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THE CITIES OF ADELAIDE, BURNSIDE, MITCHAM, UNLEY AND WEST TORRENS

## BROWN HILL KESWICK CREEK STORMWATER PROJECT

### STORMWATER MANAGEMENT PLAN 2012



301015-02356wjh120801-REP-0006 - BHKC SMP 2012.doc

10<sup>th</sup> August 2012

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**Acknowledgements**

*In addition to components of the work completed by AWE, Hydro Tasmania and Evans & Peck, WorleyParsons wishes to acknowledge the contributions to this Stormwater Management Plan made by the Cities of Burnside, Adelaide, Mitcham, Unley and West Torrens, the Adelaide and Mount Lofty Ranges Natural Resources Management Board, the Department of Planning, Transport and Infrastructure and the BHKC Project Director.*

**Cover Photo:** *Flooding in Culvert Street, Unley (Glen Osmond Creek) in April 2010*

**Project:** 301015-02356 BROWN HILL KESWICK CREEK STORMWATER MANAGEMENT PLAN 2012

REV	DESCRIPTION	AUTHOR	REVIEWER	WORLEY-PARSONS APPROVAL	DATE	CLIENT APPROVAL	DATE
A	Issued for Internal Review	WJH W Honour	CRT C Thomas		19/07/12	N/A	
0	Issued for Review	WJH W Honour	CRT C Thomas		10/08/12	N/A	



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## **EXECUTIVE SUMMARY**

### **Introduction**

This draft Stormwater Management Plan (*SMP*) covers the catchments of Brown Hill and Keswick Creeks, including Glen Osmond and Parklands Creeks, which are important drainage watercourses in metropolitan Adelaide.

The creeks have a relatively high flood risk, a low standard of flood protection and a long history of flooding issues. The combined Brown Hill and Keswick Creeks catchment is mainly contained within the local government areas of Adelaide, West Torrens, Mitcham, Burnside and Unley.

In 2008 the Stormwater Management Authority conditionally approved the 2006 Flood Management Master Plan as a stormwater management plan. However, due to subsequent community concerns, particularly in respect of proposed flood control dams in the upper reaches of Brown Hill Creek, the catchment councils and the Stormwater Management Authority agreed to prepare a revised stormwater management plan.

WorleyParsons was engaged by the Brown Hill Keswick Creek Stormwater Project in 2010 to prepare this draft *SMP* as an update to the 2006 Flood Management Master Plan (*2006 Master Plan*).

This *SMP* has been prepared in accordance with the *Stormwater Management Planning Guidelines* of the Stormwater Management Authority and with a range of objectives under the following headings:

1. Protection from flooding
2. Quality of runoff and effect on receiving waters
3. Beneficial reuse of stormwater runoff
4. Protection of watercourses and riparian ecosystems
5. Effective planning outcomes
6. Management of stormwater infrastructure

A key objective is to provide a standard of flood protection equivalent to the 100 year Average Recurrence Interval (*ARI*) event or better (*subject to economic justification*). Presently, the system is generally considered to have about a 10 year *ARI* level of protection.

### **Background**

Development of the 2006 Master Plan was carried out in three stages.



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The first stage was documented in the *Flood Mitigation Study for Brown Hill and Keswick Creeks Stage 1 Technical Report (2005)*. Over 300 potential opportunities for mitigation works to reduce flooding were identified, including flood detention works, flow diversions and increasing channel and bridge capacities. Non-structural options were also considered and opportunities to include multi-purpose benefits also were identified.

The second stage involved community consultation, which informed development of flood management measures, including a set of priority mitigation works. Final investigations involved hydraulic modelling to determine flood damages reduction provided by the works and development of the recommended flood management strategy.

Floodplain modelling for the catchment was initially developed in 2003 and subsequently updated in 2006. Based on that modelling it is determined in the current investigation that damages for a 100 year ARI flood will cost about **\$187 Million** and affect nearly 7,000 properties if no flood mitigation action is taken.

Development of this revised stormwater management plan will be a two stage process involving this SMP (*the 2012 SMP*) followed by a Final SMP.

## Development of 2012 Stormwater Management Plan

A key requirement of the current investigation, was to re-assess the proposed flood mitigation works in upper Brown Hill Creek of the 2006 Master Plan and investigate alternative options.

WorleyParsons produced a report in August 2011 (*the 2011 Draft SMP*) in which the recommended infrastructure works for upper Brown Hill Creek included a flood control dam in Brown Hill Creek Recreation Park.

The report was subject to community consultation in late 2011 from which there were significant community concerns about the proposed dam. Subsequently, other investigations into alternative options for a 'no dam' solution were investigated and found to be technically feasible. However, all options identified for upper Brown Hill Creek are subject to re-assessment as a result of updated information regarding the hydraulic capacity of the creek.

In May 2012 the catchment councils endorsed a strategy for the commencement of designated Part A Works and a commitment to undertake further investigations over a 12 month period from the date of gazettal of the 2012 SMP in order to resolve the works for upper Brown Hill Creek under a Part B Works process. Central to the strategy is a preference to pursue a feasible and community acceptable 'no dam' solution of acceptable cost.

The Part B Works, when determined in accordance with the process, will be incorporated into a Final SMP.

## Upper Brown Hill Creek Works

Under the 2011 Draft SMP investigation the two flood control dams proposed as part of the 2006 Master Plan were re-assessed to determine the flood reduction benefit they provide in isolation to other works from the 2006 Master Plan.



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Conclusions from the analysis are that flood detention in the rural part of the catchment has a significant effect in mitigating flood impacts in the Brown Hill Creek catchment. It was also determined that a single flood control dam suitably located could provide nearly as much detention benefit as the two originally proposed dams.

The analysis also showed that other measures are needed to mitigate flooding caused by overtopping of the Brown Hill Creek channel at locations between Cross Road and Anzac Highway, which leads to flow across the highway and consequent flooding through areas of West Torrens.

## Alternative Options for Upper Brown Hill Creek

For the 2011 Draft SMP, alternative flood mitigation works were investigated for Brown Hill Creek upstream from Anzac Highway, including alternative configurations for upper catchment detention. A multi-criteria analysis was undertaken to identify a number of viable options for further more detailed consideration.

They were considered by themselves or in combination to develop nine alternative scenarios:

- Flood control dam in the Brown Hill Creek Recreation Reserve (Site 1);
- Flood control dam at Site 2 (*rural part of the upper BHC catchment*);
- Flood control dam at Site 2 + weir system along Brown Hill Creek;
- Flood control dam at Site 2 + overland flow interceptor at the Glenelg Tramway (*including downstream channel upgrade*);
- Flood control dam at Site 2 + supplementary works to prevent channel overtopping;
- Overland flow interceptor at the Glenelg Tramway (*including downstream channel upgrade*);
- Overland flow interceptor at the Keswick Creek diversion (*at Leader Street, proposed as part of the 2006 Master Plan*);
- Small flood control dam at Site 1 + supplementary works to prevent channel overtopping;
- Complete channel upgrade between Anzac Highway and Muggs Hill Road in Mitcham.

Each scenario was assessed in terms of implementation cost and reduction in 100 year ARI flood damages that they would provide. The assessment found that when incorporated into the catchment-wide mitigation scheme the alternative scenarios have similar indicative benefit-cost ratios (*typically between 0.7 and 0.8*).

The selected scenario for upper Brown Hill Creek was the construction of a (*12 metre*) dam at Site 1 together with supplementary works to prevent channel overtopping, which include:

- a high-flow bypass culvert from Malcolm Street in Millswood to the Glenelg tramway in Forestville; and,
- upgrading of the Brown Hill Creek channel between Leah Street and Anzac Highway, Forestville.

Following the outcome of community consultation for the 2011 Draft SMP, WorleyParsons was commissioned to investigate other alternative options which involved increasing the capacity of the





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high-flow bypass culvert and extending it from Malcolm Street to Hampton Street in order to convey excess creek flow such that the flood control dam could be avoided (*i.e. a 'no dam' scenario*).

The resulting 'Bypass Culvert Feasibility Assessment' report was delivered in April 2012. Two route options were investigated, designated Option 3 and Option 3A for which the estimated construction costs are shown in the following table. The investigation concluded that both options are feasible from an hydraulic design perspective.

Also in April 2012, a study commissioned by the AMLRNRMB into the hydraulic condition of the catchment watercourses was delivered. It found that the hydraulic capacity of upper Brown Hill Creek was significantly lower than had been assumed for the 2011 Draft SMP investigations and the Bypass Culvert Feasibility Assessment.

Consequently, all the options for upper Brown Hill Creek will be reviewed during the Part B Works process, including impacts resulting from the findings of the Channel Capacity Assessment.

The recommended flood mitigation scheme for the whole catchment, as presented in the 2011 Draft SMP, included the selected scenario for upper Brown Hill Creek and other catchment-wide works originating from the 2006 Master Plan, together with a range of non-structural measures.

For the 2012 SMP, further investigation of flood mitigation options in upper Brown Hill Creek (*i.e. the Part B Works*) will be informed by results of the 2011 Draft SMP and the Bypass Culvert Feasibility Assessment report.

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## Recommended Stormwater Management Strategies

Recommended strategies of the 2012 SMP are summarised as follows:

### Flood Mitigation Works

COMPONENT	CAPITAL COST (2012 \$ M)		
	2011 DRAFT SMP	OPTION 3 BYPASS CULVERT	OPTION 3A BYPASS CULVERT
<b>Part A Works</b>			
Detention basins in the South Park Lands / Glenside Campus	\$17.6		
Modify Mt Osmond Interchange Dam outlet.	Completed in 2008		
Inline flood detention system in Ridge Park Reserve and stream rehabilitation	\$1.1		
Bypass Culvert at Fisher Street	\$4.5		
Keswick Creek to Brown Hill Creek Diversions at Le Hunte Street and Anzac Highway	\$31.9		
Brown Hill Creek Channel Upgrades between Forestville Reserve and Anzac Highway	\$14.9		
Brown Hill Creek Channel Upgrade from Anzac Highway to the Confluence with Keswick Creek	\$49.1		
<b>Sub-Total Cost</b>	<b>\$119.1</b>	<b>\$119.1</b>	<b>\$119.1</b>
<b>Part B Works</b>			
Flood Control Dam at Brown Hill Creek Recreation Reserve	\$10.8	-	-
Minor Channel Works in Mitcham	\$0.8	\$2.1	\$2.1
Channel upgrade between Hampton Street & Cross Road	\$2.8	\$2.8	\$2.8
Bypass Culvert between Malcolm Street and Forestville Reserve	\$14.1	\$19.0	\$18.1
Bypass Culvert between Hampton Street and Malcolm Street	-	\$11.0	\$8.5
<b>Sub-Total Cost</b>	<b>\$28.5</b>	<b>\$34.9</b>	<b>\$31.5</b>
<b>TOTAL CAPITAL COST</b>	<b>\$147.6</b>	<b>\$154.0</b>	<b>\$150.6</b>



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Implementation of the recommended structural works is expected to reduce 100 year ARI damages from **\$187 Million** to **\$17.8 Million**.

The full mitigation scheme (*effective for Part A and B works*) is estimated to have a benefit-cost ratio of approximately 0.65 based on tangible flooding impacts. The benefit-cost ratio for the Part A works alone is estimated to be 0.65. Economic ratios of this order, for flood mitigation infrastructure, can be considered favourable in terms of project justification given that intangible factors are not included.

Furthermore, the database used to quantify properties at risk has not been updated since 2003. Based on a cursory audit of the database, there are estimated to be about 20% more properties at risk than currently incorporated in the damages analysis.

The Part A Works are considered effective as a stand-alone flood mitigation scheme as well as being integral elements of the overall SMP for the catchment including Part B Works (*when defined*).

In conjunction with particular flood mitigation works there are opportunities for non flood related benefits, including rehabilitation of riparian areas, biodiversity enhancement, removal of exotic vegetation and weed species, improving recreational amenity, reduced stream bed and bank erosion and general stream rehabilitation.

**Properties affected by flooding for existing conditions**

DESIGN FLOOD EVENT	NUMBER OF FLOOD AFFECTED PROPERTIES		
	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	TOTAL
10 Year ARI	151	1,001	1,152
20 Year ARI	805	3,059	3,864
50 Year ARI	1,513	4,199	5,712
<b>100 Year ARI</b>	<b>1,712</b>	<b>5,209</b>	<b>6,921</b>
500 Year ARI	2,440	7,806	10,246





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Properties affected by flooding following proposed mitigation works

DESIGN FLOOD EVENT	NUMBER OF FLOOD AFFECTED PROPERTIES		
	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	TOTAL
10 Year ARI	42	238	280
20 Year ARI	102	473	575
50 Year ARI	142	747	889
<b>100 Year ARI</b>	<b>225</b>	<b>1,096</b>	<b>1,321</b>
500 Year ARI	1,041	4,019	5,060

The above figures do not reflect the improved results produced by the inclusion of the proposed Fisher Street bypass culvert and correction to floodplain mapping in the vicinity. Corrections to the floodplain model will be carried out in the Part B Works process.

At the whole of catchment scale, works (*Parts A and B*) are planned to mitigate the 100 year ARI flood conditions over approximately 90% of the catchment. Over the remaining area the standard of protection would be at an acceptably higher level than is current.

**Planning Policy and Development Assessment**

Councils recognise that techniques of water sensitive urban design (WSUD) provide an opportunity to assist in the management of flooding risk in the context of new development and urban consolidation.

WSUD systems are being incorporated into refurbished and new streetscape developments within the catchment, mainly by councils, and it is proposed that such systems continue to be installed as opportunities arise.

Councils will undertake investigations during the Part B Works process to obtain greater understanding of potential impacts of infill development on generation of stormwater runoff and propose improved planning policies or controls for addressing the risks.

Councils will adopt Development Plans that are in accordance with South Australian Planning Policy Library policies in respect of flood risk reduction and which seek to ensure that new development does not reduce the capacity or functionality of the existing stormwater drainage network.

Councils will implement planning policy measures which seek to limit stormwater discharge from new developments to predevelopment volumes and peak rates of discharge.



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Councils generally will prohibit new development that would obstruct or interfere with a watercourse or is at high risk of flooding and will implement planning policy measures which seek to limit stormwater discharge from new developments to predevelopment volumes and peak rates of discharge.

### Community Awareness, Flood Preparedness and Emergency Response

Councils continue to support the Floodsafe program and recommend that it be enhanced by State Emergency Services. Councils will continue to work with State Emergency Services in developing and implementing a new Emergency Response Plan for Brown Hill and Keswick Creeks.

### Creek Maintenance and Ownership Responsibilities

Gross Pollutant Traps (*GPTs*) and silt traps have already been established along the creek channels by the AMLRNRMB to reduce contamination and pollution from entering the catchment receiving waters.

A code of practice for maintenance of urban watercourses is recommended. It is noted that at the time of preparing this SMP a code of practice is being considered within the AMLRNRMB, and the BHKC Project would seek to be involved and provide assistance with any such initiative.

It is noted that under the State Government's Stormwater Strategy there is a lead responsibility group of agencies to 'evaluate options for management of urban watercourses on public and private land to further minimise flooding risk.'

The catchment councils will address creek maintenance responsibilities in the Part B Works process, in consultation with the lead responsibility group, and include an outcome in the Final SMP.

As part of that process the councils will consult with others and seek expert advice, as may be necessary, with the intention of clarifying legislative responsibilities for management and provision of funding resources (*as between the parties*) for routine maintenance.

Management of the quality of runoff and its effect on receiving waters will be negotiated with the AMLRNRMB during the Part B Works process for inclusion of targets in the Final SMP.

### Stormwater Harvesting and Reuse

Stormwater harvesting is operational at three sites within the catchment and additional stormwater harvesting opportunities at Ridge Park, Heywood Park and South Park Lands (*as a potential site*) are identified.

Total stormwater harvesting and reuse potential capacity from existing schemes in the catchment represents approximately 16% of the runoff generated within the urban part of the catchment.

The project has applied to the Commonwealth Government for funding assistance under the National Urban Water and Desalination Plan to develop a MAR scheme in the disused railway corridor in proximity to lower Brown Hill Creek (*supported in-principle by key stakeholders including DPTI as custodians of the land*).



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Strategies and targets for increasing the volume of reuse will be negotiated with the AMLRNRMB during the Part B Works process, for inclusion in the Final SMP.

**Implementation and Funding Arrangements**

In recognising that all spheres of government have an interest in reducing flood risk, the SMP reflects principles of cooperation and cost sharing in respect of implementation responsibilities.

The councils are proposing to establish a regional subsidiary in terms of the Local Government Act as the vehicle to meet their responsibilities under the SMP. Work has commenced on preparation of a charter which will be the basis of the legal agreement between the councils for operation of the regional subsidiary.

The regional subsidiary, working in partnership with or with the support of state government agencies, would be responsible for governance of the BHKC Project, management of the SMP, and design, construction, operation and maintenance of flood mitigation works owned by the BHKC Project.

The regional subsidiary would need to work with the SMA and others to secure state and Commonwealth funding for construction of the flood mitigation works and to manage the SMP and maintain the assets. Ongoing management responsibilities for watercourses and state owned infrastructure will need to be resolved.

The councils' preferred funding model is based on each sphere of government (*Commonwealth, State and Local*) contributing a one third share of the overall project capital cost. Funding of ongoing management, maintenance and finance costs will need to be discussed and resolved.

The councils have agreed on cost apportionments between themselves in respect of the local government share of the overall project costs (*capital, maintenance and administration*).

COUNCIL AREA	PERCENTAGE SHARE OF COSTS <i>(Construction and Maintenance)</i>	PERCENTAGE SHARE OF COSTS <i>(Administration)</i>
Burnside	12%	20%
Adelaide	8%	20%
Unley	21%	20%
Mitcham	10%	20%
West Torrens	49%	20%



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In respect of the assets owned by the BHKC Project it is noted that life cycle cost, including liability for depreciation expenses and renewal cost is an issue that is not settled. As between the councils, this issue will be addressed in the charter. However, it is also regarded as an issue which should be considered in terms of partnership with or with the support of State Government.

The proposed structural works comprising Parts A and B will be completed over a ten year timeframe. Year 1 is assumed to be 2012/13. The program limits expenditure to a maximum of about \$20 million in any one year.

Year	1	2	3	4	5	6	7	8	9	10
	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
<b>Works</b>										
Ridge Park Detention System	Works									
South Park Lands Detention System	Design	Works								
Lower Brown Hill Creek Channel Upgrade	Design		Works							
Keswick Creek Diversion Culverts			Design		Works					
Anzac Hwy to Forestville Reserve Channel Upgrade				Design		Works				
Bypass Culvert at Fisher St							Design	Works		
Part B Works (1)						Design	Works			
Part B Works (2)							Design	Works		
Part B Works (3)								Design	Works	

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- APPENDIX L - CONCEPT DESIGN PLANS FOR STRUCTURAL FLOOD MITIGATION WORKS**
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## LIST OF ABBREVIATIONS

AAD	Average Annual Damages
AMLRNRMB	Adelaide and Mount Lofty Ranges Natural Resources Management Board
ANCOLD	Australian National Committee on Large Dams
AR&R	Australian Rainfall and Runoff
ARI	Average Recurrence Interval
AWE	Australian Water Environments
BCR	Benefit Cost Ratio
BHKC Project	Brown Hill Keswick Creek Stormwater Project
BOM	Bureau of Meteorology
DENR	Department for Environment and Natural Resources
DPTI	Department of Planning, Transport and Infrastructure
DTM	Digital Terrain Model
GIS	Geospatial Information System
MAR	Managed Aquifer and Recharge
NRMB	Natural Resources Management Board
PCWMB	Patawalonga Catchment Water Management Board
PMF	Probable Maximum Flood
PPRR	Prevention Preparedness Response Recovery
RRR	Rainfall Runoff Routing
SAPPL	South Australian Planning Policy Library
SES	State Emergency Services
SMA	Stormwater Management Authority
SMP	Stormwater Management Plan
W&G	Wallbridge and Gilbert
WBCM	Wood Bromley Carruthers & Mitchell
WSUD	Water Sensitive Urban Design



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## **1. INTRODUCTION**

This draft Stormwater Management Plan (*SMP*) covers the catchments of Brown Hill and Keswick Creeks, including Glen Osmond and Parklands Creeks, which are important drainage watercourses in metropolitan Adelaide. The combined Brown Hill and Keswick Creeks catchment is mainly contained within the local government areas of Adelaide, West Torrens, Mitcham, Burnside and Unley (*the “catchment councils”*).

The draft *SMP* has been developed as an update to the 2006 Flood Management Master Plan (*2006 Master Plan*). The primary aim of the Plan, to be prepared in accordance with the Stormwater Management Authority Planning Guidelines, is to recommend flood mitigation works and stormwater management strategies that will reduce the impact of flooding in the urban floodplain of the catchment and provide multiple-purpose benefits where possible.

In 2008 the Stormwater Management Authority (*SMA*) conditionally approved the 2006 Master Plan as a stormwater management plan. However, due to subsequent concerns about aspects of the 2006 Master Plan, particularly in respect of proposed flood control dams in the upper reaches of Brown Hill Creek, the catchment councils and the *SMA* agreed to prepare a revised *SMP*.

Flood mitigation works and other management measures proposed as part of this *SMP* have been generally developed to a level of detail suitable for concept planning and costing only. In a subsequent stage of the project, concept designs will be prepared to outline the scope of works in more detail and may include investigation of technical and other aspects such as environmental, social and cultural heritage impacts. Those concept designs will then inform the detail designs and documentation for the construction of works.

### **1.1 HISTORICAL CONTEXT**

Brown Hill, Keswick, Parklands and Glen Osmond Creeks have a relatively high flood risk, a low standard of flood protection, and a long history of flooding issues. While widespread flooding has not occurred since the 1930s, there have been a number of times when flooding has threatened the catchment most recently in November 2005 when flooding occurred in Mitcham and Unley due to heavy rains in the upper portion of the Brown Hill Creek catchment.

Large scale channel improvement works were conducted by the State Government in the mid 1930s under the authority of the Metropolitan Drainage Act 1935. This work was confined to the lower reaches of Brown Hill and Keswick Creeks and followed major floods that occurred in 1925 and 1930.

Brown Hill and Keswick Creeks were relocated to their present alignments on the eastern and southern side of the airport as part of airport development works in the 1950s. Due to rapid post war development of the western suburbs flooding remained a major issue.

Subsequent to the 1950s, works to reduce the impact of flooding have largely been undertaken on a council by council basis, such as the Glenside detention basin and the Urrbrae wetlands. There are few examples of a coordinated approach across the catchment councils. A notable exception is the installation of a flood forecasting/warning service for Brown Hill Creek and the lower reaches of Keswick Creek by the Bureau of Meteorology (*BOM*) and local councils during the 1990s.



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Attempts to initiate and coordinate catchment-wide works have largely been unsuccessful because agreement could not be reached on the extent of the problem, works proposed, or cost sharing arrangements. This is despite a number of catchment-wide flood mitigation studies having been undertaken and a range of potential mitigation schemes having been considered.

**1.2 GOVERNANCE**

The five catchment councils took over full responsibility for implementing the 2006 Master Plan in 2007 and established the Brown Hill Keswick Creek Stormwater Project for that purpose (*the BHKC Project*).

Governance of the BHKC Project is exercised through the project Steering Group which includes the Chief Executives of the five catchment councils. In addition, the investigation by WorleyParsons has been overseen by a Study Steering Committee, which includes a representative from each of the Adelaide and Mount Lofty Ranges Natural Resources Management Board (*AMLRNRMB*), the Department of Planning, Transport and Infrastructure (*DPTI*) (*as technical representative for the SMA*) and Mitcham, West Torrens and Unley Councils.

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## **2. BACKGROUND**

### **2.1 PREVIOUS STUDIES**

Work in 1971 by consultants BC Tonkin and Associates identified a number of opportunities and barriers associated with reducing flooding in the catchment. They recommended a number of management initiatives, which included securing sections of watercourse into public ownership or the creation of easements. However, most of those recommendations were not implemented.

Work in the early 1980's by Wood Bromley Carruthers & Mitchell (*WBCM*) identified a flood mitigation strategy but further detailed investigations were never undertaken.

Investigations undertaken by Hydro Tasmania in 2001 for the Patawalonga Catchment Water Management Board involved the preparation of detailed floodplain inundation mapping and a comprehensive flood damages estimate for the first time since 1984 (*WBCM*).

### **2.2 2006 MASTER PLAN**

Hydro Tasmania Consulting, in association with Australian Water Environments (*AWE*), QED and the SA Centre for Economic Studies was appointed by the AMLRNRMB to undertake a flood mitigation study for Brown Hill and Keswick Creeks, including Parklands and Glen Osmond Creeks culminating in a flood management master plan for the catchment.

The project was carried out in three stages. The first stage was documented in the *Flood Mitigation Study for Brown Hill and Keswick Creeks Stage 1 Technical Report (2005)*. Stage 2 involved stakeholder and community consultation and Stage 3 was production of the *Flood Management Master Plan (2006 Master Plan)*.

Hydrologic modelling of the catchment was undertaken by Dr David Kemp of DPTI using the Rainfall Runoff Routing (*RRR*) model. The hydrologic modelling was based on a projected 30 year catchment condition in which current trends in urban consolidation are expected to continue.

Two dimensional hydraulic modelling using the proprietary software system MIKE Flood was completed in Stage 3 of the project to verify the effectiveness of the priority works components and to enable flood damages to be estimated assuming the priority works components had been implemented. The same hydraulic model had been used for previous floodplain mapping exercises in 2001 to 2003.

