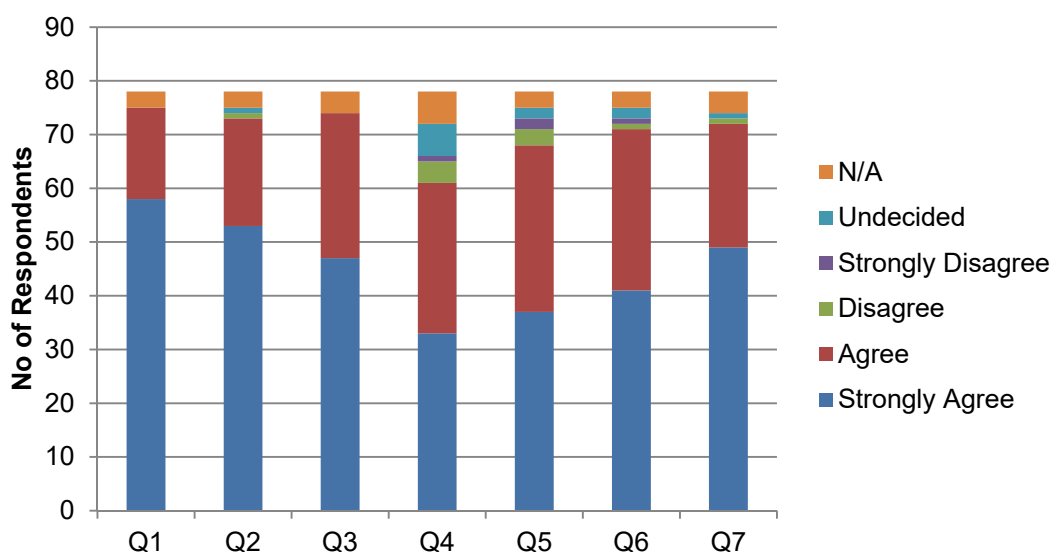


Figure 9.1 Feedback Form Response Summary

In summary, the community consultation process indicated:

- High level of agreement with the propositions put forward in the feedback form. These propositions are consistent with the objectives on which the Stormwater Management Plan strategies are based.
- General concern and lack of support for Council to bear costs for any measures that can reasonably be assigned to land development proponents
- Desire to retain, protect and rehabilitate natural urban creek systems as a characteristic features of the area

10 Stormwater Management Plan

10.1 Strategy Action Costs, Benefits and Priority Summary

The actions outlined in Sections 5.5, 6.11, 0 and 8.8 are presented in Table 10.1, together with a brief description of the benefits realised through implementation of each action. Where available, details of water quality benefits for individual actions have been detailed in terms of average annual removal of pollutant loads. Actions that are potentially eligible for Stormwater Management Authority funding support are highlighted.

10.2 Prioritisation and Timeframe

The actions outlined in this Stormwater Management Plan will require implementation to be scheduled across many years, in order to be accommodated sustainably within the District Council of Mount Barker's budget and the budgets of other potential funding partners.

Each of the actions within the plan has been assigned one of three priority levels, which has an associated anticipated timeframe as follows:

- High (0 - 5 years)
- Medium (5 - 10 years)
- Low (10+ years)

The prioritisation of each action has nominated based on the process as described for each works category in other Sections of this report. 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.

A number of flood mitigation projects have been identified that are eligible for Stormwater Management Authority funding support. It is recommended that the District Council of Mount Barker liaise with the Stormwater Management Authority to identify a timeframe for the delivery of these projects that meets the forward budget limitations of both parties.

10.3 Responsibilities for Implementation

The District Council of Mount Barker is responsible for implementation of all activities identified within this Plan.

It is expected that the Council will continue to liaise with relevant State Government departments and agencies to satisfy a variety of regulatory requirements, including the South Australia Murray Darling Basin Natural Resources Management Board and Department of Environment, Water and Natural Resources.

10.4 Implications for Adjoining Catchments

There are no significant implications for stormwater management within the Mount Barker – Littlehampton - Totness Stormwater Management Plan area on adjoining catchments.