The recommended scheme of the 2006 Master Plan comprised the following structural components:

- Upgrade of Fullarton Road / Greenhill Road culvert (*Parklands Creek*)
- Series of detention basins in the South Park Lands (*Parklands Creek*)
- Modification of the Mt Osmond interchange dam outlet (*Glen Osmond Creek*)
- Inline flood detention system in Ridge Park Reserve (*Glen Osmond Creek*)





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- Upgrade of culverts under Fisher Street (*Glen Osmond Creek*)
- “Goodwood Road” diversion culvert from Keswick Creek to Brown Hill Creek
- “Railway” diversion culvert from Keswick Creek to Brown Hill Creek
- Two flood control dams in the upper rural portion of the Brown Hill Creek catchment
- Brown Hill Creek channel upgrade between Hampton Street and Cross Road
- Upgrade of the Brown Hill Creek channel downstream from Anzac Highway to the confluence with Keswick Creek

The location of each of these works is shown in the map provided in **Appendix A**, which has been extracted directly from the 2006 Master Plan.

The proposed culvert diversions from Keswick Creek to Brown Hill Creek, the detention basins in the South Park Lands and the upgrade of the Fullarton Road / Green Hill Road culvert have been further investigated as part of work completed by Tonkin Consulting in 2009 and 2010 on behalf of the BHKC Project. The latest concept design configurations for these works are not shown in **Appendix A**, but are discussed later in this report.

A feasibility study of the two flood mitigation basins in the upper reaches of Brown Hill Creek was undertaken by GHD Pty Ltd (*October 2008*) as a first stage in the design (*i.e. prior to undertaking detailed investigations and design as subsequent stages*).

The 2006 Master Plan also incorporated non-structural management options, which included:

- Community awareness and flood preparedness; and
- Planning policy and the enhancement of development plans and assessment criteria.

### **2.3 HYDROLOGY REVIEW**

Hydrologic modelling for the 2006 Master Plan and earlier investigations was carried out by DPTI, as noted in Section 2.2. The RRR model used was calibrated on rainfall and streamflow data collected for all four creeks since 1989.

In 2010 Mitcham Council commissioned VDM Consulting to investigate the hydrology of the catchment of upper Brown Hill Creek. VDM used standard AR&R (1987) methods to determine flood flows for a range of average recurrence intervals. The VDM estimates of peak flows are greater than the DPTI estimates.

Under the BHKC Project, Sinclair Knight Merz (*specifically Mr Peter Hill*) was engaged to carry out a peer review of both the DPTI and VDM hydrology assessments and to make recommendations regarding the appropriate set of design flows to be adopted for the purposes of flood analysis, and provide comment on any further hydrological analysis that could or should be undertaken before design flows are finalised.



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The key conclusions by Hill are:

- *“The theoretical basis of the RRR model used in Transport SA studies (DPTI approach) appears sound and from the reporting provided the model has been carefully configured to account for the complex flow paths and control structures such as the freeway, various detention basins and piped sections.*
- *On the basis of the results from at-site and regional flood frequency analysis, a 1 in 100 AEP peak flow at Scotch College of between 25 and 30 m<sup>3</sup>/s would appear reasonable and this supports the peak flows from the Transport SA study which are considered suitable for design. The VDM values are somewhat higher than this which is consistent with their stated intention of being conservative.*
- *The flows from the urban areas are likely to be highly sensitive to the assumptions regarding directly connected impervious fractions. The generally good calibration to the recorded hydrographs achieved in the Transport SA study provides some assurance that the values of directly connected impervious, and hence peak flows at Cross Road, are appropriate. On this basis they are recommended for design, however it would be desirable if the approach and adopted values were further documented.”*

Hill commented also on climate change, as follows: *“There is currently a lack of quantitative information on the potential impacts of climate change on factors that affect flood magnitude. Any increase in design rainfall intensities may be partially offset by higher losses resulting from the drier antecedent conditions. Given the uncertainty in the projections it is recommended that the flood estimates are derived using the existing design information.”*

The BHKC Project accepted the assessment by Hill and confirmed that the RRR hydrology would be used in investigations for the draft SMP. Subsequently, all required additional hydrologic information required for the study was provided by DPTI / Kemp through the BHKC Project to WorleyParsons.

## **2.4 STORMWATER MANAGEMENT AUTHORITY**

In 2005 the State Government and the Local Government Association released the Urban Stormwater Policy for South Australia. In 2006 they entered into the Stormwater Management Agreement which sets out the roles and responsibilities of state and local government and provides governance arrangements for stormwater management on a catchment basis throughout the state.

A key element of strategies described in the Urban Stormwater Management Policy is the development of stormwater management plans for catchments to ensure that stormwater management is addressed on a total catchment basis with the relevant NRM Board, local government authorities and relevant state government agencies working together.

The Stormwater Management Authority was established in 2007 under the Local Government Act 1999 and is responsible for the proper operation of the Stormwater Management Agreement. The SMA has issued the *Stormwater Management Planning Guidelines* to provide a template for consistent management of stormwater through multi-objective planning, including reuse where feasible.



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## **2.5 STORMWATER PLANNING STRATEGY**

In July 2011, the Government of South Australia released *Stormwater Strategy – The Future of Stormwater Management* which provides a ‘road map’ for future stormwater management in the state.

The Strategy, in referring to a changing climate in parts of southern Australia, warns that more intense and regular storms increase the potential for:

- More severe flooding, with consequent safety, economic and property impacts;
- A decrease in water quality within both watercourses and receiving waters (*for example, Gulf St Vincent*);
- Channel erosion and increased sedimentation in watercourses;
- Loss of vegetation through erosion and replacement by invasive species, and
- A reduction in the health of aquatic habitats, both watercourses and receiving waters.

Key components of the Strategy which are relevant to the Brown Hill Keswick Creek SMP include:

- Transitioning Adelaide to a water sensitive city (*water sensitive urban design*) – the vision, in this context includes mandating in new developments sustainable water management features at an on-site, precinct and catchment scale (*retrofitting, where possible, existing urban areas with water sensitive facilities*);
- Achieving targets for stormwater harvesting, where economically and technically feasible;
- Addressing flood risk in existing and future developments and ensuring the State’s planning system includes minimum risk standards for all types of developments;
- Improving the management of flood risk by investing in flood preparedness, ensuring people are informed at the time of property purchase and evaluating adequate insurance cover; and
- Recognising that, as watercourses often pass through private land, designing, implementing and managing appropriate flood mitigation measures can be problematic as private land is not always accessible for such purposes and on-going responsibility for maintenance of watercourses on privately owned land has therefore been an issue.



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### 3. APPROACH TO DEVELOPMENT OF THE SMP

#### 3.1 SCOPE OF 2011 INVESTIGATIONS

WorleyParsons were engaged by the City of Unley on behalf of the BHKC Project to carry out investigations and produce a draft revised SMP incorporating measures of the 2006 Master Plan and any revisions to the works proposed along the section of Brown Hill Creek upstream from Anzac Highway (*upper Brown Hill Creek*), including the rural part of the catchment.

In developing the revised SMP, previous studies (*as identified in Section 2*) were reviewed and taken into account, in conjunction with input from a range of stakeholders and consideration of issues raised since 2006.

Development of the 2011 Draft SMP included the following investigations:

- Review of the economic justification of the 2006 Master Plan works that were proposed for upper Brown Hill Creek (*i.e. two flood control dams upstream from the Brown Hill Creek Recreation Reserve and the Hampton Street to Cross Road channel upgrade works*);
- Assessment of potential alternative mitigation options for upper Brown Hill Creek, involving qualitative and quantitative filtering methods;
- Further detailed assessment of the effectiveness of priority mitigation options for upper Brown Hill Creek using the existing hydrologic and hydraulic flood modelling tools for the catchment;
- An economic analysis of the selected stormwater management strategy involving the comparison of benefits versus cost; and
- An independent peer review of the economic assessment method used. This has been carried out by consultant Evans and Peck.

The Draft SMP retained the previously proposed flood mitigation and stormwater management measures proposed by the 2006 Master Plan for the other creeks within the catchment. Where appropriate, documentation of these measures was adapted from the 2006 Master Plan or from subsequent concept design work.

Measures that have been investigated further since 2006 are the flow diversions from Keswick Creek to Brown Hill Creek and the South Park Lands detention system. In those cases, the latest concept design configuration, superseding that of the 2006 Master Plan, was documented in the Draft SMP.

WorleyParsons' engagement to prepare the SMP focused on the investigation of stormwater management options for the upper portion of Brown Hill Creek. Therefore, it should be recognised that much of the content of the SMP and associated strategies for other reaches of the creeks across the wider catchment have been adapted from the work of others.

In addition, much of the general background information on catchment conditions and the characteristics of flooding presented in the Plan have also been adapted from the 2006 Master Plan. As such, due acknowledgement is given to the authors of the 2006 Master Plan.



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WorleyParsons produced a report in August 2011 as the basis for the SMP (*referred to as the '2011 Draft SMP'*). It included recommendations for structural works on upper Brown Hill Creek, including a flood control dam in Brown Hill Creek Recreation Park, as well as the recommended works for other parts of the catchment based on the 2006 Master Plan. The report was the subject of a community consultation process carried out in late 2011.

### **3.2 SUPPLEMENTARY INVESTIGATIONS**

The following reports were produced subsequent to the 2011 Draft SMP:

- Brown Hill Keswick Creek Stormwater Plan Project – Community Consultation Report (*prepared by URPS for the BHKC Project, March 2012*)

The community consultation process and report findings are discussed at Section 5.3.

- Brown Hill and Keswick Creek Survey and Hydraulic Assessment – Channel Capacity Assessment (*prepared by AWE for the AMLNRMB, April 2012*)

The AMLNRMB carried out a survey of the Brown Hill and Keswick Creek channels recognising that a comprehensive survey of the four creeks was last undertaken in the 1980s. The report on the survey states that:

*“It is to be expected that there have been significant changes to the creeks over those 30 years and (it) is intended to collect the necessary information so that the current channel capacities can be determined and mapped.*

*This information will also enable the existing condition (in terms of channel roughness / obstructions) to be mapped, along with the flood conveyance capacity at each surveyed cross section. This will provide a reference point from which the Board and Councils can work with landholders to ensure flood capacities are not further compromised in the future.”*

The results also serve to inform more detailed analysis of critical sections of channel for the purposes of interpreting floodplain mapping and future concept design for works as part of the SMP.

- Discussion Paper on the Brown Hill Keswick Creek Draft Stormwater Management Plan 2011 (*prepared by the City of Unley as its submission to the BHKC Project, May 2012*) – endorsed by Council 28 May 2012 (*refer **Appendix B***).

As a result of community concerns about the proposed dam in Brown Hill Creek Recreation Park, the investigations were commissioned:

- Brown Hill Keswick Creek Stormwater Management Plan – Preliminary Assessment – Enhancement of flood Mitigation Options (*prepared by WorleyParsons for Mitcham Council, November 2011*)

This study investigated a range of variations to the flood mitigation scheme presented in the 2011 Draft SMP, including extension of proposed flow bypass culverts in lieu of a flood control dam, and the potential impact of further reducing the size of the dam.



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- Brown Hill Keswick Creek Stormwater Project – Bypass Culvert Feasibility Assessment (*Hampton Street to Forestville Reserve*) (prepared by WorleyParsons for the BHKC Project, April 2012)

This study further investigated the feasibility of installing large flow bypass culverts through Mitcham and Unley council areas, with a focus on hydraulic design of the culverts and their potential to conflict with existing underground services, particularly sewer and water supply mains.

### **3.3 2012 SMP STRATEGY**

In May 2012, the catchment councils endorsed the following strategy for completion of the Stormwater Management Plan, which calls for the commencement of the bulk of proposed flood mitigation works throughout the catchment, while committing to further investigations over a 12 month period to resolve works for upper Brown Hill Creek. The strategy as set out below was formally communicated to the SMA by letter dated 30<sup>th</sup> April 2012 (*refer Appendix C*).

#### ***Proposed Strategy***

1. It is proposed that:
  - (a) The catchment councils recommend to the Stormwater Management Authority a stormwater management plan (*the '2012 SMP'*) comprising the following, as described in subsequent paragraphs:
    - Flood mitigation works for Part A of the catchment subject to effective flood mitigation performance and cost controls (paragraph 2)
    - A process for determination of flood mitigation works for Part B of the catchment (paragraphs 5 - 12)
    - Other flood mitigation measures (paragraph 13)
    - Other information required to satisfy the Stormwater Management Authority Planning Guidelines (paragraph 14);and
  - (b) The catchment councils, on approval of the 2012 SMP, undertake to agree on the full scope of flood mitigation works for the catchment and incorporate them in the SMP (*the 'Final SMP'*) in accordance with the process described in paragraphs 5 – 14.

#### ***Part A Works***

2. The Part A Works comprise:
  - (a) The following structural flood mitigation works of the *Draft Stormwater Management Plan* report of August 2011 by WorleyParsons (*the '2011 Draft SMP'*), as generally described in Section 11.1 and as varied by subsequent advances in design:
    - Detention basins in the South Park Lands / Glenside Campus (*concept design completed*)
    - Flood detention dam in Ridge Park Reserve (tender for full design to be let in April 2012)





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- Bypass culvert in Fisher Street
- Keswick Creek to Brown Hill Creek diversions (*Le Hunte / Leader Streets and Anzac Highway, concept design completed*)
- Brown Hill Creek channel upgrade between Leah Street and Anzac Highway (*including the Highway culvert*) to be designed to allow for the no-dam option for Brown Hill Creek
- Brown Hill Creek channel upgrade from Anzac Highway to the confluence with Keswick Creek (*concept design to be investigated in 2012/13*);

and

- (b) Channel upgrade and repairs relevant to Glen Osmond Creek, Parklands Creek and Keswick Creek as may be required as a result of the channels assessment and ongoing investigations being carried out for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.
3. Planning details for the Part A Works are established and in some cases designs have been advanced to the concept stage or are entering detailed design.
  4. The flood mitigation impact of the Part A Works (*collectively or individually*) has not been modelled. However, from extrapolation of other modelling scenarios carried out for the 2011 Draft SMP, the effect for the 100 year ARI will be assessed.

**Process – Part B Works**

5. The Councils will determine the Part B Works (*i.e. those works in upper Brown Hill Creek generally above Forestville Reserve*) by the process specified in the following paragraphs.
6. The councils, recognizing community opposition to a dam in the upper reaches of Brown Hill Creek, commit to a preference to pursue a feasible and whole of catchment community supported 'no dam' solution with a target date for agreement of a feasible solution within 12 months of gazettal of the 2012 SMP.
7. Current investigations centre on structural mitigation works as outlined in the 2011 Draft SMP (*Section 11.1*), the *Bypass Culvert Feasibility Assessment* report by WorleyParsons of April 2012 and the channels assessment by the Adelaide and Mount Lofty Ranges NRM Board, being:
  - Channel improvement works to Brown Hill Creek in Mitcham and parts of Unley
  - High flow by-pass culvert from Hampton Street to Malcolm Street (*considering two routes – one via Grove Street and the other adjacent to the main railway line*)
  - Upgraded high-flow bypass culvert between Malcolm Street and the Glenelg tramway (*Forestville Reserve*)
8. Determination of the Part B Works will include:
  - Description of the works to level of detail consistent with that of the Part A Works of the draft SMP, as a minimum standard



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- Estimated cost of design and construction to a level of detail consistent with that of the Part A Works of the draft SMP, as a minimum standard
  - Implementation program to be integrated with that of the Part A Works of the draft SMP
  - Any other information relevant to the Part B Works required for the draft SMP to satisfy the SMA Planning Guidelines (*and to meet the objectives of the draft SMP*)
9. In determining the Part B Works, the councils will:
- Engage suitably qualified experts, including consultants if necessary, for technical or other investigations (*including floodplain modelling*) as appropriate
  - Carry out community consultation in respect of the proposed Part B Works to satisfy, as minimum, the SMA Planning Guidelines and council policy requirements
  - Provide the necessary funding in accordance with the currently agreed cost sharing arrangement, or as otherwise subsequently agreed, for development of the SMP and community consultation (*the cost sharing arrangement assumes 50% contribution from the SMA*)
10. In determining the Part B Works, the councils will use their best endeavours and negotiate in good faith to reach agreement on works which have a total estimated construction cost inclusive of Part A Works not exceeding a benchmark cost and any subsequent adjustments approved by the Councils.
11. Estimated costs to be based on December 2011 values (*escalated by ABS reference data*).
12. If the councils fail to agree on a Final SMP (*paragraph 1*) within the required timeframe (*paragraph 6*) they will inform the SMA accordingly.

***Stormwater Management Plan***

13. Other flood mitigation measures, to be included in the 2012 SMP and the Final SMP are the non-structural management actions identified in section 11.4 of the Draft 2011 SMP.
14. Other content of the 2012 SMP and the Final SMP will include, but may not necessarily be limited to:
- Stormwater management objectives
  - Stormwater harvesting
  - Other multi-purpose benefits
  - Benefit-cost analysis (*for each component separately and in conjunction with the other components*)
  - SMP implementation including establishment of regional subsidiary
  - Implementation program
  - Estimated cost (construction and maintenance) and annual budgets



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**Funding Agreement**

15. The proposed flood mitigation works represent a significant project for metropolitan Adelaide and South Australia. The proposed capital works would also potentially impose an unreasonable burden on local communities and local government. As such, commitment by the five catchment councils to the 2012 SMP and the Final SMP is on the understanding that councils will continue to pursue shared funding for the whole of the detailed design and construction of the Part A and Part B flood mitigation works of the project between the three spheres of government in the following proportions:
- Commonwealth Government – 1/3
  - State Government – 1/3
  - Local Government – 1/3
16. Separate funding provisions are to remain in place to fund development of the SMP (including public consultation, investigation and preliminary scheme design) where the State (via the SMA) and local government agree to fund 50% each of the development costs.
17. Local government will continue to fund 100% of the project administration costs.
18. It is proposed that the five catchment councils cost sharing for the local government portion of the funding arrangements should be:
- Project Administration – councils sharing costs at 20% each
  - SMP development – councils sharing costs at 20% each of 50% by local government (with 50% by the State via the SMA)
  - Design and construction – local government component apportioned:
    - West Torrens – 49%
    - Unley – 21%
    - Burnside – 12%
    - Mitcham – 10%
    - Adelaide City – 8%
19. The 2012 SMP and the Final SMP will document the cost sharing arrangements as outlined above and the charter will include councils' agreed sharing arrangements, including procedures to deal with any likely cost increases.

**Charter**

In anticipation of being able to produce a SMP by the middle of this year and having it approved by the Authority, the Steering Group has formed a working group of council representatives to resume preparation of a charter (or equivalent agreement).

It is proposed that governance of the project, including responsibility for proper management of the SMP including construction, operation and maintenance of works and on-going management of other flood mitigation measures would be undertaken by the five catchment councils via a regional subsidiary. The charter would be the legal agreement between the five catchment councils which defines the creation and operation of the regional subsidiary.



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In respect of responsibility for the SMP, the regional subsidiary could utilise legislative powers available to it under Schedule 1A of the Local Government Act to manage both the SMP and infrastructure.

Whilst every endeavour will be made by the councils to agree the terms of a charter as soon as possible, it is understood that the charter would not have to be settled before approval of the SMP.

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## 4. CATCHMENT DESCRIPTION

### 4.1 CATCHMENT AREAS

The Brown Hill and Keswick Creek catchments are shown in **Figure 1**. Both catchments arise on the western slopes of the Mt Lofty Ranges and then flow westwards across the inner south-eastern suburbs of Adelaide towards the Adelaide Airport, before discharging to the sea through the Barcoo Outlet (*low flows*) or the Patawalonga Lake outfall (*high flows*).

Brown Hill Creek has a catchment area of about 32.0 km<sup>2</sup> (*upstream from Adelaide Airport*) and flows through the suburbs of Crafers West, Brown Hill Creek, Mitcham, Torrens Park, Hawthorn, Unley Park, Millswood, Forestville, Ashford, Kurralta Park, Plympton, Netley and Adelaide Airport before flowing into the Patawalonga.

Keswick Creek is fed by Glen Osmond Creek and Parklands Creek, which confluence to form Keswick Creek adjacent to Simpson Parade at Wayville. For the purposes of this report the starting point for Keswick Creek is taken as the confluence point. The creek then flows through the suburbs of Wayville, Keswick, Mile End South, Richmond, Cowandilla, Brooklyn Park and Adelaide Airport prior to joining with Brown Hill Creek. The combined catchment area of the three creeks is approximately 36.7 km<sup>2</sup>.

Glen Osmond Creek passes through the suburbs of Leawood Gardens, Mt Osmond, Urrbrae, Myrtle Bank, Fullarton, Parkside, Unley and Wayville. Parklands Creek starts at Mount Osmond and flows through the suburbs of Glen Osmond, St Georges, Glenunga, and Glenside before passing through the South Park Lands. Parklands Creek leaves the Park Lands near Peacock Road and flows through Unley before joining with Glen Osmond Creek at Wayville.

### 4.2 LAND USE AND CATCHMENT CHARACTERISTICS

Despite having an overall similar area, the land use characteristics of the Brown Hill and Keswick Creek catchments are quite varying, which impacts the behaviour of the drainage system and the potential for flooding.

A majority of the catchment of Brown Hill Creek is in its upper reaches, which consists primarily of rural land in the Hills Face Zone (*refer Figure 1*). As such, it is mainly pervious soil and a significant portion of the rain falling on the catchment is expected to infiltrate into the soil. The upper reaches of the catchment are relatively steep with defined riverine channels which limit the spread of floodwaters.

The middle and lower reaches also have defined channels that pass through urban areas, but they are of a limited capacity, which can lead to overtopping of the channel and the spread of floodwaters across the floodplain. Downstream of Cross Road the channel gradually becomes increasingly “perched” above the surrounding floodplain, which results in floodwaters spreading further and further away from the channel.

The storms that cause major flooding along Brown Hill Creek involve long periods of rainfall with relatively low intensity. It is expected that these storms would last a day or longer with flood flows resulting from more intense rainfall bursts embedded in the longer storm duration.



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The urban reaches of the Keswick / Glen Osmond / Parklands Creek system are physically similar to Brown Hill Creek with Keswick Creek becoming increasingly “perched” downstream of Anzac Highway. However, the Keswick Creek catchment has a much greater proportion of urban area. Development of land for residential housing and commercial development has increased the amount of impervious area, which contributes to increased runoff. These urban areas include a network of stormwater pits and pipes that collect runoff from roads and developed areas, and feed the water into the creek system.

As a result Keswick Creek is expected to respond rapidly to rainfall events. The type of storm that typically causes flooding problems in Keswick Creek is of short duration with intense rainfall. Peak flows along Keswick Creek can be expected to occur within two hours of the onset of heavy rainfall.

Overall, a majority of the middle and lower reaches of the catchment have been developed. Development is predominately residential in the middle (*and some upper*) reaches and is a mix of commercial and residential in the lower reaches.

#### **4.3 INTENSIFICATION OF DEVELOPMENT**

Urban development of the catchment area commenced in the Adelaide CBD and portions of Unley soon after the arrival of European settlers in 1836. Suburban growth spread out from the Adelaide centre during periods of prosperity following that time, such that by the early 1900s much of the catchment area had been developed.

The older housing stock, and in particular that originating from the pre-World War II period established a ‘character’ for many areas across the catchment. In recent years, individual Councils have revised Development Plan zones and policies in order to better protect local heritage and character. Notwithstanding this, there has been progressive redevelopment, associated particularly with division of larger allotments and extensions to existing dwellings.

Intensification of development (*more buildings and less open space*) can be anticipated over the next 30 years given the market interest and the State Government’s 30 Year Plan for Greater Adelaide which encourages urban regeneration, urban densification, transit oriented development and business and industry clustering.

The 30 Year Plan for Greater Adelaide outlines the State Government’s spatial land use framework to accommodate an anticipated population growth of 560,000 people over the next 30 years. Broadly, the Plan seeks to grow the city “upwards, not outwards” by focusing growth in new urban developments at higher densities/scale in the city and locations well serviced by public transport and other facilities.

The additional impervious areas created by redevelopment generate additional stormwater flows, and if left unchecked has the potential to progressively reduce the future performance standard provided by any proposed structural flood mitigation works. The level of impervious site coverage adopted in the hydrological modelling that supports the sizing of the proposed structural works is presented by local government area in **Table 23**. These figures were taken from the 2006 Master Plan. This is broken down further into sub-catchment areas, as shown in **Figure 2**.





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**4.4 THE DRAINAGE SYSTEM**

**4.4.1 Parklands Creek**

Parklands Creek originates as a series of minor escarpment creeks in the City of Burnside and collects runoff from the suburbs of Beaumont, Glen Osmond, Hazelwood Park, Linden Park, St Georges, Glenunga, Frewville and Glenside (*refer Figure 1*).

Once into the suburbs the various escarpment creeks have been converted into underground drains, and there is no defined creek channel upstream from Glenside Hospital. All the various drains have joined and flow through a housing development on the north side of Glenside Hospital in large twin culverts. At the downstream end of the culverts the creek flows into the Glenside Detention Basin and then under the Greenhill Road / Fullarton Road intersection and into the South Park Lands. An unlined channel conveys water through the South Park Lands before the creek departs the park lands through a culvert under Greenhill Road near Palmerston Road. It is then largely concrete-lined through the suburb of Unley to its confluence with Glen Osmond Creek at Wayville.

Parklands Creek has a predominantly urban catchment and is susceptible to flooding during short duration storms.

**4.4.2 Glen Osmond Creek**

Glen Osmond Creek originates in the foothills near Mount Osmond (*refer Figure 1*). It flows along the alignment of the South Eastern Freeway until it arrives at Cross Road, from where it is piped underground into Ridge Park Reserve.

It then flows in a north-west direction along a partly lined channel through a series of reserves until it reaches Fisher Street in Fullarton, under which it flows through a culvert and then into a concrete-lined channel.

The creek then flows west, largely between residential backyards, until Windsor Street, where it runs north and then west in a long underground culvert for approximately 2.6 km. This culvert extends to King William Road. A concrete-lined channel then conveys flows for a short distance to the confluence with Parklands Creek.

The Glen Osmond Creek catchment comprises a mixture of rural and urban areas and therefore storms of both short and long duration can cause significant flows. Downstream of Cross Road the catchment is urbanised, hence the creek becomes more susceptible to flooding during shorter duration storms.