Table 10.1 Stormwater Management Plan Works Summary

ID	Priority	Project / Activity	App C Sheet	Key Responsibility	Capital Cost (\$)	Recurrent Cost (\$/yr) ¹	Flood Mitigation Benefit	Water Harvesting Benefit	Water Quality Benefit	Other Benefits	SMA Eligible
		Stormwater Infrastructure									
1A	High	Follett Close to Mt Barker Road	2	DCMB	\$330,000	-	Reduced flood risk to 6 businesses across a commercial precinct	-	-	-	-
4A	High	North Terrace to Benjamin Gray Drive	2	DCMB	\$390,000	-	Reduced flood risk to 6 residential properties	-	-	-	-
5	High	Baker Street	3	DCMB	\$50,000	-	Reduced flood risk to 2-3 residential properties	-	-	-	-
11	High	Claret Ash Parade	3	DCMB	\$10,000	-	Reduced flood risk to 2-3 residential properties	-	-	-	-
13	High	Hallmark Road	12	DCMB	\$20,000	-	Reduced flood risk to 2-3 residential properties	-	-	-	-
27A	High	Light Crescent	9	DCMB	\$130,000	-	Reduced flood risk to 2-3 industrial properties	-	-	-	-
28A	High	Netley Street/Howard Close/Grivell Street/Craig Terrace	9	DCMB	\$430,000	-	Reduced flood risk to 4-6 residential properties	-	-	-	-
29	High	Phillip Street/Princes Road/Edward Street/Hughes Street	8	DCMB	\$580,000	-	Reduced flood risk to 4-6 residential properties	-	-	-	-
30B	High	Wunderley Drive/Victoria Road/Wiland Street	9	DCMB	\$170,000	-	Reduced flood risk to 4-6 residential properties	-	-	-	-
31	High	Albert Road (between Alexandrina Road & Wellington Road)	9	DCMB	\$20,000	-	Reduced flood risk to 2-3 industrial properties	-	-	-	-
32	High	Oborn Road	9	DCMB	\$670,000	-	Reduced flood risk to 4-6 residential properties	-	-	-	-
34	High	Sims Road Detailed Investigation	12	DCMB	\$15,000	-	-	-	-	-	-
		Flood Mitigation									
9	High	Creek capacity works and Levee Banks – Fletcher Road to Mt Barker Creek	9	DCMB	\$640,000	-	Protection of up to 20 houses in 100 year ARI event	-	-	-	\$320,000
12	High	Floodsafe Program	-	DCMB, SES	\$10,000	-	Reduced flood damage cost profile	-	-	Community awareness and education	-
		Water Quality									
-	High	Integrate identified WSUD opportunities within parks and	-	DCMB	\$10,000	-	-	-	-	-	-

ID	Priority	Project / Activity	App C Sheet	Key Responsibility	Capital Cost (\$)	Recurrent Cost (\$/yr) ¹	Flood Mitigation Benefit	Water Harvesting Benefit	Water Quality Benefit	Other Benefits	SMA Eligible
		reserves into relevant open space management strategies and plans									
-	High	Update Development Plan provisions to mandate the use of 5kL rainwater tanks	-	DCMB	\$20,000	-	-	Catchment Potential for up to 710ML/yr reuse	-	Reduced erosion risk in creeks associated with new development	-
		Stormwater Harvesting									
-	High	Review reserve management plans associated with the Duck Flat Creek and Secker Road wetland sites and ensure that the wetland concepts are appropriate and reflected in revised plans	-	DCMB	\$20,000	-	-	-	-	-	-
-	High	Prepare a Water Resource Management Plan for Mount Barker - Littlehampton - Totness	-	DCMB	\$150,000	-	-	-	-	-	-
		Stormwater Infrastructure									
2	Medium	North Terrace	3	DCMB	\$60,000	-	Reduced flood risk to 2-3 residential properties	-	-	-	-
3A	Medium	Junction Road	3	DCMB	\$400,000	-	-	-	-	Reduced road overland nuisance flows	-
3B	Medium	West Terrace	3	DCMB	\$180,000	-	-	-	-	Reduced road overland nuisance flows	-
16	Medium	Apollo Street	5	DCMB	\$10,000	-	Reduced flood risk to 1-2 residential properties	-	-	-	-
19	Medium	Pridmore Terrace/Hutchinson Street	5, 6	DCMB	\$240,000	-	-	-	-	Reduced road overland nuisance flows	-
21	Medium	Walker Street/Gawler Street/Mann Street	6	DCMB	\$260,000	-	-	-	-	Reduced road overland nuisance flows	-
25	Medium	Maurice Road/Wuttke Road/Allen Avenue	8	DCMB	\$360,000	-	-	-	-	Reduced road ponding during times of high creek level	-
30A	Medium	Wunderley Drive/Victoria Road/Wiland Street	9	DCMB	\$410,000	-	-	-	-	Reduced road overland nuisance flows	-
39	Medium	Exhibition Road/Fletcher Road	9	DCMB	\$610,000	-	Reduced flood risk to 1-2 residential properties	-	-	-	-