**4.4.3 Keswick Creek**

Parklands Creek and Glen Osmond Creek combine to become Keswick Creek adjacent to Simpson Parade at Wayville (*refer Figure 1*).

The creek channel is almost entirely concrete-lined. It flows west through Wayville and then into a culvert that passes under the Showgrounds.



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The creek then flows along the southern side of the Keswick Military Barracks, under Anzac Highway and then northwards through Keswick and Mile End South. It then travels westwards through Richmond and Cowandilla before turning south along the eastern edge of Adelaide Airport to its confluence with Brown Hill Creek. The Keswick Creek catchment is heavily urbanised and therefore, flooding in this creek is normally a result of shorter duration storms.

**4.4.4 Brown Hill Creek**

The headwaters of Brown Hill Creek extend as far east as Crafers (*refer Figure 1*). The upper rural part of the catchment is relatively large and has an area of about 18 km<sup>2</sup>. The creek flows northwest along an unlined channel before entering the urban area of Mitcham at Old Belair Road.

At locations downstream from Mitchell Street in Millswood a majority of the Brown Hill Creek channel is concrete-lined. Constrictions in the channel occur immediately upstream of Cross Road, at various locations in Millswood and Forestville and downstream of Daly Street in Kurralta Park.

Due to the large rural catchment it is expected that longer duration storms will cause the most significant flooding along the creek. The runoff from longer durations storms typically has more volume than short duration storms and it is this increased volume, as it spreads out over the downstream urbanised floodplain, that is responsible for the majority of the flood damage.

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## 5. STORMWATER MANAGEMENT OBJECTIVES

### 5.1 THE GOAL

The Cities of Adelaide, Burnside Mitcham, Unley and West Torrens have an overarching objective for stormwater management in the Brown Hill Keswick Creek catchment of becoming 'water sensitive cities' – by minimising flooding and harnessing the potential of stormwater to overcome water shortages, improve waterway health, enhance city landscapes and be utilised as a valuable community resource.

This is to be undertaken using a catchment-wide approach and a range of structural and non-structural mitigation measures which also seek to provide for multi-purpose benefits including passive recreation, pedestrian and cycle paths, water quality improvements, biodiversity improvements and stormwater reuse. Water Sensitive Urban Design (*WSUD*) is a process that will contribute to the principle of water sensitive cities.

Major flooding is considered to be that resulting from a storm greater than a 1 in 10 year Average Recurrence Interval (ARI) along the major creek lines of the catchment, as distinct from localised 'nuisance' flooding associated with the various stormwater drainage networks that feed into the major creek lines. In this regard, the management actions presented in this Plan have been developed from a catchment wide perspective to provide the most benefit across the catchment, irrespective of local government area boundaries.

The SMP has been developed with reference to a number of stormwater management objectives which apply to minor drainage systems as well stormwater management at whole of catchment scale. The objectives are described in the following section.

### 5.2 OBJECTIVES

#### 1. Protection from Flooding

The SMP seeks an acceptable level of protection from flooding for the community and private and public assets.

The backbone of the major drainage system is Brown Hill, Keswick, Glen Osmond and Parklands Creeks. The major drainage system also includes roads, open spaces, other water courses and other overland flow routes which become engaged during a major storm that causes the capacity of the minor system to be exceeded. The major system should be capable of preventing flooding that causes property damage or threatens people's safety.

The minor system comprises side entry pits and underground pipes throughout the catchment whose primary function is to minimise nuisance flooding and ponding so as to allow properties to drain and to maintain the serviceability and safety of the road network. In terms of the standard of protection that should be offered by the major system, it is considered that wherever possible this should be at least a 1 in 100 ARI year standard. There are numerous references in the existing Development Plans of each of the councils to reinforce the need for new development to be protected from the 1 in 100 year ARI flood. It is considered that a 1 in 5 year standard is an appropriate target standard for the minor system, noting that a lesser standard may well be



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acceptable when balanced against the cost to replace assets that still have a significant life ahead of them.

The floodplain mapping developed for the catchment covers the relevant sections of Brown Hill, Keswick, Glen Osmond and Parklands Creeks only. The mapping identifies the result of 'failure' of these creeks when on rare occasions the flow capacity of the creeks is exceeded and excess floodwater spreads away from the creek across the floodplain. Mostly this floodwater is shallow, less than about 150 mm deep. Water of this depth will not necessarily cause flooding above the floors of buildings.

Both the minor drainage system and those parts of the major drainage system, separate from Brown Hill, Keswick, Glen Osmond and Parklands Creeks, drain into the creeks which, as the backbone, 'tie' the system together. As such there are numerous separate major and minor drainage systems across the catchment arranged in a fractal pattern typical of drainage systems. Those numerous separate major and minor systems, in terms of the SMA Stormwater Management Planning Guidelines, are outside the scope of this SMP and therefore have not been analysed or considered in respect of any specific objectives.

**Objectives:**

- 1.1 Provide an acceptable level of protection for the community and both private and public assets from flooding. Subject to economic justification, the objective is to provide a standard of flood protection for development equivalent to the 100 year ARI standard or better.
- 1.2 Enhance flood mitigation infrastructure with multi-purpose outcomes including visual, aesthetic and amenity improvements for the benefit of the wider community, where it is economically and socially feasible.
- 1.3 Provide flood forecasting and warnings and flood preparedness measures to help the community reduce any residual damages to property and risk to life during major flood events, particularly in high hazard areas.
- 1.4 Ensure that new stormwater infrastructure does not increase the risk of flooding in downstream areas.

**2. Quality of Runoff and Effect on Receiving Waters**

The receiving water for stormwater runoff from the Brown Hill Keswick Creek catchment is Gulf St Vincent at West Beach. The principal issues of concern for Adelaide coastal waters have been identified by the EPA in its Adelaide Coastal Water Quality Improvement Plan (*ACWQIP*) as nutrient Nitrogen, suspended solids and coloured dissolved organic matter (*CDOM*).

Targets in the *ACWQIP* for stormwater include a reduction from 2003 levels of 67% in nitrogen, 50% in suspended solids and a decrease in *CDOM*. The *ACWQIP* proposes that this issue be dealt with through the reuse of stormwater (*noting the AMLRNRMB target of 75% reuse*) and widespread adoption of Water Sensitive Urban Design (*WSUD*).

The EPA has also indicated that coastal waters would benefit from reduction in the number of runoff events. This could be achieved by providing retention devices at a regional, catchment wide and



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allotment level throughout the catchment to capture the first 15 mm of smaller rainfall events. Options include rainwater tanks, rain gardens and under-driveway storage.

Secondary, but still important, issues associated with stormwater pollution include:

- Pathogens that impact on recreational water quality;
- Litter and debris that detracts from aesthetic qualities and contributes to CDOM; and
- Toxicants, including pesticides, which must be kept away from stormwater.

Existing plans and policies provide support for programmes that lead to water quality improvements, particularly WSUD, street sweeping, enforcement of codes of practice and gross pollutant trap construction and maintenance. The development plans of councils also include objectives and principles which require that development does not contribute to pollution. These policies will be further strengthened with adoption of the South Australian Planning Policy Library (SAPPL) by all catchment councils.

**Objective:**

2.1 Stormwater discharged to the marine environment should meet targets that are set from time to time including targets in the EPA's Adelaide Coastal Water Quality Improvement Plan.

**3. Beneficial Reuse of Stormwater Runoff**

The AMLRNRMB's target for harvesting and reuse of stormwater is 75%. Considerable progress toward this target has already been achieved within the region, and there are further plans to utilise public open space to treat stormwater for aquifer storage. Significant opportunities exist for increased capture and beneficial reuse of runoff. Increases in the price of mains water provide an opportunity to encourage and increase the use of rain-water.

Larger scale opportunities include wetlands and MAR schemes (*for example those operating at Glenelg Golf Course, Adelaide Airport, Urrbrae Wetlands, Ridge Park and Scotch College*) for reuse for irrigation of large open spaces.

Options on a smaller scale include WSUD techniques such as:

- Bio-filtration beds;
- Rainwater tanks connected to toilet and washing machines;
- Rain gardens; and
- Under-ground ('milk crate' type) storages.

There are synergies between objectives for reuse and water quality, where WSUD techniques for water quality improvements for road runoff will also provide water for street tree and streetscape improvement. Similarly, there are potential synergies between water reuse through retention and detention, and reduction of flood flows.



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**Objectives:**

- 3.1 Maximise the reuse of stormwater for beneficial purposes including watering of community and private open spaces where feasible.
- 3.2 Where possible the drainage network should incorporate WSUD systems that aim to capture road runoff to replenish soil moisture for maintenance of street trees and plantings.
- 3.3 Encourage on-site use of stormwater by installation of rainwater tanks, detention and retention systems in order to minimise the adverse runoff impacts of urban infill.

**4. Protection of Watercourses and Riparian Ecosystems**

Stormwater runoff should be managed in a manner that protects and enhances biodiversity, sustainability and the natural environment.

**Objectives:**

- 4.1 Watercourses and creeks in public and private ownership should be managed to an acceptable standard.
- 4.2 Where practicable and economically feasible, watercourses should be preserved in as natural condition as possible and should be revegetated and managed to maximise their ecological and biodiversity values and functions and to minimize any potential for stream erosion.
- 4.3 Allow sufficient environmental flows to maintain water dependent ecosystems.

**5. Effective Planning Outcomes**

Land used for stormwater management purposes should be developed, where possible, to facilitate recreation use and to enhance amenity. Opportunities are generally associated with new development, open space and areas intended for recreation and amenity.

Floodplain mapping for the catchment shows that most flooding originating from overflows from the main creek system is less than 150 mm deep in the 100 year ARI storm. Water of this depth is less likely to cause above floor flooding (at which significant damages can occur). If flood prone allotments are redeveloped this depth of water generally can be managed by setting floors at an appropriate level. Nevertheless, there are some areas in the floodplain where water depths are greater than 150 mm and flood mitigation works should be designed to mitigate major flood risk as far as possible up to the 100 year ARI flood event.

Urban infill development is resulting in rapid increase of impervious area in urban catchments and will, unless controls are introduced, increase the volumes and peak discharges of stormwater significantly over the next 30 years. The need for source control must be addressed in order to achieve and maintain the required level of flood protection.

**Objectives:**

- 5.1 Open space should be utilised to achieve maximisation of permeable surfaces, on site retention and infiltration and stormwater reuse wherever possible.



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- 5.2 All new development must be built at a level that ensures buildings are not subject to inundation during a 100 year ARI flood.
- 5.3 New development should be constructed so as not to cause an increase in 5 year ARI flow rates.

**6. Management of Stormwater Infrastructure**

Stormwater infrastructure should be managed and maintained on a sustainable basis. The cost of implementation of flood mitigation works, including construction and on-going operation and maintenance, needs to be spread across the community in a way that not only reflects the direct benefit to those who enjoy an increased level of protection, but also to those who already enjoy the benefit of the urban development that contributes to the quantity of flood flows.

**Objectives:**

- 6.1 Stormwater infrastructure is to be managed sustainably by development of asset management and other necessary plans for on-going management, operation and maintenance of infrastructure.
- 6.2 A governance framework will be established based on having a single entity (nominally a regional subsidiary in terms of the Local Government Act) responsible for management of project infrastructure.
- 6.3 Financial budgeting and funding arrangements (as between councils and other potential funding contributors) necessary for the timely and effective implementation of the SMP (including construction and maintenance of infrastructure) will be established.

**5.3 SMA PLANNING GUIDELINES**

The SMP is a key element of strategies described in the Urban Stormwater Management Policy for South Australia. The SMA Stormwater Management Planning Guidelines (*July 2007*) specify the scope of content and process for preparation of SMPs in general. Objectives of the BHKC SMP are based on relevant requirements of the Planning Guidelines. In addition the Planning Guidelines also outline principles which guide the development of SMPs. The following principles have been applied in developing the BHKC SMP.

**Principles:**

- 7.1 Development and implementation of the SMP and its objectives must ensure a 'whole of catchment' approach is achieved.
- 7.2 Gain agreement from the relevant NRM board on the catchment area to be covered by the SMP.
- 7.3 The objectives should provide measurable goals for the management of stormwater in the catchment.
- 7.4 A coordinated and multi-objective strategy involving studies, works and any other actions is to be described in the SMP.





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- 7.5 Costs, benefits and funding arrangements for achieving the objectives are to be set out in the SMP (Benefits should include qualitative factors, including environmental improvements, as well as quantified benefits of reduced flood damage and stormwater use).
- 7.6 Actions and strategies identified in the SMP should be prioritised and set out in a program of no more than a 10 year planning horizon.
- 7.7 Responsibilities for actions in the SMP are to be clearly identified.
- 7.8 Staff and elected members of catchment councils, the community, and relevant NRM Board and other government agencies will be consulted.
- 7.9 SMPs will be 'living documents' that are subject to period review to take account of current knowledge, changing conditions within the catchment and changing community attitudes to the management of stormwater and other water resources.

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## 6. STAKEHOLDER ENGAGEMENT PROCESS

This section outlines the stakeholder engagement process in the development of the SMP. It briefly describes the engagement work that was undertaken as part of the 2006 Master Plan and what has happened since then; and it outlines the engagement process for the 2012 SMP.

### 6.1 PHASE 1: PREPARATION OF THE 2006 MASTER PLAN

There was a three stage process of engagement in the preparation of the 2006 Master Plan.

In the first stage, which was mainly a technical assessment, the consultation process focussed on engagement between the key stakeholders (*the five councils, the Patawalonga Catchment Water Management Board and relevant state government agencies*).

The second stage of consultation focussed on councils, residents, interested groups and the general public.

In the third stage, assessment of preferred options, the consultation process focussed again on engagement between the key stakeholders (*councils, the Patawalonga Catchment Water Management Board and relevant state government agencies*) primarily through the Flood Management Group to reach agreement on the final set of priority works components, resulting in the Master Plan report.

Results from the consultation process indicated that:

- There was support across the catchment for progressing with physical works, in particular temporary storage at the South Park Lands and flood control dams in Brown Hill Creek.
- If the flood control dams in Brown Hill Creek were to proceed there would be a range of ecological issues that would need to be addressed. Support from some community groups was unlikely unless these issues are identified and addressed.
- There would be strong objections to a dam in the Brown Hill Creek Recreation Reserve.
- Many respondents were frustrated that no action has taken place as yet.
- People who were flooded in November 2005 wanted more warning and more help with the clean-up.
- Some respondents thought the flood preparedness component was included in lieu of capital works and there should be more capital works to achieve a higher level of flood protection.
- There was some support for a more coordinated approach between landholders and government on the maintenance of channel capacity.
- Some people thought that Orphanage Park should have been included as a temporary flood storage.



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A final set of priority works components was recommended to the Flood Management Group in October 2006.

A detailed report on the consultation process and outcomes is contained in a separate report (*QED, 2005*).

## **6.2 PHASE 2: YEARS 2008 – 2010 FURTHER INVESTIGATIONS**

From 2008 until mid 2010 stakeholder engagement was mainly at the local government level as a result of concerns raised by the City of Mitcham, particularly about the proposed dams in the upper catchment.

A number of reports were prepared during this period concerning the dams in upper Brown Hill Creek, catchment hydrology and the process of developing the SMP. The principal reports were by GHD, AWE, VDM Consulting and Nosworthy who conducted a mediation process on behalf of the SMA.

During the same period, community consultation was undertaken as part of development of the concept design for the South Park Lands detention basins, which form a component of the SMP.

## **6.3 PHASE 3: PREPARATION OF THE 2012 SMP**

In developing the 2011 Draft SMP:

- The study brief was drafted by the Project Technical Group, involving senior staff representatives from each of the five catchment councils, the AMLRNRMB and DPTI (*representing the Stormwater Management Authority*). In that process Mitcham Council was given opportunity to include matters of investigation that were of particular local concern. The brief was agreed by the five councils.
- In accordance with the brief and with input from the Study Steering Committee (*a subgroup of the Project Technical Group*), WorleyParsons reviewed the options identified previously for the 2006 Master Plan for upper Brown Hill Creek together with other options identified in the study brief.
- The review process involved an adaptation of the multi-criteria assessment carried out in preparation of the 2005 Stage 1 Technical Report in order to assess and filter the potential options.

The overall approach for selecting priority works components, which together comprise the recommended stormwater management strategy, follows the methodology in the Stormwater Management Planning Guidelines.

In April 2011 the five catchment councils each resolved to approve a timing and process plan for completion of a Stormwater Management Plan, including community consultation on the 2011 Draft SMP.

This consultation was carried out between 31<sup>st</sup> October and 12<sup>th</sup> December 2011 by an independent consultant team on behalf of the five catchment councils.



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**6.3.1 Consultation Process**

The consultation process aimed to:

- Provide information to stakeholders and the broader community regarding the 2011 Draft SMP;
- Receive feedback on the Draft Plan from stakeholders and the broader community; and
- Collate and summarise feedback on the Draft Plan for use by the five Councils in finalising the Draft Plan (*effectively for the 2012 SMP*).

The consultation process comprised three key aspects, namely:

- Preparation and distribution of information materials and feedback form;
- Conduct of briefings, meetings and open days;
- Receipt, collation and analysis of feedback.

A suite of community information materials was prepared, including:

- A summary report which summarised key aspects of the Draft Plan;
- A summary brochure which provided an overview of the Draft Plan, the consultation process and how people could access more information;
- Fact sheets addressing key components of the Draft Plan.

The information materials and feedback form were made available via a direct mail out to 26,539 property owners and occupiers across the catchment, as well as community, sporting and recreation groups, and Federal and State Members of Parliament, State government Ministers, government departments, and Councils. This information was also available online and from council offices.

Members of the wider community could obtain further information about the Draft Plan by attending any or all of three open days which were held during the consultation period. The open days provided an opportunity to learn more about the Draft Plan and ask questions of members of the project team. In total, approximately 160 people attended the three open days.

It was recognised that there were a number of key stakeholders that had a special interest in the Draft Plan and therefore a number of key groups within the community were invited to meet with members of the consultation team as part of the consultation process.

Consultation on the Draft Plan with representatives of the Kurna and Ramendjeri peoples was initiated during the consultation period, and is ongoing.



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**6.3.2 Consultation Findings**

In total, 2,172 feedback forms were returned by members of the community, of which 2,149 were from respondents with an interest in at least one of the five catchment councils.

Several key trends emerged from the consultation process, taking account of the various avenues for community feedback.

Overall there was general recognition of the importance of undertaking flood mitigation works to reduce the impacts of flooding across the catchment. This was particularly evident from analysis of the feedback forms, with the majority of respondents (74% *unweighted data*) considering it is important/very important to undertake flood mitigation works compared with only 12% (*unweighted data*) not considering it not important/not very important.

This support for taking action was qualified however, by the need ‘to get it right’, and ensure that appropriate infrastructure measures are implemented that adequately reduce the impacts of flooding while at the same time delivering acceptable outcomes in terms of financial, environmental and social impacts.

While views varied in relation to specific infrastructure components of the Draft Plan, the majority of respondents indicated overall support for the Draft Plan

Analysis of the feedback forms indicated high levels of support for all infrastructure components of the Draft Plan across all five catchment councils, with the exception of the proposed flood control dam at Brown Hill Creek for which there were both lower and more variable levels of support from respondents across the councils.

A petition submitted to the City of Mitcham and copied to the consultation process contained 4,010 signatures supporting the statement “*We, the undersigned, hereby PETITION Council to protect the environment and heritage of Brown Hill Creek by opposing the damming of the Creek*”.

Based on the feedback forms as well as information received via meetings and written submissions, three key viewpoints emerged with respect to the flood control dam in Brown Hill Creek:

- Strong opposition to any dam on Brown Hill Creek with a view that alternative infrastructure solutions are available;
- Strong opposition to the proposed location of the dam in the Brown Hill Creek Recreation Park based on concerns regarding visual amenity, heritage and the natural environment, but open to the possibility of another location along Brown Hill Creek; and
- Support for the dam together with concerns that opposition to the dam may delay implementation of mitigation works.

The executive summary for the Consultation Report is provided in **Appendix D**.



## 7. EXISTING FLOOD PROBLEM

### 7.1 FLOOD MODELLING

As a precursor to the 2006 Master Plan, flood characteristics within the catchment were investigated and documented in the 2003 Floodplain Mapping Study (*Hydro Tasmania Consulting, 2003*). For the purpose of previous work and this SMP, the existing conditions flood scenario is referred to as the “Base Case”.

Both hydrologic and hydraulic computer modelling tools have been used to define the Base Case flood characteristics. Outputs from the hydrologic model are used as inputs to the hydraulic model, which enables the characteristics of the runoff to be modelled across the topography of the floodplain and thereby determine the extent, depth and velocity of flow.

A brief summary of the modelling tools and related information is provided in the following sections.

#### 7.1.1 Hydrologic Modelling

The Department of Planning, Transport and Infrastructure (*DPTI*) is the developer and operator of the hydrologic model for the catchment. The hydrologic model is used to determine the rate and volume of runoff that is expected to travel down through the catchment and onto the floodplain.

The hydrologic model developed and operated by DPTI is named the Rainfall Runoff Routing (*RRR*) model. A further description of the RRR model is provided in **Appendix E**, along with a map to show the location where flow hydrographs have been extracted from the hydrologic model for use in the hydraulic modelling (*refer Section 6.1.3*).

The RRR model is not its own computer package as such, but is a structure designed to be applied using the industry standard XP-RAFTS graphical user interface.

#### 7.1.2 Hydrology

For the purposes of this report, key hydrology concepts and terminology are explained in this section.

*Runoff* occurs when rainfall, beyond the capacity of the ground to absorb, runs freely off an area of ground surface. It can be expressed as an instantaneous rate of flow (*in litres/s or m<sup>3</sup>/s*) or as a volume of stormwater produced over the duration of a storm event (*in Megalitres or m<sup>3</sup>*). Runoff enters a watercourse either directly over the ground surface or is collected via local underground drainage systems. Runoff from urban areas is conventionally referred to as *stormwater* or *stormwater runoff*.

The term *overland flow* is used to describe flow that *breaks out* of a watercourse and spreads over the floodplain. The spread (*or extent*) and depth of *inundation* is what is represented in *floodplain mapping*.



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Runoff and the subsequent flow along creeks can occur due to any combination of rainfall intensity, storm duration and catchment losses prevailing at the time of the storm.

The *critical storm* is the duration of storm that gives the maximum flow when the various design storm parameters are applied (*rainfall intensity, loss values, storage and routing parameters*).

Within the urban part of the catchment, where there are large impervious surfaces (*roads, roofs etc*) a fixed percentage of the rainfall runs off quickly and this process does not vary much from storm to storm.

The rural parts of the catchment are dominated by pervious surfaces. The response of these surfaces to rainfall is much more variable. Significant factors in this variability are the intensity of the rainfall itself and the amount of rain that has fallen previously (*related to catchment saturation*).

These runoff characteristics, together with other information for the urban and rural catchments, have been incorporated into the hydrologic model. Key outcomes are:

- The *90 minute storm* is the critical duration storm for peak runoff for most locations where the upstream catchment consists largely of urban area.
- The *36 hour storm* is the critical duration storm for peak runoff where the majority of the catchment is rural.
- In some limited areas downstream of the South Park Lands the *6 hour storm* is the critical duration storm.

As Glen Osmond Creek and Brown Hill Creek emerge from the foothills and as the percentage of urban area in the total catchment becomes larger and larger there is a transition from where the 36 hour storm produces the peak flow to where the 90 minute storm produces the peak flow.

For Glen Osmond Creek that transition occurs at Fullarton Road, Fullarton. For Brown Hill Creek it occurs downstream of the confluence between Brown Hill Creek and Keswick Creek on the east side of the Airport (*refer Figure 1*).

The use of temporary storage (*detention*) in the rural part of the Brown Hill Creek catchment effectively “removes” that part of the rural catchment above the storage such that the transition point from the 36 hour to a 90 minute critical duration storm moves upstream closer to the foothills. This concept is relevant to flood mitigation measures discussed in Section 10.

### **7.1.3 Hydraulic Flood Modelling**

Hydro Tasmania is the developer and operator of the hydraulic model used for floodplain mapping. They were engaged to undertake the hydraulic modelling for this project, through Australian Water Environments (AWE) as sub-consultant to WorleyParsons.





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The hydraulic model has been developed using the MIKE Flood proprietary system. A summary describing the development and use of the MIKE Flood model since the year 2000 has been prepared by Hydro Tasmania and is provided in **Appendix F**.

The model was developed in 2003 and subsequently updated in 2006, including verification of the model to flooding that occurred in November 2005.

The predicted extent and depth of inundation during the 100 year ARI flood is shown in **Figure 3**, which is an example of the results that can be extracted from the MIKE Flood model. As with all flood maps presented in this report, the thematic mapping indicates where the depth ranges between zero to 0.5 metres (*white to blue shading*) and where depths are expected to be greater than 0.5 metres (*darkest blue areas*).

The map shown in **Figure 3** (*and on all other floodplain maps*) shows the potential flood risk at any location within the floodplain. The map is a composite of three sets of results from the MIKE Flood model, which is used to simulate the resultant floodplain following the 90 minute, 6 hour and 36 hour critical duration storm events for any given ARI. As such, the resultant flood map does not represent any one particular flood event, but rather it shows the greater of the three extent maps for the modelled storm durations.

Since the model was created changes have occurred along particular sections of the watercourses, as well as to other physical characteristics of the catchment, which means that at a local level in some relatively small areas the flood mapping may need to be updated. The key factors include:

- New works constructed by Unley Council along Glen Osmond Creek in recent years, which have not been included in the model.
- The Channels Capacity Assessment study by AWE (*refer Section 3.2*) indicates that deterioration and associated reduction of flow conveyance capacity have occurred particularly along of sections of Brown Hill Creek and Parklands Creek.
- Minor changes in landform at the airport (*refer Section 7.2.3*).

However, it should be recognised that for the SMP, potential flooding impacts are assessed on a catchment-wide basis and floodplain mapping based on the 2003/2006 version of the model is considered fit for this purpose. It is proposed that the catchment-wide model is updated as part of the process for determination of the Part B Works (*refer Section 3.3*).

## **7.2 EXISTING FLOOD CHARACTERISTICS**

The extent and depth of flooding that could occur for a range of design flood frequencies (*100, 50, 20, 10 and 500 year ARI*) is provided in **Figures 3 to 7**. As shown in the 100 year ARI mapping, a significant area through the Unley and West Torrens council areas is at risk of flooding, in addition to areas in Mitcham, Burnside and Adelaide (*refer Figure 3*).

In comparing the 20 and 10 year ARI maps (*i.e. Figure 5 versus Figure 6*), there is a marked increase in the extent and depth of flooding for the 20 year ARI flood map. As such, it is generally considered that the catchment has an indicative level of flood protection equivalent to about the 10 year ARI level under Base Case conditions.



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The following sections describe in more detail the existing Base Case flooding conditions across the catchment for the 100 year ARI flood, as shown in **Figure 3**.

### **7.2.1 Parklands Creek**

The shorter duration storms are the primary cause of most flooding along Parklands Creek due to the responsive urban catchment:

- Parklands Creek at Conyngham Street, Glenside  
Floodwaters breakout from the creek channel due to the constriction posed by the culvert that passes under housing development on the north side of the Glenside Hospital. Flooding extends westward through the development, into Glenside Hospital, west into Eastwood, with a small amount of flow through the business area on the north eastern corner of the Fullarton Road / Greenhill Road intersection.
- The Intersection of Fullarton Road and Greenhill Road, Eastwood  
The constriction created by the culvert under this intersection causes water to back-up and overtop the road. Water flows down Greenhill Road until it reaches the intersection with Glen Osmond Road. Only minor flooding along the road goes beyond this intersection.
- Parklands Creek, South Park Lands  
Flooding occurs through the Park Lands because of insufficient capacity in Parklands Creek. Flooding spreads out immediately downstream from the Fullarton Road / Greenhill Road culvert and extends either side of the channel such that most of the Park Lands are inundated between Fullarton Road and Unley Road. Flooding extends as far north as South Terrace and as far west as King William Road / Peacock Road. Most of this water is picked-up by drains in the Park Lands and returned to Parklands Creek.
- Between Greenhill Road and the Confluence with Glen Osmond Creek  
Floodwaters are contained within a strip approximately 50 metres either side of Parklands Creek. The flow is expected to have significant depth, with an average of about 1.5 metres increasing up to 2.5 metres in some sections. Water ponds in the North Unley Play Park due to flow backing-up from the culvert under King William Road. Flow is expected to overtop the roadway; however, it is typically confined to within 20 metres of the channel.

### **7.2.2 Glen Osmond Creek**

The uppermost section of the Glen Osmond Creek catchment is rural and therefore, the 36 hour storm is the critical duration storm. However, further downstream, with increasing urban catchment, the 90 minute storm becomes the critical duration storm.

- Glen Osmond Creek at Fisher Street, Fullarton  
The culvert under Fisher Street at Wycliff Street (*to the east of Fullarton Road*) was historically a significant constriction to the flow in Glen Osmond Creek, causing floodwaters to breakout from the creek and spread in a north-westerly direction through Fullarton. The main resultant flowpath was through the St. Josephs Centre and the Southern Cross Homes Hostel before being confined to streets in Fullarton and Unley



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from where it was picked-up by the Glen Osmond Creek channel in the vicinity of Unley Road.

A new 1500 mm diameter culvert was installed in 1996 that effectively bypasses the culvert at Wycliff Street. The culvert has not yet been incorporated into the hydraulic model of the creek system. This oversight dates back to the 2006 Master Plan and was only identified late in the course of the current investigation. It is estimated that the culvert has sufficient capacity to take a majority of the existing 100 year ARI flow along Glen Osmond Creek (*and is expected to accommodate the entire flow if upstream detention works are carried out*).

As a result, in reality the extent of the flow breakout at this location is expected to be significantly reduced (*and almost eliminated*), compared to that shown in **Figure 3**.

- Between Fullarton Road and Windsor Street, Fullarton  
Flow in Glen Osmond Creek backs-up at the inlet to a short section of culvert approximately 400 m downstream of Fullarton Road, which causes overtopping of the creek that contributes further to the overland flow described above.
- Between George Street and Porter Street and downstream from Unley Road, Unley  
The mapping also indicates that there are floodwater breakouts for these two sections of creek upstream and downstream of Unley Road. Both sections of creek have been upgraded in capacity to approximately 100 year ARI standard and undergrounded by Unley Council on its own initiative since 2006. The hydraulic model has not been updated to reflect the changes. However, there remains a likely constriction due to the potential of the twin cell layout of the Unley Road culvert to catch debris. This old road culvert is now located in the middle of a long reach of single cell box culverts.

### **7.2.3 Keswick Creek**

Shorter duration storms are the cause of some of the flooding along Keswick Creek, which collects additional runoff from urban areas downstream from the confluence between Parklands and Glen Osmond Creeks. However the effect of such storms, west of the railway, is “swamped” by overflows from Brown Hill Creek, which is responding to the longer 36 hour critical duration storm.

- Downstream from confluence of Parklands and Glen Osmond Creeks  
Floodwaters spread up to 50 metres from the Keswick Creek channel between the confluence and the entry point to the culvert under the Showgrounds, affecting some residential housing.
- Keswick Creek at Showgrounds  
The Showgrounds culvert has insufficient capacity to carry the peak flow and therefore, flow is expected to spill out of the upstream channel and inundate the area surrounding the Showgrounds. Flow then travels northwards along the railway line to the Keswick Terminal or westwards along Maple Avenue and through the Keswick Military Barracks to meet up with overland flow that spills from the Brown Hill Creek channel to the south. The combined flow inundates large parts of the suburbs of Ashford, Keswick, Kurralta Park, Richmond and Marleston.



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- Between Richmond Road and South Road, Mile End South  
Flow overtops the Keswick Creek channel for parts of this reach. The channel section between Scotland Road and South Road has insufficient capacity and is responsible for much of the overflow. These floodwaters combine with other flows coming from the Keswick Terminal area to spill over South Road and flow west.
- Downstream from South Road, Mile End South  
The creek channel is also overtopped at a number of locations between South Road and Brooker Terrace, Richmond. A constriction in the channel at Ellen Street contributes to the overflow.

Floodwaters spread out onto the floodplain to the north of the channel through the suburb of Cowandilla, with water depths of up to 1 metre expected along this flow path as the “plume” of flow then curls back south towards the Airport, to the west of Marion Road. Most of the flow is picked-up by either the Keswick Creek channel or by the Airport Drain, which diverts water around the northern and western sides of Adelaide Airport.

- Adelaide Airport  
Water enters Adelaide Airport via two main locations; the first is at the western end of Lyons Street in Brooklyn Park. This inflow travels in a south-easterly direction once inside the airport. This water is expected to pool in the area where most of the terminal facilities are location. Flow also enters the airport at the south-east corner of the airport, to the north of the Glenelg Golf Course.

The flowpath through the airport is likely different from current Base Case mapping due to extensive developments on the property since the hydraulic floodplain model was created in 2003. Notwithstanding, the risk to the airport due to its location at the bottom end of the floodplain, and particularly with residual flow from Keswick Creek, has not diminished. Adelaide Airport Ltd (*airport operator*) advises that they intend to carry out their own flood management investigation, commencing in 2011/12.

#### **7.2.4 Brown Hill Creek**

A significant portion of the Brown Hill Creek catchment is in the rural area of the Adelaide Hills and therefore, the catchment is expected to respond most significantly to longer duration storms.

- Upstream of the Mitcham Shopping Centre at Torrens Park  
The width of flow typically extends to less than 20 metres from the creek channel, with the exception being in the vicinity of Paisley and Fife Avenues, where the total spread of flow is about 100 metres wide. It is considered that the large box culvert beneath Mitcham Shopping Centre has sufficient capacity to carry the 100 year ARI flow.
- Between Mitcham Square Shopping Centre and Hampton Street, Hawthorn  
The flow is generally contained within Soldiers Memorial Park and the downstream reserve to George Street, with some minor flooding of some George Street properties. In the 2005 flooding, the Over 50s Club and houses in Durdin Avenue were affected. A breakout occurs between George and Kent Streets, with flow directed northward along Clifton and Kent Streets that continues over Cross Road and into Unley Park on the eastern side of the creek.



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▪ Hampton Street, Hawthorn to Victoria Avenue, Unley Park

Flow is expected to spill out of the creek channel at Hampton Street and flow west along the roadway and then north along Denning Street and Hilda Terrace. This flow will continue over Cross Road on the western side of Brown Hill Creek and travel further north along Whistler and Victoria Avenues, as well as along the railway line.

Overland flow along the railway first crosses over the line near Rutland Avenue, with additional crossing points down to Goodwood Road. Flow is expected to pond to a depth more than 4 metres in the Millswood underpass on Goodwood Road. A small amount of water crosses over Goodwood Road (*and the catchment boundary*) into Clarence Park.

A significant depth of inundation is expected in the direct overbank area upstream from Cross Road at properties along Denning Street.

Some localised breakouts will occur down to Heywood Park, but most of the flow is expected to return to the creek channel at Victoria Avenue, apart from that which has been lost over the railway or on the floodplain further to the east.

▪ Between Victoria Avenue, Unley Park and Ethel Street, Forestville

Breakout occurs from the channel in a number of locations due to insufficient capacity in the channel. Overflow along the western bank is generally contained within 100 metres of the channel, whereas significant breakouts from the eastern bank are directed north along Regent Street and Goodwood Road towards the Showgrounds and Keswick Creek west of the railway.

▪ Between Ethel Street, Forestville and Anzac Highway, Everard Park

A significant amount of flow is expected to spill from both the north and south side of the channel in this reach, firstly due to the constriction at Ethel Street and also due to the undersized channel between Leah Street and Anzac Highway.

Spillage to the south of the channel flows to the west, inundating a large area of Forestville and Everard Park down to Anzac Highway and South Road. Overflow from the north bank flows in a north-west direction, inundating large areas between Brown Hill and Keswick Creeks before overflowing across the highway and into the West Torrens Council area.

▪ Daly Avenue, Kurralta Park to Marion Road, Plympton

Overtopping of the channel occurs to the north and south in this reach. Flow to the south joins overland flow that spreads west from Everard Park and then travels further west along Hawson and Kinkaid Avenues, North Plympton, towards the commercial area near the south-east corner of the Airport.

Flow to the north of the channel spreads towards Netley through Plympton and Marlestone and along Marion Road. It passes through the Netley Commercial Park, before most of the flow is fed back into the Brown Hill Creek channel or the Keswick Creek channel just upstream of their confluence.

▪ Adelaide Airport

As described above under Keswick Creek.



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**7.3 EXISTING FLOOD RISK**

The characteristics of flooding in the catchment have been described above. The associated risk to property and the safety of people living in the floodplain can be further investigated through the comparison of the predicted flood extent with the location of roads, properties and other infrastructure that will be affected by this inundation.

The number of properties affected by flooding has been determined through comparison of the floodplain mapping with a properties database that has been compiled using information from the catchment council’s Geographical Information System (G/S) databases.

The total database of properties that have been included in the flood risk assessment is shown in **Figure 8** overlaid upon the flood extent for the 100 year ARI Base Case scenario. A total of about 27,000 properties are included in the database, of which about 7,000 are identified within the 100 year ARI floodplain.

A summary of the number of properties at risk from flooding for the range of design flood scenarios is provided in **Table 1**. As shown, the information is separated into properties that are subjected to over-floor flooding (*i.e. dwelling or structure damage*) and those affected by under-floor inundation (*i.e. peripheral property damage only*).

**TABLE 1 PROPERTIES AFFECTED BY FLOODING FOR EXISTING CONDITIONS**

DESIGN FLOOD EVENT	NUMBER OF FLOOD AFFECTED PROPERTIES		
	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	TOTAL
10 Year ARI	151	1001	1152
20 Year ARI	805	3059	3864
50 Year ARI	1513	4199	5712
<b>100 Year ARI</b>	<b>1712</b>	<b>5209</b>	<b>6921</b>
500 Year ARI	2,440	7,806	10,246
Probable Maximum Flood (PMF)	~ 10,000 *	10,000+ *	20,000+ *

\* Estimates for PMF only based on visual comparison with mapping from 2003 Floodplain Mapping Study (Hydro Tasmania, 2003)

The property database was compiled as part of work to prepare the 2003 Floodplain Mapping Study and has not been updated with additional properties since that time.

The BHKC project carried out a limited audit of the West Torrens Council portion of the property database in 2011. It identified an approximate 20% increase in the number of properties in the





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100 year floodplain compared with the number from the database. However, it was beyond the scope of this investigation to update the property database.

Further information on the properties database is provided in the section below on flood damages.

The preparation of flood hazard mapping can also assist in determining the level of flood risk. Refer to **Figure 9** for 100 year ARI flood hazard mapping for the catchment, which is based on the hazard categories adopted for the 2006 Master Plan. These categories are based on the combination of the velocity and depth of flow at any location and in more practical terms can be expressed as:

- Low hazard – if necessary, children and elderly people could wade to safety with little difficulty.
- Medium hazard – Fit adults can wade to safety, but children and the elderly may have difficulty.
- High hazard – Fit adults have difficulty in wading to safety.
- Extreme hazard – Wading is not an option because of the rate of rise and depth and velocity.

As shown in **Figure 9**, the creek channels are typically characterised as extreme hazard, which is to be expected due to the significant depth and velocity of flow. High hazard areas are typically limited to areas adjacent to the channel or along major flowpaths such as through the Showgrounds or up through the rail terminal. There are also some high hazard flowpaths along some streets, including Leader Street and South Road as flow crosses the Anzac Highway and spreads north towards Mile End South.

Medium to High hazard areas are expected in Cowandilla and at the Airport, primarily due to high depths rather than high velocities. The remainder of the floodplain is typically characterised by Low to Medium hazard (*refer green and blue areas in Figure 9*).

The AMLNRMB engaged Tonkin Consulting to undertake a risk management assessment of the potential for severe and catastrophic outcomes from flooding along Brown Hill and Keswick Creeks. The investigation included interviews with residents that had been affected by the flooding that occurred in November 2005.

The preliminary findings of this investigation (*Tonkin Consulting, 2011*) include the following general observations:

- Rapid response flash flooding is more likely to cause deaths and injury than slower response riverine flooding. This contrast was evident in the recent Queensland flooding where the flash flood that swept through the Lockyer Valley claimed a number of lives but the subsequent flooding of Brisbane, where sufficient time was available for evacuation, did not.
- There is risk of injuries both during a flood event and also during the recovery period as residents return to their homes to clean-up and make repairs.

In specific reference to the Brown Hill Keswick Creek catchment, the study indicates the following:

- The floodplain of Brown Hill and Keswick Creeks is densely populated. During a major flood there will be many people in close proximity to areas that are classified as high and extreme hazard (*refer Figure 9*). Many of these areas will have deep fast-flowing floodwaters and therefore, flooding presents a serious risk to the safety of people in parts of the floodplain.





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- During a major flood there will be a considerable amount of debris carried by the floodwaters. This can originate from damaged structures such as fences, sheds, decks and other landscape features, in addition to fallen trees. This debris can alter the course of the floodwaters by blocking narrow sections of the creeks, culverts and bridges. This may cause rapid changes in the direction and level of floodwaters presenting further danger to people.
- There is no available evidence of any physical injuries caused by recent flood events in Brown Hill Creek (*i.e. during the 2005 flood*), although examples were given of “near misses” that could have had worse outcomes. These were the collapse of a bridge parapet, the risk of electrocution and the case of a council worker who was apparently saved from being swept away after stumbling into floodwaters.
- A major flood will cause significant erosion and scour of the existing creek banks. This has the potential to threaten the stability of structures built close to the creek and can also change the “lie of the land” that people are familiar with, causing them to become disorientated.
- The difference between life and death near fast-flowing floodwaters could be as simple as a slip or a poor decision to enter floodwaters. Serious injury or deaths during a major flood event in the Brown Hill and Keswick Creek catchment must be considered as possible, or even likely.

#### **7.4 EXISTING FLOOD DAMAGES RISK**

Flood damages are adverse impacts to people, property and services as a consequence of flooding. They can be both tangible and intangible and are usually measured in terms of a dollar cost.

Tangible damages include direct damages such as the damage to property as a consequence of inundation (*e.g. the cost of replacing carpets and removing mud from houses in the aftermath of a flood*). Tangible damages can also be indirect damages such as the cost to the community of individuals being unable to get to work because they are isolated due to flooding. These costs can usually be measured and data has been gathered over many years to provide a reliable indication of the likely damage costs that can be incurred by residential, commercial and industrial property owners.

It is more difficult to quantify intangible damages. Intangible damages include less readily measurable impacts such as the trauma felt by individuals as a result of a major flood and the associated health related impacts. Only limited data is available, but it is thought that intangible damages could be as much or more than the tangible damage cost.

##### **7.4.1 Direct Tangible Damages**

Direct tangible damages are those that arise from the destruction of or damage to physical assets. These include losses as a result of damage to buildings, be they residential, commercial or industrial. They can be:

- Private or public buildings and the contents of buildings (*e.g. furniture and fittings, retail stock, machinery and goods used for production of a commercial product*);
- Private or public infrastructure, such as roads, railway lines, telecommunications, pipelines, electricity generation and distribution systems; and



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- Vehicles and plant.

#### **7.4.2 Indirect Tangible Damages**

Indirect tangible losses are those incurred as a consequence of the flood, but are not related directly to the physical damage that has been incurred. These costs include such items as:

- The marginal cost incurred by emergency service organisations in responding to the flood;
- The equivalent cost of volunteers' time in assisting with the response effort;
- Costs incurred by landholders in cleaning up after the flood, including their time;
- Emergency assistance grants given to people to help them deal with urgent situations (*e.g. alternative temporary accommodation, replacing a fridge, fixing damaged windows*); and
- Disruption to business.

Of the above indirect tangible damages the following have not been included in the quantification of damages undertaken as part of this project:

- The marginal cost incurred by emergency service organisations in responding to the flood; and,
- The equivalent cost of volunteers' time in assisting with the emergency response effort.

#### **7.4.3 Intangible Costs**

Intangible flood damages are those that are difficult to quantify in monetary terms. These damages are related to the physical and mental health of individuals, environmental impacts and disruption to essential community services and operations.

They include:

- loss of life;
- personal injury and associated losses and expenses;
- destruction of memorabilia (*e.g. family photos*);
- loss of heritage and cultural features;
- increased medical costs and reduced life expectancy associated with increases in levels of sickness in a community following a disaster;
- emotional stress and mental illness that can stem from a number of experiences associated with damage to family homes and businesses, including:
  - ⇒ replacement of damaged property, particularly if there is no flood insurance or it is insufficient;



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- ⇒ living in temporary accommodation;
- ⇒ children attending a different school;
- ⇒ death of pets; and
- ⇒ loss of business goodwill.

Interviews undertaken by Tonkin Consulting (2011) indicate that some emotional trauma has continued for residents in the City of Mitcham who were affected by flooding in 2005, and it is possible that there are a number of people affected by flooding along Brown Hill Creek who have suffered mental health impacts.

Although it was found that some creek-side residents are relatively at ease with the situation, other residents expressed fear of rainfall and others are vigilant and prepare for a flood during periods of heavy rainfall.

Intangible costs are those for which no market exists and hence there is no agreed method in place to quantify them. Accordingly, these costs have not been included in the quantification of flood damages.

However, it is agreed that this type of intangible damage to the well-being of residents and the community could be significant in the event of a major flood. It is possible that the intangible damage cost could be close to matching or may even exceed the total tangible damage cost.

#### **7.4.4 Damages Calculation Method**

A 'GIS Flood Cost Estimator Tool' was constructed by Hydro Tasmania Consulting as part of their original Floodplain Mapping Study (2003) for the Brown Hill and Keswick Creek catchments. The damages estimator tool was subjected to a peer review by Australian Water Environments (AWE) as part of work to prepare the 2005 Stage 1 Technical Report (precursor to the 2006 Master Plan).

This incorporated a check on the methodology used and also the accuracy of the model compared to local and recent case studies of flood damages.

The flood damages model is GIS-based and allows the user to select any area or land use type in the catchment and obtain an estimate for the likely damage for any of the design flood events simulated using the MIKE Flood model of the creek system.

Each property within the floodplain is assessed according to the land use type, specified as either:

- Residential;
- Commercial retail;
- Commercial office;



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- Industrial;
- Institution;
- Public utility;
- Recreation; or
- Vacant land.

The properties that have been included in the damages assessment are shown in **Figure 8** overlaid upon flood modelling results for the 100 year ARI Base Case scenario.

The GIS model calculates the damages for each property using information contained in the Digital Terrain Model (*DTM*) for the catchment, survey information for building floor levels contained in the property database and the flood model results for each design event.

An improved value was also assigned to each property, which represents the value of the structures or infrastructure that are susceptible to damage. This value also incorporates a portion of the damage costs to public utilities throughout the catchment, not just at the property itself.

The flood model results were used to determine the depth of flooding at each property and whether the inundation is above or below floor level. A depth curve consisting of damage multipliers was established for each property type, in which a multiplier is specified according to “above” versus “below” floor flooding and also subject to the depth of inundation, falling into the following ranges:

- 0 - 0.1 metres
- 0.1 - 0.25 metres
- 0.25 - 0.5 metres
- 0.5 - 1.0 metres
- 1.0 - 1.5 metres
- 1.5 - 2.5 metres
- 2.5 - 5.0 metres.

Using this approach, an appropriate multiplier is applied to the improved value of each property to determine the expected damages. A copy of the original multiplier curves from 2003 is included in **Appendix G**. These curves have since been updated to reflect an inflation factor of approximately 56%, based on increases in the Building Price Index for Adelaide since that time, as documented in Rawlinson’s Australian Construction Handbook (2012).



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As discussed in the *2005 Stage 1 Technical Report*, the original multipliers were determined from a number of sources and refined in the model by trial and error as follows:

- Chris Wright (2001) completed a comprehensive review of the impact of a flood in the Mile End/Keswick industrial/commercial zone. This study was an analysis of approximately 130 businesses in the area and determined the impact of a 1 in 100 year flood on their operations.
- The Insurance Council of SA provided insight into flood damages on residential and commercial properties. This information was used to develop the damages curves for the corresponding multipliers.
- Councils provided improvement values for each property and these were correlated with Valuation/DPTI data. The property values were based on the then current 2000 valuation records.
- Real estate agents and valuers provided assistance and knowledge with respect to the value of residential land institutional properties
- Interviews with stakeholders in the areas affected by recent floods (*residential, commercial, industrial and government*).
- Airport damages were determined separately as one single lot through interviews with airport owners, West Torrens Council, the then Patawalonga Catchment Water Management Board (*PCWMB*) and other stakeholders. An inflation factor has been applied to the previously estimated airport damages to update them to 2011 dollars. It is also recognised that the Airport has undergone extensive redevelopment since then, which may reflect a greater amount of damages in real terms now, compared with 2005. This has not been incorporated into the analysis.

From this consultation, the likely damages for properties were determined at various flood depths and these were applied to the damages model. Adjustments to the various land uses and depths were made by empirical trials until a reasonable match was achieved (*PCWMB, 2005*). The validity of the damages estimator tool developed by Hydro Tasmania was demonstrated by AWE through comparison of the damages results with per-lot damage estimates derived from actual flood events.

This method of flood damages calculation has been adapted by WorleyParsons for use with its specialist floodplain management software called *waterRIDE™*. The software is GIS based and has been developed over several years. It is commonly adopted as the industry standard in NSW for the presentation and interpretation of flood modelling results. The relevant state agencies often request that the results of flood modelling investigations be provided in *waterRIDE* compatible format.

The method of damages analysis using *waterRIDE* adopts the same approach used in previous studies, in terms of the damage multiplier curves being applied to the improved value of each property according to the depth of flooding. Verification of the *waterRIDE* damages results was carried out by matching the damages for Base Case mapping with that reported in previous studies for the catchment.



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**7.4.5 100 Year ARI Flood Damages**

The *waterRIDE* software has been used to determine that the tangible flood damages cost associated with 100 year ARI flooding is approximately **\$187 Million**. Full results of this analysis are presented in **Table 2**.

This estimate is considered to be a lower bound amount, because intangible damages are not included. If intangible damage costs are as high as the tangible damages (*as is likely*), the total 100 year ARI damages cost could be in the order of \$370 Million.

Also, as discussed in Section 7.3, the number of properties being assessed may be understated in the existing properties database from 2003, and therefore the damages are also likely to be understated.

The results of the 100 year ARI flood damages analysis were interrogated further to estimate the damages on an area-by-area basis for each of the catchment councils (*refer Table 3*).

**TABLE 2 100 YEAR ARI BASE CASE FLOOD DAMAGES BY PROPERTY TYPE**

PROPERTY TYPE	NUMBER OF FLOOD AFFECTED PROPERTIES			DAMAGES (2012 \$)*
	TOTAL	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	
Residential	5905	1558	4347	\$57,697,000
Commercial Retail	365	67	298	\$37,548,000
Commercial Office	323	46	277	\$14,985,000
Industrial	169	28	141	\$13,525,000
Institutions	109	8	101	\$7,921,000
Public Utilities	35	3	32	\$1,263,000
Recreation	15	2	13	\$399,000
Airport				\$53,249,000
<b>TOTAL</b>	<b>6921</b>	<b>1712</b>	<b>5209</b>	<b>\$186,587,000</b>

\* Note – individual damage values are rounded to nearest \$'000



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**TABLE 3 100 YEAR ARI BASE CASE FLOOD DAMAGES BY COUNCIL AREA**

LOCAL GOVERNMENT AREA	NUMBER OF FLOOD AFFECTED PROPERTIES			DAMAGES (2012 \$)*
	TOTAL	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	
Burnside	59	9	50	\$3,119,000
Adelaide	18	0	18	\$2,451,000
Unley	2722	603	2119	\$40,680,000
Mitcham	105	33	72	\$3,042,000
West Torrens	4017	1067	2950	\$84,046,000
Airport				\$53,249,000
<b>TOTAL</b>	<b>6921</b>	<b>1712</b>	<b>5209</b>	<b>\$186,587,000</b>

**7.4.6 Flood Damages for Other Design Flood Frequencies**

A summary of total tangible damages cost for a range of design ARI is provided in **Table 4**.