ID	Priority	Project / Activity	App C Sheet	Key Responsibility	Capital Cost (\$)	Recurrent Cost (\$/yr) ¹	Flood Mitigation Benefit	Water Harvesting Benefit	Water Quality Benefit	Other Benefits	SMA Eligible
44	Medium	Junction Road Culvert	1	DCMB	\$70,000	-	-	-	-	Reduced risk of road overtopping	-
46	Medium	North Terrace Detailed Investigation	1	DCMB	\$20,000	-	-	-	-	-	-
49	Medium	Hawthorn Road Culvert	5	DCMB	\$70,000	-	-	-	-	Reduced risk of road overtopping	-
50	Medium	Bernhard Court	9	DCMB	\$370,000	\$20,000	Reduced flood risk to 6-8 residential properties	-	-	-	-
		Flood Mitigation									
4	Medium	Bollen Road Storage	8, 11	DCMB	\$600,000	\$30,000	Protection of up to 4 houses in 100 year ARI event	-	-	-	\$50,000
5	Medium	Adelaide Road to Railway Line Levee Banks	6	DCMB	\$170,000	-	Protection of up to 9 houses and 20 commercial properties in 100 year ARI event	-	-	-	\$165,000
6	Medium	Druids Ave to Gawler Street Levees	6	DCMB	\$140,000	-	Protection of up to 4 commercial properties in 100 year ARI event	-	-	-	\$205,000
7	Medium	Gawler Street to Home Maker Centre Levee	6	DCMB	\$80,000	-	Protection of Homemaker retail/commercial precinct in 100 year ARI event	-	-	-	\$205,000
10	Medium	Totness Dam Overflow	2	Private	\$70,000	-	Protection of Industrial Estate	-	-	-	-
		Water Quality									
-	Medium	Integrate WSUD opportunity identification into standard practice for relevant road asset management / replacement programs	-	DCMB	\$10,000	-	-	-	Reduced pollutant impacts on receiving environments on an opportunistic basis	-	-
1	Medium	Junction Road Reserve bioretention basin	1	DCMB	\$80,000	\$4,000	-	-	3330, 2.9, 143, 0 (SS, P, N, GP kg/yr)	-	-
2	Medium	Spring Park Farm Reserve constructed wetland and GPT	1	DCMB	\$200,000	\$10,000	-	-	10140, 14.6, 53, 2170 (SS, P, N, GP kg/yr)	-	-
3	Medium	Benjamin Gray Reserve vegetated swale and GPT	1	DCMB	\$100,000	\$5,000	-	-	5040, 5.6, 114, 285 (SS, P, N, GP kg/yr)	-	-
4	Medium	Junction Road Culvert GPT	1	DCMB	\$100,000	\$5,000	-	-	910, 7.5, 0, 2410 (SS, P, N,	-	-