**TABLE 4 BASE CASE FLOOD DAMAGES**

DESIGN FLOOD MAP	TOTAL DAMAGES (2012 \$)
10 Year ARI	\$12,929,000
20 Year ARI	\$71,839,000
50 Year ARI	\$141,581,000
<b>100 Year ARI</b>	<b>\$186,587,000</b>
500 Year ARI	\$424,713,000
Probable Maximum Flood (PMF)	\$1,000,000,000*

\* Note – PMF damages are a rough estimate based on original estimates contained in the Floodplain Mapping Study (Hydro Tasmania, 2003)





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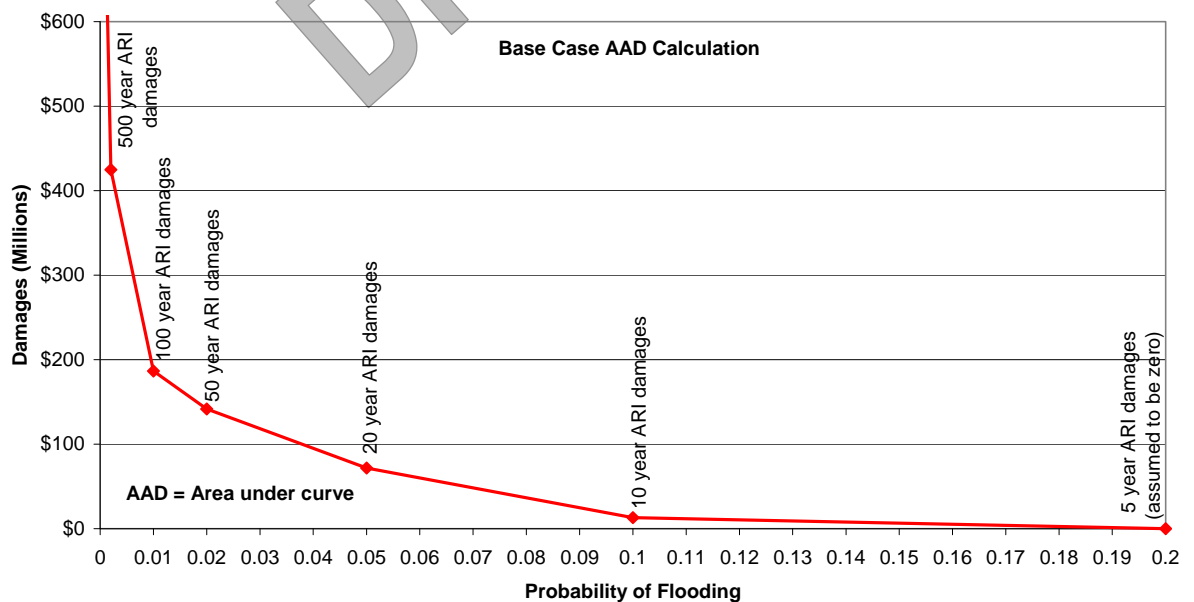
As shown, the **\$12.9M** damage bill for the 10 year ARI flood extent is less than 20% of the damage costs for the 20 year ARI flood extent, which indicates that a large portion of properties would be protected if flooding is restricted to the 10 year ARI extent. This is further confirmation that the existing creek system has about a 10 year ARI level of flood protection.

Expected damages for the Probable Maximum Flood have not been calculated using the *waterRIDE* software and the value of \$1 billion is based on original estimates contained in the 2003 Floodplain Mapping Study.

**7.4.7 Average Annual Damages**

The relative cost of the potential flood damages is typically expressed in terms of the Average Annual Damages (AAD). The AAD is the average damage per year that would occur from flooding over a very long period of time. In understanding this concept, there may be periods where no floods occur or the floods that do occur are too small to cause significant damage. On the other hand, some floods will be large enough to cause extensive damage.

In calculating the AAD, the probability of damages occurring is plotted against the expected value of damages for that probability of event occurring (e.g. a 100 year ARI event has a probability of 0.01 in any given year). The area under the curve effectively represents the AAD (refer chart below). It provides a measure for comparing the economic benefits of potential flood damage reduction options.



The AAD for the catchment under existing conditions (*Base Case*) was determined to be **\$11.5M**.



## 8. OPPORTUNITIES FOR FLOOD MITIGATION AND STORMWATER MANAGEMENT

### 8.1 GENERAL

Potential flood mitigation measures are considered in the following two categories:

- Structural measures – “on-ground” works that aim to physically modify existing flood behaviour or reduce the flood impact on properties within the catchment.
- Non-structural measures – typically planning measures and flood emergency response actions that can be implemented to prevent or reduce the risk to safety and property.

Flood management measures can be implemented separately or in combination with other measures to achieve a catchment-wide benefit.

Types of generic measures are described below. The same types of measures have been considered as potential alternative options for upper Brown Hill Creek as part of the additional work to develop this SMP (refer **Section 9**).

### 8.2 POTENTIAL STRUCTURAL MEASURES

#### 8.2.1 Flood Control Dams

Flood control dams provide for the temporary storage of floodwaters during a major storm event and act to reduce the peak flow downstream of the dam, thereby reducing the potential for channel breakouts and subsequent floodplain inundation.

The relatively flat and highly urbanised nature of the middle and lower parts of Brown Hill and Glen Osmond / Parklands / Keswick Creek catchment generally precludes the use of flood control dams, which typically require large areas of land to provide sufficient water storage volume.

The upper catchment of Brown Hill Creek is characterised by relatively steep-sided valleys cut by narrow creeks. Much of the native vegetation was cleared in the past for crops and sheep grazing with little remnant native vegetation remaining intact.

Flood control dams in the upper Brown Hill Creek catchment have been considered as part of previous studies. Following investigation of four sites, the 2006 Master Plan recommended two flood control dams (refer **Appendix A**).

In the upper reaches of the Glen Osmond Creek catchment there is the (*existing*) Mount Osmond Interchange flood control dam, which was modified in 2008 in accordance with a recommendation of the 2006 Master Plan.



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**8.2.2 Detention Basins and Wetlands**

In the context of this SMP, detention basins are similar to flood control dams, but are of smaller scale and/or are located within the urban areas of the catchment, typically in parks, reserves and open spaces.

They provide temporary storage for floodwaters during a storm event and reduce peak channel flows downstream. They can be implemented as either on-line structures (*through which all flow would pass*) or as off-line structures (*which might only capture a portion of the flow*).

Detention basins located further upstream can be more effective in reducing peak flow for all downstream areas and have a greater cumulative effect in reducing downstream flooding.

Potential detention basin locations have been investigated across the whole catchment, with the emphasis placed on the ability to capitalise on any existing open space.

Investigations for the 2006 Master Plan determined that detention basins would provide attenuation of peak flows at locations within the urban area along Parklands Creek (*South Park Lands*) and Glen Osmond Creek (*Ridge Park*).

**8.2.3 Overland Flow Interceptor Culverts**

The impact of overland flows that originate from upstream breakouts from the channel (*including spillage across Anzac Highway*) could be mitigated to some degree by capturing these overland flows into underground conduits via large side-entry pits. These so called “interceptors” would feed the flow back into the channel.

The use of interceptors may be perceived as inequitable in terms of flood protection given to properties downstream as compared with upstream of the interception line. An interception system also presents additional operational risks compared with measures that prevent channel breakouts in the first place.

**8.2.4 Flow Diversions**

In the context of this SMP a diversion is defined as the transfer of flow away from the main creek channel into another creek system. Diversions require detailed hydrologic and hydraulic assessment to ensure that the existing flooding problems in the receiving creek system are not exacerbated.

Opportunities for diversion of flows have been considered at various locations across the catchment (*Tonkin Consulting, 2002*).

Potential diversions investigated were typically sized to transfer a required magnitude of flow such that the residual downstream flow can be contained within the channel and thereby avoid breakouts. The spare flow capacity of the receiving channel was also considered.

A diversion system between Keswick and Brown Hill Creeks upstream from Anzac Highway was recommended in the 2006 Master Plan.



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**8.2.5 Flow Bypasses**

A flow bypass is defined as a diversion of flow away from the main creek channel to reduce downstream breakouts, which is returned to the same creek system further downstream beyond the problem area. Underground conduit systems along roadways may be required due to the lack of alternative locations in urban areas to construct additional open channels. The use of bypasses is limited by constraints on the downstream flow capacity of the creek so as to not transfer potential breakout areas to downstream locations.

**8.2.6 Channel Upgrades to Increase Capacity**

Channel upgrades typically involve channel widening or modification of the cross-sectional channel shape to provide additional flow conveyance and thereby reduce the amount of flow breakout. A significant issue with this option is the potential to transfer breakouts to downstream locations, hence the general need to undertake such works on a whole of reach basis. A further consideration is the lack of effectiveness of channel upgrades if bridges or culverts along that reach are not also upgraded to the same capacity.

As part of work to develop the 2006 Master Plan the downstream reaches of Brown Hill and Keswick Creeks were identified as significant problem areas; i.e. downstream of Anzac Highway to the airport for Brown Hill Creek and Richmond Road to the airport for Keswick Creek. Upgrading of the shorter channel length only (*Brown Hill Creek*) was recommended in the 2006 Master Plan.

**8.2.7 Bridge / Culvert Upgrades**

Several bridges and culverts along the creeks (*primarily road or rail crossings*) provide a constriction to flow, typically in the case that the adjacent channel sections have a higher capacity. At these locations it is expected that flow will “back-up” against the upstream side of the bridge and breakout from the channel, leading to the spread of floodwaters across the floodplain or the creation of overland flowpaths along local streets and roadways.

Upgrade of these hydraulic structures would however be largely ineffective if under-capacity sections of channel exist upstream or downstream. Similar to channel upgrades, an issue with bridge upgrades is the potential to transfer breakouts to downstream locations.

**8.2.8 Other Miscellaneous Options**

Other mitigation opportunities that were considered during the course of developing the original 2006 Master Plan and this SMP included:

**Under-Grounding or Covering**

While it would be technically possible to convey the estimated 100 year ARI flows within an underground culvert system placed in the creek (*as has been done for a large proportion of Glen Osmond Creek*), long sections of the creeks, especially between the railway and the foothills are in private ownership and relatively inaccessible in individual owners backyards.



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Whilst this option could be accompanied by some form of community benefit above ground, such as a linear park, property acquisitions would be required. Furthermore, the under-grounding of creeks is sometimes inconsistent with good practice natural resource management and may not readily allow major overland flows (*i.e. flows in excess of the capacity of the existing underground drainage network*) to enter such a creek system.

**Channel Lining (no increase in cross-section area)**

Unlined sections of channel can be concrete lined to decrease the hydraulic roughness of the channel and thereby increase flow capacity. Whilst this is not an ideal policy approach from a natural resource management perspective, it may be appropriate for those sections of channel where space is limited and the banks of the channel are overly steep, or where no other mitigation options are feasible at short reaches where capacity is limited and localised overtopping occurs.

**Channel Maintenance**

Channel maintenance is a contentious issue within the catchment due to the current demarcation of responsibility between councils, the AMLNRMB and private landowners.

The responsibility to maintain the function of the creek network lies with the landowner, be it the councils or private landowners. Currently this is not being undertaken in a consistent manner, with little maintenance being done by private landowners on sections of the creek system where there is reduced hydraulic capacity due to excessive vegetation or erosion.

To maintain the modelled hydraulic characteristics of the creek system it is essential that the creek system be well maintained to reduce the risk of obstructions caused by debris accumulating along the channel or at bridge structures.

Channel maintenance is further discussed as a non-structural flood mitigation measure in Section 8.3.5.

**Flow Containment – Levees and Walls**

This type of mitigation option assumes that the design flow is to be contained wholly within the existing channel by raising the sides of the channel above their existing level. The heights of the containment structures depend on both the flow to be contained and the amount of space available to implement the structure.

Such structures can be constructed as earthen embankments or as concrete retaining walls. These types of works were also considered in conjunction with larger-scale channel upgrades (*refer above*).

**Road Diversions**

In the event of a flood, the road network in the catchment would provide some storage of flood water. Water would be partially contained within the road reserve along existing kerb and gutters according to the natural fall of the land. A potential mitigation option previously investigated in the development of the 2006 Master Plan was to increase the amount of storage offered by roads by artificially creating areas capable of storing additional volumes of water.



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While this is a potentially attractive option, it would not be possible to achieve significant storage gains without major structural works and lowering of some road networks, which in turn might increase localised stormwater problems and pose a significant safety hazard.

**Raising Floor Levels**

Providing floor levels above the design flood level is typically a non-structural option as it is more suited to planning policy for new or upgraded properties. In the case of Brown Hill and Keswick Creeks it was not considered cost-effective to raise floor levels for existing properties, particularly due to the age and type of construction of the majority of properties involved. The primary objective in these cases would be to provide other structural works or use flood preparedness measures to reduce damages during times of flooding.

New developments should be constructed with floor levels above the peak 100 year ARI flood level to reduce the risk of flooding and damage. This is currently a requirement for a number of the councils and is seen as a best practice flood damage reduction measure (*refer planning measures below*).

**8.3 POTENTIAL NON-STRUCTURAL FLOOD MANAGEMENT MEASURES**

Potential non-structural flood management options have been considered under five categories:

- Planning policy and development assessment process;
- Flood awareness and preparedness;
- Flood warning and emergency response;
- Supporting policies and programs; and
- Channel maintenance and clearing.

In light of major flooding that has recently occurred in Brisbane and in other areas of Australia, an issue that has attracted much debate is flood insurance. Providing comment on the issue is not an objective of this SMP. However, it is recognised that there may be calls from some sections of the community for flood insurance to be considered as a valid flood management measure, to be implemented in lieu of hard structural mitigation works or other non-structural measures.

This approach is not considered appropriate, primarily because the purchase of flood insurance will not reduce the flood hazard and risk that residents are exposed to. Accordingly, it has not been included as a valid non-structural flood management measure for Brown Hill and Keswick Creeks.

**8.3.1 Planning Policy and Development Assessment**

Planning policy can contribute to flood mitigation and storm water management outcomes by applying restrictions or specific requirements to new development. For example, planning policy may:

- Prohibit development that would obstruct or interfere with a watercourse;





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- Prohibit development, or particular types of development in areas where the risk of flooding is high;
- Require new buildings to be designed and constructed to prevent the entry of flood waters to a specified standard (*e.g. 1 in 100 year average return interval flood event*);
- Require development to be set back a specified distance from a watercourse.

Where such policies apply, it is important that the community and particularly the applicants for development approval understand that the purpose of the policies is to protect against the risk of flooding.

While planning policy can influence how new development contributes to storm water management and flood risk management, it cannot have an impact where buildings and structures have been constructed in areas subject to flood risk.

South Australian Planning Policy Library

Planning policy is contained within Development Plans which exist for each council in the Adelaide metropolitan area.

The South Australian Planning Policy Library (*SAPPL*) is a set of Development Plan policies developed by the DPTI that deal with issues common to most councils, including stormwater management and flood risk management.

These policies have been derived from the Development Plans of a number of councils and input from government agencies, and are considered to be current leading practice. The *SAPPL* policies are consistent with the current State Planning Strategy.

All councils are required to update their Development Plans in accordance with the *SAPPL*, however this is occurring over time and different councils are at different stages of the process.

The Development Plans of each council within the Brown Hill and Keswick Creek catchment currently contain policies relating to stormwater management and flood risk mitigation, however not all Development Plans have adopted the *SAPPL*.

The 30-Year Plan for Greater Adelaide

The *30-Year Plan for Greater Adelaide* is a strategic document used by the State Government to guide the planning and delivery of services and infrastructure within the greater metropolitan area.

The 30-Year Plan identifies areas that will be the focus of higher density development over the next thirty years to accommodate expected population growth. Amongst these areas are the inner south-west and inner west parts of metropolitan Adelaide, which fall within the urban catchment of Brown Hill and Keswick Creeks.

Higher density development could be expected to result in an increase in the impervious area within the catchment over time, as more buildings and paved areas replace private





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gardens and some open space. This in turn could increase the risk of flooding from both local stormwater flows and from the Brown Hill and Keswick Creeks during storm events.

In these new development areas, potentially increased flood risk will be reduced by councils' adoption of the SAPPL.

### **8.3.2 Flood Awareness and Preparedness**

Experience shows that informing people about the flooding risks they and their properties could be exposed to enables them to reduce their vulnerability and increase their resilience against flood damage.

Community awareness of flood risk and potential for flood damage in the catchment has been elevated with the recent flooding in Queensland, New South Wales and Victoria. This has likely boosted the interest that was originally shown when the floodplain mapping was previously published for the catchment (2003) and the interest shown after the flood of November 2005.

However, public interest tends to focus on recent events and diminishes rapidly thereafter, unless a concerted effort is made to maintain a high level of awareness.

The Adelaide community does not, by and large, have any experience of flood (*Tonkin Consulting, 2011*). Many houses have changed ownership since previous flooding and many people who could be affected by an extreme flood along Brown Hill and Keswick Creeks are likely to be ill prepared and taken by surprise.

Flood maps produced for the catchment provide the best available estimate of flood flows and extent, which indicate to residents where water is most likely to travel, and what depth it might reach; vital information for helping landholders to understand the scale of the flood problem, and therefore be able to mitigate potential damages.

The 100 year ARI flood map for Brown Hill and Keswick Creeks shows that much of the flooded area is affected by shallow water (*less than 150 mm*) (refer **Figure 3**). In most cases the flow will not be deep or fast enough to break through glass doors or windows, meaning that blocking door seals and wall vents by sand bagging may be sufficient to alleviate the problem. Raising furniture and belongings to well above floor level or to upper storeys would also help alleviate flood damages.

It is considered, in general, that through effective community awareness and flood warning, flood damages can be reduced by up to 50% in particular cases assuming individuals or businesses are able to invest in substantial work and have the capability to respond at critical times. However, it is unlikely that such a reduction could be achieved on a catchment-wide basis. The warning time for Brown Hill and Keswick Creeks is relatively short compared to larger river systems and so the reduction in damages may not be so high (*Tonkin Consulting, 2011*).

In addition to the financial and economic benefits from reduced damages are intangible benefits of flood warning and flood preparedness. An informed community is likely to more resilient to flooding; simple actions like relocating photographs and other valuable items to a higher cupboard or second storey are easily implemented and could significantly reduce the



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longer-term trauma of a flood event. A community that understands the dangers of floodwaters will likely be safer than a community that is ill informed about flood behaviour (*Tonkin Consulting, 2011*).

There is an obligation that flood mapping information be made public through the Natural Resource Management Boards and councils, but understanding flood maps and the implications of flooding as well as options to reduce risks is not necessarily straightforward.

Access to people with appropriate technical knowledge of the catchment is necessary to assist people to make informed decisions about property purchase, property development, and appropriate responses to flood risk.

In New South Wales and Victoria, Catchment Management Authorities and Councils have the authority to issue a flood report or certificate when a property is in a flood-prone area. Agents, owners or potential purchasers can obtain a report or certificate as part of property enquiries. The content of the certificate is limited and basically advises that the property is within the calculated flood-prone area.

An opportunity exists to incorporate similar advice in South Australia on Section 7 searches required as part of the Real Property Act 1886. The purpose of providing such advice would be to inform owners and occupiers of flood-prone land such that they can make informed decisions.

To help residents manage the impact of flooding and reduce damages to their own property, the 2006 Master Plan indicated that an ongoing awareness program was needed to achieve a reasonable and sustainable level of community awareness and raise levels of awareness in emergency management and response procedures.

The FloodSafe Program has since been established across nine councils in partnership with the State Emergency Services (SES), including the catchment councils of the City of Mitcham, Unley, West Torrens and Adelaide. It is understood that the City of Burnside has also joined the program (*Tonkin Consulting, 2011*).

A key communication tool used as part of the FloodSafe Program is a “*Flood Pack*”, which is distributed to at-risk residents and contains information on methods for flood-proofing dwellings and properties, in addition to advice on flood preparation, safety and recovery.

The material is of a generic nature in that it does not include any site-specific information for residents to identify the specific flood risk. However, the information pack includes a template for residents to prepare their own Emergency Flood Plan. This encourages residents to think through and plan any actions they need to take before and during the onset of a flood and also provides a useful reference for key information. The SES has indicated that the template is being used by a high percentage of people that they contact (*Tonkin Consulting, 2011*).

It is understood that distribution of the FloodSafe materials to residents is done periodically by councils through a mailing list with a covering letter to indicate that the SES is available to provide assistance in preparation of an emergency plan. The current cost of the FloodSafe Program is less than \$200,000 per year, which covers nine council areas.



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**8.3.3 Flood Warning and Emergency Response**

In South Australia the Bureau of Meteorology (*BOM*) issues formal Flood Warnings only for the Gawler, Torrens and Onkaparinga Rivers (*Tonkin Consulting, 2011*). The BOM has developed technology that automatically collects rainfall and river flow information and automatically generates SMS and e-mail messages for distribution to staff from BOM, SES and councils. It has been historically known as the ALERT system. It is now called the Enviromon system. The BOM (*in conjunction with state agencies*) maintains and operates the network of rain gauges and river level gauges within these catchments.

The BOM also issues generalised Flood Watches, which indicate on a regional scale that predicted rainfall could cause flooding. These are issued up to three days ahead of the weather and are updated as more accurate forecasts are made. These are not official Flood Warnings and severe flooding may occur only once for every ten Flood Watches that are issued.

Severe Thunderstorm or Severe Weather Warnings are issued up to 6 hours before the onset of bad weather that could potentially lead to flooding.

However, the BOM does not have responsibility for issuing official Flood Warnings in catchments that are subject to flash flooding, which is defined as any catchment where the time from the onset of rain to the onset of flooding is less than 6 hours (*Tonkin Consulting, 2011*). The rationale behind this is that 6 hours would be the minimum time that is required to undertake monitoring and modelling of a flood situation and then issue warnings in order to provide any worthwhile warning time.

Brown Hill and Keswick Creeks are regarded by BOM as falling within the category of flash flooding and therefore, it is not responsible for issuing official Flood Warnings for the catchment.

Notwithstanding this, there are 13 rainfall and river level stations within the catchment that form part of the ALERT system. These stations are an asset of local government who are financially responsible for maintenance and replacement as necessary.

The BOM is currently undertaking the operation and maintenance of these gauges on a fee basis for the councils. Although it does not issue official Flood Warnings based on the gauged data, it is understood that the data is available in near real-time on the BOM's external website.

Due to the relatively quick response time of the Brown Hill Keswick Creek catchment it is likely that by the time an alarm from the Enviromon system is triggered by water depths or rainfall, flooding may be imminent or may already have commenced in some areas of the catchment. The alarm would have some benefit, but in terms of reducing flood damages it is expected to be limited (*Tonkin Consulting, 2011*).

Accordingly, the use of meteorological predictions for rainfall as part of the BOM's Flood Watches and Severe Weather Warnings will be the only way to provide sufficient time to allow flood preparations to be made. Due to the difficulties in predicting extreme rainfall, in many cases there will be false alarms and possibly even a failure to predict a flood event.



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Currently the alarms generated by the Enviromon system, based on measured rainfall, only go to the emergency response agencies and do not get distributed to the communities that might be at risk. During a major flood event it may give emergency response personnel some warning time, which could be up to a few hours, depending on the pattern of rainfall (*Tonkin Consulting, 2011*).

There is also benefit in receiving Enviromon alerts during smaller, more frequent events that do not pose significant damages but may require action from the councils, such as clearing of blocked drains or monitoring their performance.

The SES in 2011 was preparing an Emergency Response Plan for Brown Hill and Keswick Creeks based on the Prevention Preparedness Response Recovery model (*PPRR*). The plan will target vulnerable communities and include strategies for their protection and/or evacuation (*Tonkin Consulting, 2011*). The SES was consulting the five catchment councils, the BOM and the AMLRNRMB as part of development of the plan. It was expected to be completed in 2011 and tested through desktop simulations and field exercises.

This overall Emergency Response Plan would complement any existing internal flood and storm response plans that are currently in use by the councils.

### **8.3.4 Supporting Policies and Programs**

Preparation of the SMP considered the following supporting policies, protocols and programs and the degree to which they could be applied in support of flood mitigation objectives.

Neighbourhood planning in strategic areas of concern along watercourses at identified areas of infill development and urban renewal was identified as a means of addressing potential future flooding and stormwater management issues through targeting actions at the regional, neighbourhood and property level.

As the inner suburbs of Adelaide undergo further infill and urban renewal there may be opportunities to address stormwater management issues through developing neighbourhood plans that cover particular regions of risk, rather than at a local government area level.

There maybe further opportunity to develop policies and programs related to open space and road reserve management within the five council areas, with the intent of providing detention of stormwater within the neighbourhood. Works could be incorporated during the construction of roads and footpaths or at the time of development of open spaces.

The South Australian Government is seeking to integrate Water Sensitive Urban Design (WSUD) into all urban development and buildings to achieve a more secure and sustainable future for Greater Adelaide. WSUD provides for the sustainable use and reuse within developments of water from various sources, including stormwater.

WSUD measures that can be applied to developments in the Greater Adelaide region include rainwater tanks, pervious pavements, urban water harvesting and reuse, gross pollutant traps, infiltration systems and measures to enhance biodiversity and amenity.

On-site detention through the compulsory fitment of rainwater tanks to residential properties is a potential WSUD measure. While it has other benefits, hydrologic analysis of the



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catchment confirmed the conclusions of work elsewhere that rainwater tanks for on-site detention on their own have little effect in reducing peak flows during large flood events (Pezzaniti, 2003), with the effect diminishing with increasing size of the flood event.