ID	Priority	Project / Activity	App C Sheet	Key Responsibility	Capital Cost (\$)	Recurrent Cost (\$/yr) ¹	Flood Mitigation Benefit	Water Harvesting Benefit	Water Quality Benefit	Other Benefits	SMA Eligible
									GP kg/yr)		
5	Medium	Mt Barker Road, Totness GPT	2	DCMB	\$140,000	\$7,000	-	-	18600, 15.5, 0, 6040 (SS, P, N, GP kg/yr)	-	-
7	Medium	Mt Barker Showgrounds vegetated swale and detention basin	9	DCMB	\$80,000	\$4,000	-	-	6070, 9.4, 25.4, 1340 (SS, P, N, GP kg/yr)	-	-
11	Medium	Duck Flat Creek constructed wetland and GPT	9	DCMB	\$2,500,000	\$40,000	-	-	13330, 29.8, 194, 1520 (SS, P, N, GP kg/yr)	-	-
12	Medium	Secker Road constructed wetland and GPT	9, 10	DCMB	\$2,000,000	\$40,000	-	-	13330, 29.8, 194, 1520 (SS, P, N, GP kg/yr)	-	-
		Stormwater Harvesting									
-	Medium	Undertake further feasibility assessment of the wetland and MAR concept at the Duck Flat Creek and Secker Road wetland sites and scope infrastructure associated to store harvested stormwater	-	DCMB	\$150,000	-	-	Potential yield of 450 ML/year	-	Biodiversity enhancement, linear park recreational integration opportunities	-
		Stormwater Infrastructure									
1B	Low	Mount Barker Road	2	DCMB	\$140,000	-	-	-	-	Reduced road overland nuisance flows on DPTI road	-
4B	Low	Fulford Tce to North Tce	3	DCMB	\$760,000	-	Reduced flood risk to 12 residential properties	-	-	-	-
6	Low	Spring Park Drive	1	DCMB	\$40,000	-	-	-	-	Reduced road overland nuisance flows	-
7	Low	Saint James Drive/Edson Court/Gum Tree Drive	1	DCMB	\$110,000	-	-	-	-	Reduced overland nuisance flows	-
8	Low	Barrow Court/Durham Court	3	DCMB	\$120,000	-	-	-	-	Reduced overland nuisance flows	-
9	Low	Pontiac Road	4	DCMB	\$50,000	-	-	-	-	Reduced overland nuisance flows	-
10	Low	Sheridan Court	7	DCMB	\$90,000	-	-	-	-	Reduced overland nuisance flows	-
14	Low	Wilkinson Court	8	DCMB	\$15,000	-	-	-	-	Reduced overland nuisance flows	-
15	Low	Cook Court	8	DCMB	\$10,000	-	-	-	-	Reduced overland nuisance flows	-
17	Low	Hill Street	5	DCMB	\$10,000	-	-	-	-	Reduced overland nuisance flows	-

ID	Priority	Project / Activity	App C Sheet	Key Responsibility	Capital Cost (\$)	Recurrent Cost (\$/yr) ¹	Flood Mitigation Benefit	Water Harvesting Benefit	Water Quality Benefit	Other Benefits	SMA Eligible
18	Low	Hawthorn Road/Adelaide Road	5	DCMB	\$180,000	-	-	-	-	Reduced overland nuisance flows	-
20	Low	Cameron Road/Gollan Circuit	6	DCMB	\$10,000	-	-	-	-	Reduced overland nuisance flows	-
22	Low	Hutchinson Street	6	DCMB	\$10,000	-	-	-	-	Reduced overland nuisance flows	-
23	Low	Morphett Street/McLaren Street	6	DCMB	\$10,000	-	-	-	-	Reduced overland nuisance flows	-
24	Low	Gawler Street	6	DCMB	\$10,000	-	-	-	-	Reduced overland nuisance flows	-
26	Low	Cameron Street/Druids Avenue	6	DCMB	\$15,000	-	-	-	-	Reduced overland nuisance flows	-
27B	Low	Secker Road	9	DCMB	\$140,000	-	-	-	-	Reduced risk of excessive road overland flows	-
28B	Low	Daw Avenue	9	DCMB	\$340,000	-	-	-	-	Reduced risk of excessive road overland flows	-
30C	Low	Wunderley Drive / Victoria Road	9	DCMB	\$370,000	-	-	-	-	Reduced risk of excessive road overland flows	-
35	Low	Hack Street	9	DCMB	\$430,000	-	-	-	-	Reduced risk of excessive road overland flows	-
36	Low	Newland Street	9	DCMB	\$85,000	-	-	-	-	Reduced risk of excessive road overland flows	-
37	Low	Hutchinson Street/Victoria Crescent	6, 9	DCMB	\$320,000	-	-	-	-	Reduced risk of excessive road overland flows	-
38	Low	Alexandrina Road	9	DCMB	\$270,000	-	-	-	-	Reduced risk of excessive road overland flows	-
40	Low	Madion Street/Wellington Road/Alexandrina Road	9	DCMB	\$580,000	-	-	-	-	Reduced road overland nuisance flows on main road	-
41	Low	Stephenson Street	8	DCMB	\$15,000	-	-	-	-	Reduced risk of excessive road overland flows	-
42	Low	Lewis Avenue/Barton Circuit	9	DCMB	\$270,000	-	-	-	-	Reduced risk of excessive road overland flows	-
43	Low	Albert Road	12	DCMB	\$150,000	-	-	-	-	Reduced risk of excessive road overland flows	-
47	Low	Wellington Road (North Railway	9	DCMB	\$490,000	-	-	-	-	Reduced road	-