### **8.3.5 Creek Maintenance**

The flood capacity of the creek system is directly affected by the presence of vegetation within and alongside the creek channels. Where the creeks flow in natural channels, both native and exotic trees and shrubs become established, and this can reduce the capacity to convey floods. In an urban environment, where natural flows are augmented by urban stormwater, it is necessary to manage the channel and the vegetation in it, in order to ensure adequate flood capacity and to prevent erosion of banks and the stream-bed.

Private ownership of the watercourse is particularly relevant to Brown Hill Creek upstream of Anzac Highway because of the way in which the creek, particularly in its 'natural' or unkempt condition has become or is perceived to be an aesthetic feature of some properties. Such a condition in fact presents potential flooding risk (*either due to limited channel cross-section, vegetation overgrowth and lack of maintenance or a combination of two or more of these factors*) and may not represent the full environmental, biodiversity and amenity potential of the watercourse.

The effects of a lack of creek maintenance are highlighted in the Channel Capacity Assessment report by AWE (*refer Section 3.2*).

Public and private ownership along the creek system is as follows:

Lower Brown Hill Creek (downstream of Anzac Highway): More than 95% of the channel is contained in a council reserve before it enters Adelaide Airport. Approximately 60% of that length is lined. Brown Hill Creek is maintained by the State Government (*SA Water*) from the Patawalonga Basin to approximately Packard Street, Plympton (*the end of the first section of concrete lining section upstream of the airport*) under the authority of the Metropolitan Drainage Act 1935.

Keswick Creek (downstream of Anzac Highway): Approximately 50% of Keswick Creek is in private property, mostly east of South Road. Most of its length is concrete-lined and maintained by the State Government (*SA Water*) up to the downstream end of the Anzac Highway culvert under the authority of the same Act.

Glen Osmond Creek: The majority of Glen Osmond Creek is in council land. The only significant length in private ownership is between Fisher and Windsor Streets, Fullarton, which is concrete lined with short sections of pipe, mainly in backyards. It is undergrounded in a box culvert from Windsor Street to King William Road, Unley, and lined channel down to the start of Keswick Creek. From Ridge Park to Fisher Street it is partially lined channel for most of its length.

Parklands Creek: A short length of unlined channel from King William Road to the confluence with Glen Osmond Creek is privately owned and in poor condition. Most of the length from King William Road to Greenhill Road is in council owned land or easement and is concrete lined to varying degrees. Upstream of the South Park Lands the channel / pipe is in





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State Government land or council easement until Conyngham Street from where it is fed by underground drains located in road reserves.

Upper Keswick Creek: The creek is in government ownership (*Commonwealth and State*) from Anzac Highway to Goodwood Road. From there to the Parklands Glen Osmond Creek confluence it is largely in private ownership. It is concrete-lined for most of its length. Under the showgrounds it is located in a twin cell box culvert.

Upper Brown Hill Creek: The creek is privately owned for most of its length, and is unlined or partially lined except for sections generally downstream of Mitchell Street in Unley.

In general: Where the creeks are in public ownership, and for those sections that come under the 1935 Metropolitan Drainage act, maintenance is undertaken by public authorities. Where they are in private ownership, responsibility for maintenance is vague, debatable and unsatisfactory in terms of maintaining flood carrying capacity.

It is reasonable for landowners to regard the watercourse as a valuable asset (*perhaps ignoring the flood risk*), but there may be potential for that value to be increased under a system of managed maintenance, which may include progressive transfer of responsibility from private owners to public authority.

#### **8.4 OPPORTUNITIES FOR MULTI-PURPOSE OUTCOMES**

There are numerous examples where flood mitigation works have been expanded or adapted to provide benefits other than reducing flood damages. Opportunities for multi-purpose outcomes include the following:

- Flood mitigation works are typically designed to deal with large and infrequent flows and therefore, only operate to their design capacity on rare occasions. If a proposed detention system requires large areas of land that would go unused for the majority of the time, then it would be worthwhile to incorporate other benefits such as increased recreational amenity.
- Flood mitigation works can involve the use of large amounts of public funds, much of which will be sourced directly or indirectly from the community (*taxpayers and ratepayers*) who may not receive any direct benefit from the works. Incorporating multiple use benefits from the works will share the benefit to a wider portion of the community.
- Achieving a wider array of multi-purpose outcomes from the works offers the opportunity to attract a wider range of investors in the works and therefore the costs can be distributed over a larger funding base.

For the BHKC Project, opportunities for achieving multiple outcomes were considered on both a reach-by-reach and a catchment-wide basis in preparing the 2006 Master Plan. However, any multi-purpose works firstly had to be associated with a practical flood mitigation measure.

Each flood mitigation and stormwater management option considered in development of the SMP was considered in terms of its potential to provide one or more of the following additional benefits:

- water quality improvement;



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- improved biodiversity;
- passive recreational opportunities;
- formal recreational opportunities;
- water harvesting and reuse opportunities;
- natural infiltration and replenishment of local shallow groundwater;
- transport corridors; and
- visual amenity.

A summary of how these opportunities have been incorporated within the priority works components is discussed in **Section 13.8**.

### **8.5 2006 MASTER PLAN FILTERING AND ASSESSMENT PROCESS**

As part of work to develop the 2006 Master Plan information was gathered from stakeholders and reviews were made of flood inundation maps, land use mapping, and the hydraulic characteristics of watercourses in the catchment. The watercourses were divided into approximately 30 reaches with similar characteristics which allowed catchment scale flooding to be assessed on a local scale.

Over 300 potential opportunities for mitigation works to reduce flooding were identified in this way. These were checked for their technical and economic viability, which resulted in a short-list of around 80 viable options.

While the primary focus was flood risk management, opportunities to include multi-purpose benefits were also identified. Those benefits included stormwater reuse, water quality improvements, improvements in biodiversity, passive recreational opportunities and improved amenity.

A multi-criteria analysis technique was used to rank the 80 options. The criteria were:

- expected cost of works;
- flooding reduction within the reach;
- flooding reduction across the catchment;
- potential for increasing open space and recreation opportunities;
- potential for improving water quality and providing reuse opportunities;
- opportunity to improve biodiversity; and
- degree of “at source” management.





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The process resulted in a further short-listing of options down to around 20 components, which were evaluated in more detail by reviewing their expected costs and estimating the contribution they made individually to reducing flood damages and flood hazards.

Many of the structural components were found to be closely interrelated and the way in which they were combined would have a significant effect on the scale of hazard and damage reduction as well on the cost effectiveness.

The final short-listed components effectively became the priority works components for the flood management strategy contained in the 2006 Master Plan (*refer Section 2.2*).

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## 9. BENEFIT-COST OF 2006 MASTER PLAN WORKS ON UPPER BROWN HILL CREEK

Development of the 2011 Draft SMP involved review of the economic justification of the 2006 Master Plan works that were proposed for upper Brown Hill Creek (*refer Section 2.2*).

The 2006 Master Plan included the following works for upper Brown Hill Creek:

- Two flood control dams upstream from the Brownhill Creek Recreation Park; and
- Channel upgrade between Hampton Street and Cross Road.

### 9.1 2006 MASTER PLAN WORKS FOR UPPER BROWN HILL CREEK

#### 9.1.1 Flood Control Dams in the Upper Brown Hill Creek Catchment

Four potential locations for flood control dams were originally investigated in the Brown Hill Creek catchment as part of the *2005 Stage 1 Technical Report (precursor to the 2006 Master Plan)*.

Based on hydrologic modelling for a range of scenarios with the four dams, it was determined that the preferred option was a combination of Dam 2 (~20 metres height) and Dam 4 (~19 metres height), with storage volumes of 335 ML and 60 ML respectively (*refer Figure 10*).

This option would reduce the downstream flow at Scotch College from 27 m<sup>3</sup>/s to approximately 13.1 m<sup>3</sup>/s during the 36 hour 100 year ARI storm.

The 2006 Master Plan recommended that an earth embankment design be adopted as a robust lower cost dam that would be suitable for a range of differing foundation conditions. A qualifier to this recommendation was the requirement for further survey and geotechnical investigations to be undertaken to determine the foundation conditions.

Preliminary investigations, including a geotechnical review, were undertaken on behalf of the BHKC Project in 2008. The relevant report is *'Preliminary Assessment of Flood Detention Basins on Brown Hill Creek; Report for Stage 1' (GHD, 2008)*. No engineering issues of concern were identified.

It is understood that no further hydrologic modelling was undertaken during the preparation of the 2008 report and therefore the modelled performance of the flood detention dams, as documented in the 2006 Master Plan, has remained unchanged

#### 9.1.2 Channel Upgrade between Hampton Street and Cross Road

The Stage 1 Technical Report identified Cross Road as a known break-out point for flows travelling down Brown Hill Creek (*refer Figure 10*). The channel upstream of Cross Road has limited capacity and floodwaters are expected to overtop the channel banks in the



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10 year ARI event. During events larger than the 20 year ARI flood the overflow spills to the east and west along Cross Road resulting in flood damages through downstream suburbs.

Upgrading this section of channel would ideally contain flow within the channel up to the equivalent capacity of the Hampton Street and Cross Road bridges (*both about 30 m<sup>3</sup>/s*).

For the Master Plan it was determined that the Brown Hill Creek flood detention dams would limit the peak 100 year ARI flow to less than 25 m<sup>3</sup>/s in the critical 36 hour storm. The corresponding channel upgrade between Hampton Street and Cross Road would require about 250 metres of concrete-lined channel with dimensions of 4 metres base width and 2 metres height. The concept design also allowed for transitioning of the height to 3 metres over a distance of 50 metres upstream from the culvert at Cross Road.

Without the detention offered by one or more dams, the channel upgrade would require additional width to offer a similar level of protection. The bridge at Hampton Street and culvert at Cross Road would also require upgrade by way of an additional box culvert at each crossing to accommodate the 100 year ARI peak flow.

## **9.2 ECONOMIC ASSESSMENT APPROACH**

The economic assessment was undertaken as part of preparation of the 2011 Draft SMP. Accordingly, the dollar values included in the assessment are presented in 2011 dollars, both in terms of the cost of works and the reduction in flood damages afforded by the works. Despite not being updated to reflect 2012 dollars, it is considered that the analysis is relative and appropriate, and the outcomes of the analysis would not significantly change if an update to 2012 values was undertaken.

Determining the cost of works involved updating previous cost estimates prepared for the 2006 Master Plan to account for the effect of cost escalation, which was determined to be 24.9% between 2006 and 2011, as extracted from the building price indices for Adelaide documented in Rawlinson's Construction Handbook (2011).

The value of future benefit has been determined through assessment of the relative reduction in flood damages afforded by the works on upper Brown Hill Creek.

This has required the comparison of the expected flood damages for the 2006 Master Plan with the damages that would be expected for the 2006 Master Plan without the works on upper Brown Hill Creek (*i.e. removal of the two flood control dams and the channel upgrade between Hampton Street and Cross Road*). The method for flood damages calculation is described in **Section 7.4**.

Benefit-cost analyses for flood mitigation works involve the calculation of flood damages associated with the full range of design flood events (*i.e. the 10, 20, 50, 100 and 500 year ARI floods and the Probable Maximum Flood*).

The damage estimates for all the design events are then converted into an estimate of the Average Annual Damages (*as discussed in Section 6.4 for Base Case conditions*), which can be used directly in determining the present value of relative benefits.



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The reduction in AAD associated with the works on upper Brown Hill Creek has been determined through hydraulic modelling of the 2006 Master Plan works with and without the works on upper Brown Hill Creek.

The PMF flood damage cost for the 2006 Master Plan was not previously determined and has not been modelled during the preparation of this report. As a conservative approach for the assessment of the works on upper Brown Hill Creek it has been assumed that the works will offer no benefit in such an event. It has been assumed that the PMF damages in either case is \$1 billion, which is the same as for Base Case (*refer above*).

**9.3 INVESTIGATION FINDINGS**

**9.3.1 Effect of Dams on Catchment Hydrology**

The hydrologic modelling for the 2006 Master Plan was modified to incorporate the scenario without the flood control dams at Sites 2 and 4.

The results shown in **Table 5** indicate that the dams would have the effect of reducing the peak flow during the 36 hour storm by about 13 m<sup>3</sup>/s for areas upstream of Anzac Highway.

**TABLE 5 FLOW REDUCTION AFFORDED BY THE FLOOD CONTROL DAMS**

LOCATION	PEAK FLOW DURING 36 HOUR STORM (m <sup>3</sup> /s)		
	BASE CASE (no dams)	DAMS AT SITES 2 AND 4 (2006 Master Plan)	REDUCTION
Scotch College	26.1	13.1	13.0
Belair Road	30.2	16.9	13.3
Cross Road	36.4	23.1	13.3
Goodwood Road	37.1	23.6	13.5
Hydrograph volume above 18 m <sup>3</sup> /s at Goodwood Road	250 ML	42 ML	208 ML
Anzac Highway	38.9	25.7	13.2

The flows contained in **Table 5** are based on the assumption that flow down through the floodplain is all contained within the channel.

The flow capacity of the Brown Hill Creek channel upstream from Anzac Highway was modelled typically at about 18 to 22 m<sup>3</sup>/s (*WBCM, 1983*). Accordingly, for that flow capacity range the total volume of flow at times when this threshold is exceeded can provide an indication of the volume of flow that will spill out onto the floodplain. In the case of the



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36 hour duration storm, the volume of runoff is significant and therefore widespread inundation is expected to occur (*refer to Figure 3 as an example*).

Goodwood Road has been chosen as a sample location in **Table 5** to show that up to 250 ML of flow could be expected to spill onto the floodplain under existing conditions. This analysis assumes that overtopping has not occurred at any locations upstream, but it is useful nonetheless to provide an indication of the total volume of flow onto the floodplain.

In contrast, the volume of runoff above 18 m<sup>3</sup>/s during the 90 minute storm is estimated to be less than 20 ML (*i.e. less than 10% of the volume during the 36 hour storm*), which indicates that the longer duration storm is responsible for a majority of the widespread inundation across the floodplain in the Base Case scenario.

The analysis in **Table 5** shows that the flood control dams at Sites 2 and 4 offer significant reduction in the total volume of runoff above the threshold of 18 m<sup>3</sup>/s, which is expected to transfer into a reduction in peak flood extent.

This analysis shows that any form of detention in the upper rural catchment has the potential to significantly reduce downstream flooding.

The hydrologic modelling also showed that a dam at Site 2 is expected to provide a majority of the flood detention benefit, primarily because it captures runoff from a much larger upstream catchment than Site 4. One flood control dam would provide nearly as much detention benefit as the two originally proposed dams.

The above analysis does not take into account the recent Channel Capacity Assessment (AWE, 2012), which has shown that the existing channel capacity of upper Brown Hill Creek may be overestimated in the current flood mapping. Accordingly, there is potential for overtopping from the channel to occur at flows of less than 18 m<sup>3</sup>/s. In this case, the relative impact of the proposed dams would be expected to be greater, albeit that it is accepted that increased detention would be required to limit the volume of spillage to that currently modelled; for example, to 42ML at Goodwood Road.

### **9.3.2 Effect of Dams on Flooding**

The 100 year ARI mapping for the 2006 Master Plan is provided in **Figure 11**. Comparison with **Figure 3** for Base Case conditions shows that the 2006 Master Plan works offer a significant reduction in flood extent and depth throughout the floodplain.

It has been determined that up to 3,400 properties would still be affected by flooding during the 100 year ARI event if the 2006 Master Plan were implemented without modification. Of those properties, about 550 properties would be subject to over-floor flooding (*as shown in Figure 11*).

The residual flood extent is largely a result of flows overtopping the Brown Hill Creek channel upstream from the Anzac Highway, spreading out across areas of Unley and then traveling overland across the Highway into the West Torrens council area.

**Figure 12** provides a visual comparison of the 100 year ARI floodplain maps for the Master Plan works versus the Master Plan works minus the upper Brown Hill Creek works. The



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area shaded in pink represents the additional area that is expected to be inundated if the works on upper Brown Hill Creek were to be removed from the 2006 Master Plan.

As shown by the black dots in **Figure 12**, there are a number of additional properties that would be subject to over-floor flooding, predominantly within the council areas of Unley, Mitcham and West Torrens.

Similar comparisons are provided for other design ARI maps in the figures contained in **Appendix H**.

**9.3.3 Effect of Dams on Flood Damages**

A flood damages analysis was undertaken for the range of ARI mapping up to the 500 year ARI event, for both the 2006 Master Plan works and the Master Plan works minus the works on upper Brown Hill Creek. A summary of the results is provided in **Table 6**.

**Table 6 COMPARISON OF FLOOD DAMAGES**

DESIGN EVENT	FLOOD DAMAGES*		
	2006 MASTER PLAN WORKS	2006 MASTER PLAN WORKS EXCLUDING THE UPPER BROWN HILL CREEK WORKS	INCREASE
10 YEAR ARI	\$5,192,000	\$6,274,000	\$1,082,000
20 YEAR ARI	\$7,955,000	\$22,642,000	\$14,687,000
50 YEAR ARI	\$23,682,000	\$36,778,000	\$13,096,000
<b>100 YEAR ARI</b>	<b>\$41,304,000</b>	<b>\$66,863,000</b>	<b>\$25,559,000</b>
500 YEAR ARI	\$96,097,000	\$132,680,000	\$36,583,000
AAD	\$3,033,000	\$4,377,000	\$1,344,000

\* All values are in 2011 \$

As shown in the table, removing the works on upper Brown Hill Creek is expected to increase the 100 year ARI damages by more than **\$25.5M**.

The overall increase in Average Annual Damages (AAD) is expected to be about **\$1.34M**. This also represents the average annual benefit afforded by the upper Brown Hill Creek works. The estimate is conservative because it was assumed that the works would not offer any additional benefit during the PMF event.



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**9.3.4 Benefit-Cost Analysis**

Revised cost estimates for the works on upper Brown Hill Creek, updated from the 2006 Master Plan to be in 2011 dollars, are provided in **Tables H1** and **H2** of **Appendix H**.

For the purpose of cost estimation, it is assumed that construction of the dams would start within three years and be completed within about six years.

A summary of the estimated costs for the works is as follows:

- **\$22.3M** for the flood control dams in the upper catchment at Sites 2 and 4;
- **\$2.4M** for the channel upgrade between Hampton Street and Cross Road; and,
- **\$30,000** per year for maintenance of the dams.

The estimate of the total costs has been brought back to 2011 dollars by a net present value calculation assuming a 7% real discount rate over 30 years.

Similarly, the expected annual reduction in flood damages afforded by the works (*i.e.* \$1.34M) was also brought back to 2011 dollars by a present value calculation.

Benefit-cost calculations are provided in **Table H3** of **Appendix H**. A summary of the benefit-cost analysis is provided in **Table 7**.

The analysis does not consider intangible flood damages which, if included, could as much as double the Benefit-Cost Ratio (*BCR*) shown in the table.

**Table 7 BENEFIT-COST ANALYSIS FOR UPPER BROWN HILL CREEK WORKS**

SCENARIO	AVERAGE ANNUAL DAMAGES*	RELATIVE AVERAGE ANNUAL BENEFIT	PRESENT VALUE OF BENEFIT^	PRESENT VALUE OF COST**	BENEFIT COST RATIO
2006 Master Plan works <u>excluding</u> the works on upper Brown Hill Creek	\$4,377,000	-	-	-	-
2006 Master Plan works <u>including</u> the works on upper Brown Hill Creek	\$3,033,000	\$1,344,000	\$10,272,000	\$18,625,000	0.6

\* All values are in 2011 \$

\*\* Cost of upper Brown Hill Creek works, including allowance for ongoing maintenance costs for dams

^ Based on a real discount rate of 7% and a design life of 30 years

It is evident that there is only marginal flood mitigation benefit provided by a dam at Site 4, but at significant additional cost. A majority of the benefit can be provided by one dam.





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Also, flood detention in the upper Brown Hill Creek catchment is still warranted as a whole-of-catchment flood mitigation measure in order to mitigate the 36 hour peak storm (*refer Section 7.1.2*).

As discussed in Section 7.2.3 and shown in **Figure 11**, there is still evidence of residual overtopping and flooding from Brown Hill Creek in areas through Unley, leading to significant overland flow across Anzac Highway and into West Torrens.

Therefore, other alternative options for flood mitigation works along upper Brown Hill Creek were investigated, particularly works to reduce overflow from the channel and resultant overland flow through Unley and West Torrens.

In light of the findings of the recent Channel Capacity Assessment (*AWE, 2012*), which has shown that the existing channel capacity of upper Brown Hill Creek generally has been overestimated, it is also considered that there could be further breakouts at areas further upstream.

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## 10. ALTERNATIVE FLOOD MITIGATION OPTIONS FOR UPPER BROWN HILL CREEK

### 10.1 INVESTIGATION APPROACH (2011 DRAFT SMP)

As identified in Section 3.1 (*Scope of 2011 Investigations*), development of the SMP involved review of the recommended flood mitigation options of the 2006 Master Plan for upper Brown Hill Creek and exploration of alternative options. This section outlines the preliminary assessment process used to arrive at the options determined in the 2011 Draft SMP and subsequently presented in the community consultation process.

The approach to the investigation of alternative options was to:

- Revisit previously identified options and re-assess them, where appropriate and where required;
- Identify and investigate additional options based on analysis of flood modelling results and other suggestions from the community;
- Undertake a preliminary assessment of specific options suggested by the Study Steering Committee (*as contained in the Brief and discussed during site inspections and meetings*);
- Obtain information suitable for comparing relative factors of risk, opportunity and cost for the options;
- Using this information qualitatively compare all options and identify the most appropriate ones through a multi-criteria assessment (*similar to the methodology used in the development of the 2006 Master Plan, refer Section 8.5*);
- Short-list options for further technical assessment in developing a recommended mitigation scheme for the project.

### 10.2 FLOOD MITIGATION WORKS (2011 DRAFT SMP)

The following reports were reviewed to identify potential structural options for upper Brown Hill Creek:

- 2005 Stage 1 Technical Report;
- 2008 report by Australian Water Environments titled, '*Brown Hill Creek Flooding; Preliminary Assessment of Alternative Options*', which investigated a variety of flood mitigation scenarios involving alternative works upstream from Cross Road; and,
- 2010 report by Ian Nosworthy (*Mediator for public consultation for the SMA*), which incorporated suggestions for flood management measures by residents and community groups.

The potential alternatives for structural flood mitigation options on upper Brown Hill Creek are shown in **Figures 13 to 18**. Further information on each option is provided in **Appendix I**.



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Options were separated into the following categories:

- Flood detention options for the upper rural portion of the Brown Hill Creek catchment (*refer Figure 13*);
- Minor detention basins along Brown Hill Creek at various locations upstream from Anzac Highway (*refer Figure 14*);
- Channel upgrades to increase flow capacity (*refer Figure 15*);
- Bridge / culvert upgrades at road and rail crossings and removal of flow “choke-points” (*refer Figure 16*);
- Overland flow interceptor culverts to capture any flow across the floodplain and feed back into the channel (*refer Figure 17*);
- Flow diversion culverts to divert runoff from one catchment to another or re-direct channelled flows around choke-points (*refer Figure 18*);
- High-flow bypass culverts to carry a portion of the in-channel flow, thereby reducing the load on the existing channel (*refer Figure 18*);
- Other miscellaneous options:
  - ⇒ Revegetation of cleared rural areas of the upper Brown Hill Creek catchment
  - ⇒ Use of rainwater tanks
  - ⇒ Water sensitive urban design methods
  - ⇒ Creation of creek meanders in reserves
  - ⇒ Clear channel of trees and vegetation (*channel maintenance*)
  - ⇒ Raising house floor levels

### **10.3 NON-STRUCTURAL FLOOD MITIGATION MEASURES**

The following non-structural options were considered, which could also apply across the wider Brown Hill Keswick Creek catchment:

- Purchase of properties with high flood risk;
- Channel maintenance and clearing;
- Flood awareness and preparedness;
- Flood warning and evacuation procedures; and
- Building controls and planning policy.



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**10.4 PRELIMINARY ASSESSMENT OF ALTERNATIVE FLOOD MITIGATION OPTIONS**

The alternative options identified above were subjected to a qualitative filtering process similar to the method adopted for preparation of the 2006 Master Plan (*refer* Section 8.5).

Each option was assessed in terms of a high, moderate or low rating for defined assessment criteria, including multi-purpose benefits (*refer* **Table 8**). A nil rating was applied where the criteria were not applicable to a particular option or where the rating would be of little significance. The assessment criteria used were as follows:

- Flooding reduction across the catchment (*this is considered to be of primary importance*);
- Technical feasibility (*whether the option can be implemented successfully from an engineering perspective*);
- Likely community acceptance;
- Water quality and reuse potential;
- Protection of environmental features (*also an indication of any potential environmental impacts*);
- Provision of recreational amenity; and
- Opportunity to improve biodiversity.

The approximate relative cost of implementation for each option was also considered in the assessment.

A summary of the results of the multi-criteria assessment is provided in **Appendix I**.

In terms of the assessment criteria ratings, red or green shading is used in **Appendix I** to highlight the primary reason(s) why a particular option was chosen for further investigation (*green*), or why it was not selected (*red*).

Hydrologic modelling was undertaken to assess the hydrologic benefits for detention options in the rural part of the catchment (*i.e. Options A1 to A8*). The results of the modelling are documented in **Appendix I** as reductions in peak 100 year ARI flow at the Scotch College streamflow gauging weir.



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**Table 8 Multi-Criteria Assessment (adapted from 2005 Stage 1 Technical Report and 2006 Master Plan)**

CRITERIA	DESCRIPTION OF RATINGS
Flooding reduction across the catchment	<p>The degree to which the option assists in reducing flooding on a catchment scale is rated by this category. This allows the inclusion of options in reaches that are not subject to flooding themselves but provide the opportunity to reduce peak flows nearer their source or simply to protect downstream areas. A qualitative high, moderate, low rating is given according to the expected reduction in flooded areas by reference to the published flood maps and flood hydrology across the catchment.</p> <ul style="list-style-type: none"> <li>▪ High or Moderate: applied to options that are expected to offer catchment-wide benefits in reducing the extent/depth of flooding.</li> <li>▪ Low: upgrading local constrictions generally receive a Low rating because these only address site specific issues and generally result in an increase in flows downstream. When used in combination with other works to mitigate flooding downstream the rating may increase to Moderate.</li> </ul>
Technical feasibility	<ul style="list-style-type: none"> <li>▪ High rating: feasible</li> <li>▪ Moderate rating: feasibility needs to be verified.</li> <li>▪ Low rating: unlikely to be feasible, either on technical grounds or political reasons (<i>significant property acquisitions etc</i>)</li> </ul>
Likely community acceptance	<ul style="list-style-type: none"> <li>▪ High: Options that are likely to have no or only short-term impacts (<i>e.g. the inconvenience of traffic disruptions whilst a bridge crossing is upgraded</i>). Most people do not even realise that the Glen Osmond flood detention dam exists and hence are unlikely to be concerned if it were modified (<i>attracted a high rating for the 2006 Master Plan</i>).</li> <li>▪ Moderate: Options that could be expected to create differing views across the community with lobbying expected for both the for and against cases. For example, the creation of a wetland and detention system in the parklands around Adelaide is likely to attract a wide range of views both for and against.</li> <li>▪ Low: Options that could be expected to result in widespread or significant community opposition.</li> </ul>



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CRITERIA	DESCRIPTION OF RATINGS
Water quality and reuse	<p>It is assumed that these two go together in that, for reuse to take place, reed bed water treatment is required. An extensive reed bed system would be associated with the South Park Lands detention system and therefore, this was given a high rating as part of the development of the 2006 Master Plan. Rehabilitation of Glen Osmond Creek through Ridge Reserve would reduce erosion but not provide an extensive filter system.</p> <ul style="list-style-type: none"> <li>▪ High: options that allow flows to be slowed and filtered through natural reed bed treatment systems.</li> <li>▪ Moderate: options that reduce the velocity of flows or reduce stream bed and bank erosion, but do not have extensive reed bed systems.</li> <li>▪ Low: minimal to no water quality and reuse benefit.</li> </ul>
Protection of environmental features	<ul style="list-style-type: none"> <li>▪ High: minimal environmental impacts.</li> <li>▪ Moderate: moderate environmental impacts.</li> <li>▪ Low: potential for significant environmental impacts.</li> </ul>
Improve recreational amenity	<p>A qualitative rating is given on the basis of the opportunity to incorporate open space and recreation opportunities with the strategy.</p> <ul style="list-style-type: none"> <li>▪ High: the option must provide an improvement in public access or use on a catchment scale. The South Park Lands detention and wetland system was given a high rating because it creates a new recreational focal point.</li> <li>▪ Moderate: options that result in localised improvements. Riparian rehabilitation works associated with a proposed detention system in Ridge Park received a moderate rating because this would result in a minor improvement and localised benefits.</li> <li>▪ Low: typically any bridge, culvert, concrete lining or works of a similar nature. Similarly, many of the areas considered for stormwater detention are existing open space areas and hence may restrict public access or opportunities.</li> </ul>
Opportunity to improve biodiversity	<ul style="list-style-type: none"> <li>▪ High: the option would provide an improvement in biodiversity on a sub catchment scale.</li> <li>▪ Moderate: the option would improve biodiversity on a localised scale.</li> <li>▪ Low: the option is not expected to improve biodiversity.</li> </ul>



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Based on the multi-criteria assessment the following alternative structural options were short-listed for further investigation and hydraulic modelling as part of the 2011 Draft SMP investigations:

- Flood control dam at Site 1;
- Flood control dam at Site 2;
- Multiple weirs to provide flood detention along the channel of Brown Hill Creek extending upstream from the caravan park (*Brownhill Creek Recreation Park*);
- Overland flow interceptor culvert at the Glenelg Tramway;
- Various channel upgrades and high-flow bypass culvert configurations to contain flow and prevent overtopping along sections of the creek immediately upstream from Anzac Highway;
- Overland flow interceptor to feed into the proposed Keswick Creek diversion culverts at Leader Street, Forestville; and,
- Complete upgrade of the channel between Anzac Highway and Muggs Hill Road in Mitcham, where required, to contain flow and prevent overtopping. This option was only considered because it offers a technical alternative to other measures. However, it is unlikely to gain community acceptance because of significant landowner issues over a large number of properties affected.

Further details of these options and their detailed assessment are provided in Section 11.

This investigation confirmed that, as reported by the 2006 Master Plan and VDM Consulting (2010), minor detention basins within parks such as Soldiers Memorial Gardens and Orphanage Park would only offer minimal storage capacity compared with the volume of flow that will spill onto the floodplain as a result of runoff from the upper rural portion of the catchment. As such, their benefit would be very minimal, either individually or in combination with other viable options.

Non-structural stormwater management options chosen for further consideration were:

- Clarifying responsibilities for ensuring appropriate channel maintenance and clearing activities;
- Increasing flood awareness and preparedness through continuation and improvement of the FloodSafe Program;
- Implementation of the new Emergency Response Plan being prepared by SES; and,
- Building controls and planning policy to reduce / avoid flood damages and management stormwater runoff.

## **10.5 FURTHER INVESTIGATIONS**

As outlined in Section 3.3 (*2012 SMP Strategy*) a Part B Works process will be carried out with the objective of determining suitable works on upper Brown Hill Creek which are cost-effective, preferably do not include a flood control dam in Brown Hill Creek Recreation Park and are acceptable to the community. It will be informed by the Supplementary Investigations (*refer Section 3.2*) and any further work which may be undertaken.





## 11. FLOOD MITIGATION SCENARIOS FOR UPPER BROWN HILL CREEK

Nine flood mitigation scenarios were investigated for upper Brown Hill Creek during preparation of the 2011 Draft SMP. As a result of community response regarding the flood control dam at Brown Hill Creek Recreation Park, additional scenarios have since been considered, including the feasibility of an extended high-flow bypass culvert system as an alternative to the dam.

### 11.1 ASSESSMENT METHOD – 2011 DRAFT SMP

Nine alternative flood mitigation scenarios were developed for upper Brown Hill Creek based on the structural options short-listed in **Appendix I**. The scenarios comprise either a standalone option or a combination of options.

For the proposed upper catchment detention options, the impact of each scenario in reducing peak 100 year ARI flow was assessed using hydrologic modelling, for both the 90 minute and 36 hour storms. Hydraulic modelling was undertaken to determine the impact of the mitigation scenarios on 100 year ARI floodplain inundation.

In the case of both the hydrologic and hydraulic modelling all other mitigation works that are proposed across the wider catchment were retained in the models (*i.e. all other works included in the 2006 Master Plan*). In this way, the options for upper Brown Hill Creek were not assessed in isolation, but rather the assessment also considered the potential for an option to interact with other mitigation works across the whole catchment to provide an overall reduction in flooding catchment-wide.

Due to the significant modelling and results processing time involved, it was considered appropriate at this stage of investigation to assess the mitigation scenarios in terms of their impact only on the 100 year ARI event.

Hydraulic modelling results for each scenario were converted to floodplain maps and used to determine the reduction in 100 year ARI flood damages compared to Base Case conditions. The savings in damages were converted to an annual average benefit using a simplified version of the typical Average Annual Damages approach (*i.e. without the full range of ARI events*). The benefit was then converted to a present value by applying a discount rate of 7% over an economic appraisal period of 30 years.

The present value of the benefit was compared with the estimated cost of works to determine an indicative benefit-cost ratio. The estimated costs of works were determined, where appropriate, by escalating 2006 Master Plan estimates, as outlined in Section 9.2. As for the analysis in Section 9, the dollar values presented in Section 11.2 reflect 2011 dollars, both in terms of the cost estimates for the works and the calculated flood damages reduction that they are expected to provide. The values have not been updated during preparation of this 2012 SMP report.

Although not a comprehensive assessment of benefit-cost in the absence of modelling the full range of ARI events, the approach used was considered suitable for a relative comparison between the mitigation scenarios.



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Each mitigation scenario was also considered in terms of potential environmental, heritage and social impacts, and any land acquisition requirements.

The progression of investigations was to firstly consider alternative options for upper catchment detention, and then to assess other measures further down the catchment.

## **11.2 FLOOD MITIGATION SCENARIOS – 2011 DRAFT SMP**

Alternative flood mitigation works were considered by themselves or in combination with others to develop nine alternative scenarios:

1. Flood control dam in the Brownhill Creek Recreation Park (*Site 1*)
2. Flood control dam at Site 2 (*rural part of the upper BHC catchment*)
3. Flood control dam at Site 2 + weir system along Brown Hill Creek
4. Flood control dam at Site 2 + overland flow interceptor at the Glenelg Tramway (*including downstream channel upgrade*)
5. Flood control dam at Site 2 + supplementary works to prevent channel overtopping
6. Overland flow interceptor at the Glenelg Tramway (*including downstream channel upgrade*)
7. Overland flow interceptor at the Keswick Creek diversion (*at Leader Street, proposed as part of the 2006 Master Plan*)
8. Smaller flood control dam at Site 1 + supplementary works to prevent channel overtopping
9. Complete channel upgrade between Anzac Highway and Muggs Hill Road in Mitcham

Analysis of the above scenarios is contained in **Appendix J**, with the exception of Scenario 8, which is discussed below in Section 11.2.2.

### **11.2.1 Analysis of 90 Minute Critical Storm**

Investigations for Scenario 7 (*interceptor at Leader Street*) involved assessment of how such a system would function in both the 36 hour and 90 minute critical storm durations for the catchment.

In separating the floodplain mapping into the component 36 hour and 90 minute storms it is evident that the 90 minute storm (*in isolation*) will cause overtopping of the Brown Hill Creek channel between Forestville Reserve and Anzac Highway, and further upstream near Regent Street, Millswood.

This indicates that no amount of upper catchment detention would help in completely eliminating the overland flow through parts of Unley and across the highway into West Torrens as shown in the 100 year ARI floodplain map.

With interception of the 90 minute overland flows into the diversion culverts not being a feasible option (*as outlined for Scenario 7 in Appendix J*), flood mitigation works would need to rely on accommodating the peak 90 minute flow within the channel or an alternative flowpath.



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It follows that if works are undertaken to accommodate the peak 90 minute flow where it exceeds the existing channel capacity, then the requirements for detention need only reduce the peak 36 hour flow to the equivalent peak 90 minute flow in order to prevent breakouts during the 36 hour storm.

With this design approach in mind, mitigation Scenario 8 was developed and assessed, as outlined in the following.

**11.2.2 Smaller Dam at Site 1 (12m spillway height) + Supplementary Works**

In light of the analysis of the 90 minute storm, a smaller version of the dam at Site 1 was proposed in order to provide sufficient detention in the upper catchment to reduce the peak 36 hour storm flow to the level of the peak 90 minute flow.

For such a mitigation scenario the dam would need to be complemented by additional supplementary works at areas upstream from Anzac Highway to ensure that the peak 90 minute flow is contained within the channel.

The key features for this scenario are:

Flood control dam at Site 1 (refer Figures 19 and 20)

- Height of dam to spillway level for a dam at Site 1 is approximately 12 metres, which represents the peak level of storage during the 100 year ARI 36 hour storm. The length across the crest (*from side to side*) is approximate 100 metres.
- Storage volume at the spillway level is approximately 110 ML.
- Storage of runoff would be temporary (*up to about 24 hours*) and the dam would otherwise be empty under normal seasonal weather conditions.
- The dam orifice diameter is 1450 mm to control the rate of discharge during events up to and including the 100 year ARI storm.
- The form of the dam and spillway is subject to further detailed investigations.
- The existing Brown Hill Creek Road would have to be relocated a small distance up the side of the hill to above the 100 year ARI maximum storage level (refer Figure 20).
- None of the four houses in the vicinity are affected and any impact on private property (*for road relocation*) is relatively minor.
- Department of Environment, Water and Natural Resources (*DEWNR*) is custodian of the Recreation Park. The Brownhill Creek Recreation Park Management Plan contemplates that a flood control dam may be located within the Park.
- Relevant Commonwealth and State Government approvals would be required for any action that may have significant ecological or heritage impacts. Preliminary advice from DEWNR indicates that there are no threatened vegetation communities or high value habitat at risk in the immediate area.



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- Estimated cost (*in 2011\$*) was **\$10.3M** (*refer Appendix J16*).

High-Flow Bypass Culvert – Malcolm Street to Glenelg Tramway

- Installation of a 1710 metre long 1.8m (W) x 1.5m (H) box culvert to act as a high-flow bypass between Malcolm Street and the Glenelg Tramway (*refer Figure 21*).
- The culvert would carry a flow of up to 12 m<sup>3</sup>/s to reduce the load on the channel between these points, thereby reducing the potential for breakouts in this section.
- The route of the bypass culvert would be such that the works will be largely restricted to roadway reserves so that private property is avoided.
- Estimated cost (*in 2011\$*) was **\$11.3M** (*refer Appendix J17*). Note that this cost estimate has not been updated to reflect latest cost estimates as part of work to further investigate the feasibility of the culvert.

Channel upgrade works – Leah Street to Anzac Highway

- Upgrade of the channel capacity involves widening the channel by 3 metres and removal of the existing low-flow channel tier.
- A majority of this work would be undertaken within the creek section adjacent to Wilberforce Walk, with potential for minor impact on privately owned land immediately upstream from Anzac Highway.
- The creek adjacent to Wilberforce Walk is in private ownership and acquisition of this section of the creek, together with the section immediately upstream from Anzac Highway would be required.
- The upgrade works would be configured such that widening of the channel would encroach into council land, rather than increase the current footprint of the channel over private land.
- The channel upgrade would also involve works to increase the capacity of bridge culverts at Leah Street and Third Avenue (*subject to verification*), First and Second Avenues, Anzac Highway and Charles Street. The bridge at Ethel/Nichols Street is planned to be upgraded by Unley Council in the near future and presumably it will be designed to accommodate the peak 100 year ARI flow.
- Estimated cost (*in 2011\$*) was **\$10.1M** (*refer Appendix J6*).

Hampton Street to Cross Road channel upgrade

- The channel upgrade would be retained as part of this scenario. However, an additional 1 metre of channel width is required compared to the upgrade retained for detention scenarios. The estimated cost (*in 2011\$*) was approximately **\$2.7M** (*refer Appendix J18*).



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**Impact on Peak Flows**

A summary of the impact that the dam would have in reducing flows for the 100 year ARI storm is provided in **Table 9**. It was an iterative process to develop a design for the dam that meets the requirement that peak rural flows are reduced to the peak urban flows.

The corresponding 90 minute peak flows have been included in **Table 9** to show how the primary design requirement has been met. It is noted that for areas upstream of Belair Road the dam will not achieve a full reduction in peak flows to match the 90 minute storm. However, there is still significant benefit for the upstream areas in that the peak 36 hour flow is reduced by between 6.6 and 8.5 m<sup>3</sup>/s.

As expected, the dam will not have any impact on the peak flows during the 90 minute storm (refer **Table 9**).

**TABLE 9 FLOW REDUCTION AFFORDED BY SMALLER DAM AT SITE 1**

LOCATION	PEAK FLOW (m <sup>3</sup> /s)			
	BASE CASE (no dams)		DAM AT SITE 1 (12 m height to spillway)	
	36 Hour Storm	90 Minute Storm	36 Hour Storm	90 Minute Storm
Scotch College	26.1	3.7	19.5	3.7
Belair Road	30.2	18.7	21.7	18.7
Cross Road	36.4	27.8	27.7	27.8
Goodwood Road	37.1	29.4	28.2	29.4
Anzac Highway	38.9	33.9	29.7	33.9

**Reduction in 100 Year ARI Flood Damages**

100 year ARI floodplain mapping was produced for the mitigation scenario using the hydraulic flood model. Downstream from Malcolm Street the reduction in flood extent is significant (refer **Figure 21**), with minimal to no overtopping through Forestville and therefore, no overland flow across Anzac Highway into West Torrens.

For areas upstream of Malcolm Street the effect of the dam at Site 1 provides a worthwhile reduction in the Base Case flood mapping, with only very minor breakout remaining at George Street (which is proposed to be upgraded anyway) and noticeably less flow width in areas around Mitcham shopping centre and Scotch College.



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It is envisaged that relatively minor works to clear vegetation and remove “choke” points could be undertaken within the stretch between Mitcham and Paisley Avenue to further reduce the residual overbank flow. An allowance of **\$0.8M** was made to cover this work.

The floodplain mapping was used to estimate that this mitigation scenario would reduce 100 year ARI damages to approximately **\$16.9M**, which corresponds to a damages saving over the Base Case of approximately **\$161M** in 2011 \$.

**11.2.3 Comparison of 2011 Draft SMP Mitigation Scenarios**

An indicative benefit-cost ratio was determined for each of the scenarios based on the damage reduction afforded for the 100 year ARI event and estimated cost of the works.

The costs and benefits apply to the whole Brown Hill and Keswick Creeks catchment.

The estimated cost of works outside of the upper Brown Hill Creek area (*i.e. downstream from the highway and along Keswick Creek*) was updated from the 2006 Master Plan to reflect 2011 dollars and subsequent changes to certain mitigation works (*e.g. the South Park Lands detention system and the Keswick Creek diversion culverts*). The estimate was approximately **\$98.0M** in 2011 dollars.

Cost estimates for the alternative mitigation scenarios for upper Brown Hill Creek were added to the amount of \$98M to arrive at the ‘Total Scheme Cost’ shown in **Table 10**. The ‘100 Year ARI Damages’ were also applied to the whole of the catchment, thereby resulting in an indicative benefit-cost ratio for the total catchment-wide mitigation scheme.

The Benefit-Cost Ratios (*BCR*) indicate that most scenarios will fall within the *BCR* range of 0.7 to 0.8, with the exception of the interceptor culvert at the Keswick Creek diversion culverts. However, this option is unlikely to be feasible based on hydrologic analyses.

The tramway interceptor and a single dam at Site 1 also scored marginally higher than other options. However the tramway interceptor has disparity between flood protection offered upstream compared with downstream of the interceptor. A single dam at Site 1 with spillway height of 15 metres is effective in dealing with the 36 hour peak storm, but will not completely address downstream flooding and residual overland flow across Anzac Highway into West Torrens.

The small variation between the *BCRs* for each scenario is a reflection that if the cost of an option is relatively low, it is typically balanced by a reduced flood damages benefit. Conversely, the more costly scenarios typically have an increased level of damages reduction.





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**Table 10 COMPARISON OF ALTERNATIVE MITIGATION SCENARIOS**

#	FLOOD MITIGATION SCENARIO FOR UPPER BROWN HILL CREEK	TOTAL SCHEME COST* (\$M)	100 YEAR ARI DAMAGES* (\$M)	INDICATIVE BENEFIT-COST RATIO**	KEY NOTES
-	BASE CASE ( <i>Existing conditions</i> )	-	177.6	-	
-	2006 MASTER PLAN ( <i>Dams 2 and 4</i> )	123	41.6	0.74	Residual flooding upstream and downstream from Anzac Hwy
1	DAM AT SITE 1 ( <i>15 m spillway height</i> )	114	28.9	0.80	Residual flooding upstream and downstream from Anzac Hwy
2	DAM AT SITE 2 ( <i>20 m spillway height</i> )	115	41.6	0.73	Residual flooding upstream and downstream from Anzac Hwy
3	DAM AT SITE 2 + WEIR SYSTEM	124	28.9	0.74	Residual flooding upstream and downstream from Anzac Hwy
4	DAM AT SITE 2 + TRAMWAY INTERCEPTOR + CHANNEL WORKS	129	18.9	0.76	Reduced benefit upstream of tramway
5	DAM AT SITE 2 + SUPPLEMENTARY WORKS	133	16.7	0.75	Some impact on private property for channel upgrades
6	TRAMWAY INTERCEPTOR + CHANNEL WORKS	117	29.5	0.78	No benefit upstream of tramway
7	INTERCEPTOR AT DIVERSION CULVERTS	108 <sup>^</sup>	33.4	0.82 <sup>^</sup>	Insufficient spare capacity to intercept overland flows, no flood protection for upstream areas
8	SMALLER DAM 1 ( <i>12 m spillway height</i> ) + ALTERNATIVE SUPPLEMENTARY WORKS	133	16.9	0.75	Significant reduction in damages, limited impact on private property
9	ENTIRE CHANNEL UPGRADE ( <i>Anzac Highway to Muggs Hill Rd</i> )	145	15.7	0.69	Significant impact on private property ( <i>and dwellings</i> ), low community acceptance

\* Cost estimates and damages in 2011 \$.

\*\* Benefit-Cost Ratio indicative only; derived from 100 year ARI mapping only. BCR applies to total catchment-wide scheme.

<sup>^</sup> Cost of works does not allow for enlargement of diversion culvert or services relocation. This may reduce Benefit-Cost Ratio.





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#### 11.2.4 Conclusion

Based on the information in **Table 10** and other considerations, including social, environmental, heritage and engineering feasibility factors, the selected scenario for upper Brown Hill Creek was the smaller (*12 metre*) dam at Site 1 plus associated supplementary works (*Scenario 8*). Further information on these works is provided in **Appendix K**, as presented in the 2011 Draft SMP.

This mitigation scenario was selected for the following reasons:

- It has the most favourable flood mitigation potential of all the viable scenarios. Upgrading the entire channel offers marginally better flood mitigation, but is impracticable due to private property impacts and would have significantly greater cost.
- The proposed high-flow bypass would provide more effective flood mitigation in the Unley council area and would be more practicable to implement, compared with other supplementary works options.
- Other viable scenarios having comparable flood mitigation potential and cost involve a flood control dam at Site 2 which would be a significantly higher dam (*20 metres compared with 12 metres*) with a larger footprint and would involve increased impact on private property than the selected scenario.

#### 11.3 EXTENDED BYPASS CULVERT FEASIBILITY ASSESSMENT

In September 2011 WorleyParsons was engaged by the City of Mitcham to investigate the potential for alternative flood mitigation options that would eliminate the need for, or reduce the size of, the flood mitigation dam in the upper catchment. The alternative options are documented in the report titled '*Preliminary Assessment – Enhancement of Flood Mitigation Options*' (WorleyParsons, November 2011).

Option 3 (as *labelled in the report*) was configured such that the construction of the flood mitigation dam in the upper catchment could be avoided if the following set of alternative downstream works were feasible:

- Construction of a 1,670 metre bypass culvert with a capacity of 20 m<sup>3</sup>/s between Malcolm Street and Forestville Reserve, following a similar alignment to the originally proposed bypass culvert in the 2011 Draft SMP; and
- Construction of a 1,480 metre bypass culvert with a capacity of 9 m<sup>3</sup>/s between Hampton Street and Malcolm Street that follows an alignment to the east of Brown Hill Creek along Jervois Street, Grove Street, Northgate Street and Wood Street.

The original bypass culvert proposed as part of the 2011 Draft SMP has a design capacity of 12 m<sup>3</sup>/s, which accounted for the flow attenuation provided by the proposed detention dam in the upper catchment. With the dam removed from the scheme, the peak 100 year ARI flow along Brown



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Hill Creek in this area is expected to increase by 8 m<sup>3</sup>/s. Accordingly, the design flow capacity of the Option 3 culvert between Malcolm Street and Forestville Reserve would be 20 m<sup>3</sup>/s.

The originally proposed Hampton Street to Cross Road channel upgrade would need to be retained as part of this option. To avoid the channel upgrade at this critical section of the creek the capacity of the culvert between Hampton Street and Malcolm Street would need to be increased significantly beyond 9 m<sup>3</sup>/s.

In November 2011 WorleyParsons was engaged by the BHKC Project to undertake a detailed feasibility assessment for the alternative culvert works to investigate the following:

- The ability to fit the culverts along the proposed roadways between existing services, including sewer lines, water pipes and telecommunications, gas and underground electricity lines.
- The capacity to relocate any of the above services so that the culverts can be accommodated within the roadways and demonstrate how this could be achieved.
- The costs associated with the alternative culvert works, including any required relocation or adjustment of services.

During the investigation it was requested that WorleyParsons undertake similar investigations into the feasibility of an alternative route for the upstream section of culvert between Hampton Street and Malcolm Street. This route would bypass flow to the west of the creek via Hampton Street, Hilda Terrace, Wurilba Avenue and across Cross Road into the railway reserve down to Malcolm Street. This option is referred to as Option 3A.

The findings of the feasibility assessment are documented in the WorleyParsons' report titled, *Bypass Culvert Feasibility Assessment (April 2012)*.

The proposed routes of the Option 3 and 3A culverts are shown in **Figures 22** and **23**, respectively.

The works will involve the following sizes of box culvert (*internal dimensions*):

Option 3 Culvert

From Malcolm Street to Forestville Reserve (*upstream to downstream*):

- 2.4m (W) x 1.8m (H) (607 metres)
- 2.7m (W) x 1.8m (H) (190 metres)
- 3.3m (W) x 1.8m (H) (366 metres)
- 3.6m (W) x 1.8m (H) (548 metres)

From Hampton Street to Malcolm Street (*upstream to downstream*):

- 1.5m (W) x 1.5m (H) (816 metres)



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- 2.1m (W) x 1.5m (H) (384 metres)
- 1.8m (W) x 1.8m (H) (291 metres)

Option 3A

From Malcolm Street to Forestville Reserve:

- 1.8m (W) x 1.8m (H) (408 metres)
- 2.4m (W) x 1.8m (H) (199 metres)
- 2.7m (W) x 1.8m (H) (190 metres)
- 3.3m (W) x 1.8m (H) (366 metres)
- 3.6m (W) x 1.8m (H) (548 metres)

From Hampton Street to Malcolm Street:

- 1.5m (W) x 1.5m (H) (1,342 metres)
- 1.8m (W) x 1.5m (H) (140 metres)
- 1.8m (W) x 1.8m (H) (15 metres)

Option 3A culvert would feed into the proposed Malcolm Street culvert near the railway. The capacity of the downstream culvert would be 20 m<sup>3</sup>/s, as discussed for Option 3. However, the section of the culvert between Brown Hill Creek and the junction would only need to have a capacity of about 11 m<sup>3</sup>/s (*i.e. because it will combine with flow of 9 m<sup>3</sup>/s from the Option 3A culvert*). This means a smaller section of culvert can be used along Malcolm Street.