ID	Priority	Project / Activity	App C Sheet	Key Responsibility	Capital Cost (\$)	Recurrent Cost (\$/yr) ¹	Flood Mitigation Benefit	Water Harvesting Benefit	Water Quality Benefit	Other Benefits	SMA Eligible
		Terrace)								overland nuisance flows on main road	
48	Low	Wellington Road (South Railway Terrace)	9, 12	DCMB	\$840,000	-	-	-	-	Reduced road overland nuisance flows on main road	-
		Flood Mitigation									
1	Low	Clems Lane Flow Diversion	2	DCMB	\$390,000	\$10,000	Reduced flood risk to 10 residential properties	-	-	-	\$195,000
2	Low	SGA Detention Basin Storages	11, 12	DCMB, Developers	\$610,000	\$30,000	Protection of 3-6 houses in 100 year ARI event	-	-	Provides strategy for future land development	-
3	Low	Pipe Diversion – Adelaide Road to Western Flat Creek ³	5	DCMB, Developers	\$1,560,000	-	Protection of 3-6 Town Centre commercial properties in 100 year ARI event	-	-	Provides strategy for future land development	-
8	Low	Creek Reconstruction – Faehrmann Avenue to Wellington Road	9, 12	DCMB	\$1,620,000	-	Reduced flood risk to 10 properties adjoining the creek reserve	-	-	Weed removal, riparian biodiversity enhancement	-
11	Low	Cameron Road to Littlehampton Creek	6	DCMB	\$100,000	-	Reduced flood risk to 2 groups of courtyard homes	-	-	-	-
		Water Quality									
6	Low	Edward Street Reserve bioretention basin and GPT	8	DCMB	\$100,000	\$5,000	-	-	13200, 14, 112, 2630 (SS, P, N, GP kg/yr)	-	-
8	Low	Wellington Road GPT	9	DCMB	\$120,000	\$6,000	-	-	10300, 8.7, 0, 3340 (SS, P, N, GP kg/yr)	-	-
9	Low	Fletcher Road GPT	9	DCMB	\$80,000	\$4,000	-	-	3730, 3.2, 0, 1045 (SS, P, N, GP kg/yr)	-	-
10	Low	Ascent Estate Reserve GPT	9	DCMB	\$100,000	\$5,000	-	-	300, 0.3, 0, 50 (SS, P, N, GP kg/yr)	-	-
					\$24,495,000	\$225,000					\$1,140,000

¹ Recurrent cost of new water quality, detention basin assets estimated as 5% of capital cost

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Appendix A

Stormwater Infrastructure, Existing Conditions Performance



Appendix B

**‘Remaining Areas’ Inlet
Approach Flow, Surface
Overflows Performance**



Appendix C

Proposed Structural Works & Upgrades



Appendix D

Flood Plain and Hazard Maps – Existing Scenario



Appendix E

Flood Plain and Hazard
Maps – Proposed
Upgrades, Ultimate
Scenario



Appendix F

Creeks Flood Mitigation Concept Plans



Appendix G

Detention Basin Concept Plans