The investigations outlined above and the preliminary design drawings contained in the report demonstrate that the proposed Option 3 and Option 3A bypass culvert systems are feasible from a hydraulic design perspective. Other key conclusions are as follows:

- DPTI advised that use of Cross Road at the railway line for the installation of a culvert could have a potential impact on any future grade separation of the Cross Road level crossing (*it is understood from later discussions that DPTI will give this matter further consideration*). The Department has indicated agreement in principle to a culvert within the rail corridor further downstream from Cross Road.
- In both the case of SA Water and Telstra (*and likely the other service providers*) further development of the design would involve these entities undertaking a more detailed assessment of the scope and cost of the required services relocation works.
- Each option may involve the removal of select trees along the route of the culvert; however, for the most part the existing trees along the side of the road or railway corridor are not expected to be significantly impacted.
- The larger section of culvert between Malcolm Street and Forestville Reserve (*common to both options*) is at the limit of the maximum width that can be employed, particularly in light of the additional rider sewers that may be required.



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- Accordingly, there will need to be close consultation with SA Water to make sure that sufficient horizontal clearances are provided between water mains and sewers.
- Sustained local community disruption can be expected as the culvert is installed. This will especially be the case where sewers and/or water mains are required to be altered prior to the culvert being installed.

Typical design sections of culvert, together with construction dimensions, are shown in **Figures 24 to 26** for the two options.

Estimated construction costs of the above works are summarised at Section 13.1.

For the culvert between Malcolm Street and Forestville Reserve a comparison with the original bypass culvert (*12 m<sup>3</sup>/s capacity*) proposed in the 2011 Draft SMP is provided in **Table 11**. The cost estimate of \$14.1M is increased from the original estimate of \$11.3M in the 2011 Draft SMP due to an increased allowance for services relocation resulting from the feasibility investigations, and also an increased allowance for managing the major crossings at the Glenelg Tramway, the railway and Goodwood Road.

**Table 11 COMPARISON OF BYPASS CULVERT SYSTEMS**

DESIGN FACTOR	ORIGINAL CULVERT (2011 DRAFT SMP)	OPTION 3 CULVERT
Approximate design capacity (m <sup>3</sup> /s), based on 100 year ARI flow	12	20
Dimensions of largest section of box culvert (W x H internal)	2.4m x 1.8m	3.6m x 1.8m
Maximum width of trenching required (metres)	3.4	4.6
Dimensions of smallest section of box culvert (W x H internal)	1.8m x 1.8m	2.4m x 1.8m
Length of required sewer relocation / rider sewer (metres)	1,430	1,870
Length of required water main relocation (metres)	710	880
Cost	\$14.1M *	\$19.0M

**11.4 UPDATED COST ESTIMATES FOR UPPER BROWN HILL CREEK WORKS**

Due to price escalation between 2011 and 2012, and increase in the scope of particular works components, revised cost estimates for works on upper Brown Hill Creek are presented in **Table 12**.



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**TABLE 12 UPDATE OF COSTS FOR UPPER BROWN HILL CREEK WORKS**

WORKS COMPONENT	COST (2011 \$M)	COST (2012 \$M)
Flood Control Dam in Brown Hill Creek Recreation Reserve	10.3	10.8
Minor Channel Works in Mitcham	0.8	0.8
Hampton St to Cross Rd Channel Upgrade	2.7	2.8
Malcolm Street to Forestville Reserve Bypass Culvert	11.3	14.1*
Leah Street to Anzac Hwy Channel Upgrade	10.1	14.9*

\* Cost estimate updated in light of revised scope / modification of works (i.e. not just due to escalation).

**11.5 FURTHER INVESTIGATIONS**

Further investigation of flood mitigation works for upper Brown Hill Creek will be carried out under the Part B Works process which is discussed later in this report at Section 13.3.

**11.6 CHANNEL UPGRADE BETWEEN LEAH STREET AND ANZAC HIGHWAY**

If a 'no dam' option is determined for upper Brown Hill Creek the channel upgrade works between Leah Street and Anzac Highway would need to be extended to include the length of the creek through Forestville Reserve.

These works can be implemented independently of the final flood mitigation works determined for upper Brown Hill Creek and therefore can be implemented immediately as part of the Part A Works (refer next section).



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## 12. PART A FLOOD MITIGATION WORKS

Under the catchment councils' strategy for the 2012 SMP (*refer Section 3.3*), the proposed structural flood mitigation works have been separated into (*refer Figure 27*):

- Part A works – design and construction to commence immediately; and
- Part B works – upper Brown Hill Creek works subject to further investigation and determination.

The proposed flood mitigation works components comprising the Part A Works are:

- 2006 Master Plan works for which further work or concept designs have been carried out:
  - ⇒ Detention system for South Park Lands / Glenside Campus, which has involved deletion of the culvert upgrade beneath Fullarton Road / Greenhill Road intersection.
  - ⇒ Keswick to Brown Hill Creek diversion culverts, with revised configuration.
  - ⇒ Works to modify the Mount Osmond interchange dam outlet, which were completed in 2008.
- Works taken directly from the 2006 Master Plan, for which no additional work has been undertaken to review or revisit the concept proposal, but cost estimates have been updated to reflect 2012 dollar values:
  - ⇒ Upgrade of Brown Hill Creek channel downstream from Anzac Highway to the confluence with Keswick Creek.
  - ⇒ Flood detention system for Ridge Park Reserve (*Glen Osmond Creek*).
- Bypass culvert for Glen Osmond Creek at Fisher Street in Fullarton. This measure is proposed in lieu of the original Fisher Street culvert upgrade that was included in the 2006 Master Plan.

The Part A Works also include the channel upgrade of the Brown Hill Creek channel between Forestville Reserve and Anzac Highway which was part of mitigation Scenario 8 for upper Brown Hill Creek in the 2011 Draft SMP.

Each of these works components are described in the following sections.

### 12.1 DETENTION BASINS IN THE SOUTH PARK LANDS / GLENSIDE CAMPUS REDEVELOPMENT

Parklands Creek flows east to west through a number of parks within the South Park Lands. The 2006 Master Plan proposed six temporary storage basins in the South Park Lands between Fullarton Road and Peacock Road. Those proposals were constrained by the use of Victoria Park for horse racing.



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Since then, horse racing has ceased at Victoria Park and the City of Adelaide has produced a master plan to redevelop Victoria Park which includes the establishment of wetlands on the northern side of Parklands Creek in the southern precinct of Victoria Park. This has allowed for the original proposal of six detention basins to be reassessed.

Furthermore, since 2006, the State Government has commenced redevelopment of the Glenside Campus of SA Department of Health. As part of the redevelopment a significant area has been set aside for community open space, which is available to extend the current role of the north western part of the site for stormwater management and wetlands. SA Health has indicated that the design could be integrated with requirements of the BHKC Project.

In 2009 Tonkin Consulting was engaged to undertake investigations and design development for a series of flood mitigation storages, wetlands and MAR potential in the South Park Lands. In their report '*Stormwater Management in the South Park Lands; Stage 1 – Feasibility Study*' Tonkin Consulting indicates that required flood mitigation measures can be achieved in the South Park Lands by the establishment of temporary flood detention basins in three areas, being:

- Enlargement of the existing basin in Glenside Campus, from a storage capacity of 18 ML to 37 ML, to limit the flow into South Park Lands for the 100 year ARI storm to within the capacity of the existing culvert under the Fullarton and Greenhill Roads intersection.
- Creation of storage of up to 115 ML incorporating the proposed wetlands that are to be constructed as part of the Victoria Park Master Plan.
- Construction of a levee to create storage of up to 47 ML in the southern and western part of Park 20, which is located between Peacock and Unley Roads.

In 2009/10 consultation on a feasibility design was carried out with relevant authorities and community and park lands user groups and outcomes were used to inform the subsequent stage of concept design.

Tonkin Consulting has produced a concept design, for which key elements were outlined in information produced for stakeholders and the community in March 2011. Environmental and cultural heritage studies have been carried out. Further investigation is now required due to the presence of Checkered Copper Butterfly Habitat and this will require additional review and remodelling to assess the impact and the works associated to retain the existing habitat.

The temporary flood storage basins in the Glenside site, at the wetlands in Victoria Park and in Park 20 are designed to reduce the flow of stormwater in Parklands Creek to 8 m<sup>3</sup>/s downstream from Park 20, during events up to a 100 year ARI storm.

Concept design sketches for the detention system are included in **Appendix L**.

Key features of the concept design are:

- Reduction in flood risk downstream from Greenhill Road;
- Utilisation of the existing gross pollutant trap at the Glenside site and construction of an enlarged sedimentation basin to improve the quality of water entering the South Park Lands;





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- Diversion of stormwater flow out of Parklands Creek and through a series of ephemeral wetlands in the southern portion of Victoria Park;
- The wetlands will slow down water flow and provide further treatment prior to returning water back into Parklands Creek;
- The wetlands have been designed to operate within a range of water levels under normal conditions to ensure environmental integrity (*re-seeding of ephemeral plants, reduced potential for nutrient release in the sediment substratum and minimization of nuisance insects*);
- Improvement in the biodiversity of each site through the inclusion of native vegetation and habitat opportunities;
- Provision of an alternative flow path in Park 20 to reduce erosion of Parklands Creek and control the release of water under Greenhill Road;
- Enhanced amenity and recreational opportunities for the southern part of Victoria Park;
- Potential for harvesting of stormwater through a MAR facility, should aquifer capacity be suitable and prove to be of value.

The estimated cost is **\$17.6 Million** (*in 2012 \$*).

## **12.2 MODIFICATION OF THE MT OSMOND INTERCHANGE DAM TO REDUCE OUTFLOWS**

Investigations for the 2006 Master Plan determined that the original flood control dam at the Mt Osmond Interchange was over-designed for the 100 year ARI event.

It was proposed that the existing orifice plate on the culvert inlet could be reduced from 610 mm to 475 mm to achieve a reduction in the outflow from 3.2 m<sup>3</sup>/s to 1.9 m<sup>3</sup>/s, while still avoiding any overtopping of the dam or compromising its safety and stability. This reduction in the outflow benefits downstream flood mitigation.

The proposed works were completed in 2008 at minimal cost. This measure is included in this report for reference, but no further works are required for this option.

## **12.3 FLOOD DETENTION SYSTEM FOR RIDGE PARK RESERVE**

Design and documentation is underway for a MAR reuse project involving the harvesting of 60ML per annum of stormwater from Glen Osmond Creek via an in-line storage dam located at the western end of Ridge Park.

The Unley Council has confirmed that the hydrogeology of the area is suitable for MAR and they would be able to extract water during average flow events for the MAR re-use. The harvesting component will comprise either a 0.9ML or 1.2ML active storage.



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In conjunction with the MAR facility, it is proposed that the flood detention dam is constructed at the downstream end of Ridge Park to reduce the 1 in 100 year ARI flood downstream of Ridge Park to a maximum  $8\text{ m}^3/\text{s}$  flow rate. Peak inflow from the upstream channel is estimated to be approximately  $8.9\text{ m}^3/\text{s}$ , which is governed by the modification that was made to the Mt Osmond interchange dam outflow in 2008.

A concept design sketch is included in **Appendix L**.

The BHKC Project has undertaken some initial modelling to determine the required storage based on  $8\text{ m}^3/\text{s}$  outflow over the weir. On behalf of the BHKC Project, DPTI is assisting in determination of spillway slot or orifice dimensions to control peak flow discharge based on a range of spillway crest levels and peak water levels.

The duration of inundation during the 100 year ARI event would only be about 4 hours, meaning that the existing significant River Red Gums and existing structures could be retained on the site and appropriate offsets to existing infrastructure would be maintained.

To achieve the combined detention and harvesting requirements, a composite earth and concrete dam wall with a rock spillway has been proposed (*refer concept sketch in Appendix L*). The height of the earth bund would be about 3 metres above the existing creek level, and the height of the concrete wall above the bund would be a further 3 metres. The total length of the concrete wall (*bund crest*) would be approximately 65 metres.

This component of the structural works provides a range of multi-purpose community benefits (*recreation and biodiversity enhancement*), as well as being relatively low cost and effective in reducing the peak flow of shorter duration storm events from the Mt Osmond Interchange dam.

The cost of the flood control component of the project is estimated to be approximately **\$1.06M**.

#### **12.4 BYPASS CULVERT AT FISHER STREET (GLEN OSMOND CREEK)**

The 2006 Master Plan recommended the upgrade of the Fisher Street culvert at Wycliff Street to increase its capacity from approximately  $3.5\text{ m}^3/\text{s}$  to  $8\text{ m}^3/\text{s}$ , which is equivalent to the 100 year ARI flow assuming that the proposed upstream detention works are carried out.

However, it has been confirmed since then that a new 1500 mm diameter pipe was installed in 1996 that effectively bypasses this culvert. The new culvert was configured with a design capacity of about  $8\text{ m}^3/\text{s}$  and therefore, the Fisher Street culvert upgrade works proposed as part of the 2006 Master Plan are no longer required.

Therefore, it is likely that the Base Case flood extent associated with the breakout from the Glen Osmond Creek channel to the east of Fullarton Road will be significantly reduced compared to that shown in **Figure 3**.

Furthermore, with the modified outlet at the Mt Osmond interchange dam and the proposed detention system for Ridge Park Reserve it is expected that the 100 year ARI flow breakout to the east of Fullarton Road would be completely removed.

It is recommended that alternative works be undertaken to reduce potential breakouts further downstream on Glen Osmond Creek between Fullarton Road and Windsor Street and to effectively



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reduce reliance on the creek within private properties where maintenance of the creek is problematic.

It is proposed that a bypass culvert be installed along Fisher Street between Wycliff Street and Windsor Street according to the following basic concept design (*refer Figure 28*):

- The off-take for the culvert would be from the 1500 mm diameter pipe as it turns north from Fisher into Wycliff Street. The culvert would extend west along Fisher Street for about 1,000 metres before turning north into Windsor Street. It would feed back into the Glen Osmond Creek about 100 metres to the north.
- The culvert would have a pipe size increasing from 1500 mm to 1800 mm diameter along Fisher Street and then change to a 3.3 m (W) x 0.9 m (H) box culvert for the short section along Windsor Street, to accommodate the peak 100 year ARI flow of between 8 and 12 m<sup>3</sup>/s along this length of Glen Osmond Creek. These flows assume that the proposed upstream detention works are completed.
- The bypass will be installed within the Fisher and Windsor Street roadways and therefore have no impact on private property.
- The existing section of Glen Osmond Creek that is effectively bypassed by this proposal will have to be retained for local drainage purposes.
- It is recommended that detailed hydrologic and hydraulic investigations be undertaken for this option as part of further design work.
- The residual breakout between Fullarton Road and Windsor Street for the 100 year ARI event will be removed.
- Estimated cost (*preliminary concept only*) is **\$4.5 Million**.

The design and implementation of the proposed bypass will need to further consider the implications on the downstream Windsor Street culvert, which has less than 100 year ARI capacity.

## **12.5 KESWICK CREEK TO BROWN HILL CREEK DIVERSION CULVERTS**

### **A) Le Hunte Street Diversion**

The existing Keswick Creek culvert through the Showgrounds has a capacity of approximately 25 m<sup>3</sup>/s. At higher flows it forms a constriction which subsequently leads to flooding of areas through the Showgrounds, down into Keswick and along the railway line and into the commercial areas of Mile End South. Hydrologic modelling predicts that the existing 100 year ARI flow is approximately 34.5 m<sup>3</sup>/s at the Goodwood Road entrance to the culvert. Diverting a portion of the flow from upstream of the Showgrounds culvert will allow the reduced flow to be contained within the culvert with a subsequent reduction in flood damages downstream.

The proposed system would divert up to 14 m<sup>3</sup>/s of flow from where Keswick Creek crosses Le Hunte Street (*approximately 500 m upstream of the culvert entrance*) and convey it via a new culvert through the Showgrounds to Leader Street, continuing along Leader Street to Anzac



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Highway, and then down Anzac Highway to discharge into Brown Hill Creek downstream of the present Anzac Highway culvert.

Key technical information for the Le Hunte Street diversion is provided below:

- Existing Keswick Creek channel 100 year ARI flow is approximately 34.5 m<sup>3</sup>/s at the entrance to the Showgrounds culvert. The existing twin culverts are 1520 mm high by 2320 mm wide, which provide a total capacity of approximately 25 m<sup>3</sup>/s.
- The diversion inlet will be at Le Hunte Street, approximately 500 metres upstream from the Showgrounds culvert and will divert up to 14 m<sup>3</sup>/s.
- A diversion of 14 m<sup>3</sup>/s will typically require a single 3.3 m (W) x 1.5 m (H) box culvert, but the dimensions are expected to vary, particularly at locations where existing underground services are to be avoided.
- Culvert length is approximately 2000 metres.
- Limited property acquisition may be required at the Le Hunte Street inlet.
- Detailed survey will be required to confirm levels during the detailed design.
- Estimated cost is **\$23 Million** (based on *Tonkin Consulting, 2010a*).

This component significantly reduces downstream flooding in the high flood damage area of the Showgrounds and the suburbs of Keswick and Mile End South. It provides an additional benefit for the suburbs further downstream along Keswick Creek, as the effect of transferring flows to the Brown Hill Creek catchment eliminates the requirement for channel upgrades downstream on Keswick Creek.

Concept drawings for the diversion are available in the diversions *Stage 2 Preliminary Design Report (Tonkin Consulting, 2010a)*.

## **B) Anzac Highway Diversion**

The existing Keswick Creek culvert under Anzac Highway has a capacity of approximately 25 m<sup>3</sup>/s. At higher flows it forms a constriction and subsequently floods areas through the suburbs of Ashford, Keswick and Mile End South. The capacity of the Keswick Creek channel further downstream varies between 20 m<sup>3</sup>/s and 25 m<sup>3</sup>/s and it continues to pick up further inflows. This results in substantial flooding in the commercial area of Mile End South and residential suburbs further to the west.

Diverting water upstream of the Anzac Highway culvert into Brown Hill Creek allows the flow to be reduced to below the existing channel capacity downstream. This provides substantial reductions in flood damages immediately downstream and in the commercial district of Mile End South and areas further west.

This project will divert flow (10 m<sup>3</sup>/s) from Keswick Creek where it crosses Anzac Highway, along the Anzac Highway median strip to discharge into Brown Hill Creek downstream of the present Anzac Highway Bridge culvert.



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Key technical information for the diversion is as follows:

- The diversion inlet is located at the Anzac Highway culvert crossing and diverts 10 m<sup>3</sup>/s into Brown Hill Creek in order to substantially reduce flood damages and inundation further downstream in Keswick Creek.
- A diversion of 10 m<sup>3</sup>/s requires a single 3.0 m (W) x 1.5 m (H) RC Box Culvert.
- Culvert length is approximately 500 metres.
- Estimated cost is **\$8.9 Million** (based on *Tonkin Consulting, 2010b*).

This component reduces the risk of downstream flooding in the flood prone area of Keswick, Ashford, Mile End South and suburbs further downstream.

Concept drawings for the diversion are available in the diversions *Stage 2 Preliminary Design Report (Tonkin Consulting, 2010a)*.

## **12.6 BROWN HILL CREEK CHANNEL UPGRADE FROM ANZAC HIGHWAY TO THE CONFLUENCE WITH KESWICK CREEK**

For much of its length downstream of Anzac Highway to the confluence with Keswick Creek the Brown Hill Creek channel consists of a concrete-lined channel within a narrow drainage reserve. In areas where the stream remains unlined, it typically consists of an incised earth channel devoid of native vegetation. The capacity of the channel varies considerably from 25 m<sup>3</sup>/s to 40 m<sup>3</sup>/s due to localised obstructions and varying channel cross-section geometry.

To substantially reduce inundation and flood damages along both Keswick Creek and Brown Hill Creek to the west of Anzac Highway, the proposed Le Hunte Street and Anzac Highway diversion culverts need to be complemented by an upgrade of the Brown Hill Creek channel.

The proposed diversion rate of 24 m<sup>3</sup>/s at the peak of the 90 minute storm (*Le Hunte Street Diversion = 14 m<sup>3</sup>/s and Anzac Highway Diversion = 10 m<sup>3</sup>/s*), in addition to the existing 100 year ARI flow of approximately 34 m<sup>3</sup>/s during the 90 minute storm in the Brown Hill Creek channel, requires the channel to be upgraded to a capacity of approximately 60 m<sup>3</sup>/s. This flow rate is dependent on all upstream components being adopted.

During the 36 hour storm the diverted flow from Keswick Creek would reach a peak of 18 m<sup>3</sup>/s. The upgraded channel with 60 m<sup>3</sup>/s capacity is expected to accommodate this diverted flow plus the peak flow in Brown Hill Creek of 39 m<sup>3</sup>/s during the 36 hour storm.

The original concept for the proposed channel upgrade is as follows (*refer to Appendix K for concept drawings*):

- Design flow of approximately 60 m<sup>3</sup>/s is made up of the 100 year ARI flow contributed from the Brown Hill Creek channel (*maximum 34 m<sup>3</sup>/s in the 90 minute storm*) and diversions from Keswick Creek (24 m<sup>3</sup>/s) and local inflows. Local inflows downstream from Anzac Highway are expected to be minimal once the peak flow arrives from upstream areas.



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- For cost estimating purposes, a concrete-lined channel has been assumed for the entire length of upgrade, with vertical walls of 2 metre average depth with a base width of 8 metres. Dimensions will vary locally, depending on specific drainage corridor widths and depth constraints. As concrete-lining may draw adverse public comment alternative cross-sections should also be investigated prior to finalising this proposal.
- Channel widening will not be effective if carried out in isolation. Structure upgrades of each of the bridges and pedestrian walkways through this reach will be required, as well as the removal of particular flow restrictions. Proposed structure upgrades include:
  - ⇒ Farnham Road
  - ⇒ Daly Street
  - ⇒ Birdwood Terrace
  - ⇒ Marion Road
  - ⇒ Harvey Street
  - ⇒ Beare/Watson Street
  - ⇒ Pedestrian bridges (*Beauchamp Street, Warwick Street, Packard Street and Gray Street*)
- Any existing steps in the channel invert have been smoothed out to minimise hydraulic inefficiencies.
- An allowance for property acquisition has been made in the following locations due to insufficient drainage corridor width:
  - ⇒ Acquire approximately a 10 metre strip of land from up to nine private residences downstream of Daly Street.
  - ⇒ Acquire approximately a 2 metre strip of land from potentially seven private residences between Marion Road and Beare/Watson Street bridges.
  - ⇒ The properties identified for acquisition and precise land areas need to be confirmed following further investigations and detail design.
- Existing trash racks, floating litter booms and silt basins will be kept at existing locations to aid rubbish removal and reduce maintenance costs.
- Detailed survey will be required to confirm levels during the detail design.

The estimated cost of the channel upgrade is **\$48.7 Million**.

**12.7 BROWN HILL CREEK CHANNEL UPGRADES BETWEEN FORESTVILLE RESERVE  
AND ANZAC HIGHWAY**

As discussed above, upgrading this section of Brown Hill Creek channel is required to accommodate the peak 100 year ARI flow during the 90 minute storm of about 34 m<sup>3</sup>/s (*refer Table 9*).





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With no upper catchment detention, the peak 100 year ARI flow during the 36 hour storm is expected to be about 39 m<sup>3</sup>/s. At this stage the channel upgrade works are planned to accommodate this flow. The scope of works may be revised if during the course of Part B investigations it is determined that some form of detention is to be provided upstream from the channel works.

The concept for the proposed channel upgrade is as follows (*refer Figure 21*):

- Upgrade of the channel between Leah Street and the Anzac Highway by widening the channel by 3 metres and removing the existing low-flow channel tier. The slope of the channel banks would be about 2(V):1(H). Some additional bunding up to 0.5 metres high would be required along the bank to accommodate the increased design flow.
- Additional channel upgrade works will also be required through Forestville Reserve between the Glenelg Tramway and Unley Pool to accommodate the design flow.
- The works will include upgrades to bridges/culverts at First and Second Avenues and Anzac Highway. Charles Street is located about 100 metres upstream from Leah Street, but it is also proposed to be upgraded to ensure that no spillage occurs as a result of flow backing-up against the roadway. The culvert/bridge beneath the Glenelg Tramway will also need to be upgraded to provide increased capacity.
- It is understood that the Third Avenue bridge has been recently upgraded by the City of Unley, but its capacity may be less than the 100 year ARI flow (*to be verified*) and the bridge at Ethel/Nichols Street is planned to be upgraded in 2011/2012.
- The Leah Street bridge has also been recently upgraded. However, it is understood that the works may not have capacity to pass the design flow of 39 m<sup>3</sup>/s and therefore, an allowance has been made to undertake some further work.
- A majority of the channel widening and bridge upgrade works will be undertaken within road reserves including Wilberforce Walk on the north side of the channel. However, it is understood that the existing channel is largely located within properties along the south side of the channel. Although there will be no further encroachment into private property, given the open location of this section of the channel, acquisition of this section of the channel will be required.
- Wilberforce Walk does not extend all the way to Anzac Highway. Subject to further design, it is envisaged that some channel widening will need to be undertaken through residential allotments between Third Avenue and Anzac Highway, which will also require an easement over or acquisition of this section of channel.
- It is envisaged that the channel upgrade works could involve measures to improve the recreational amenity of Wilberforce Walk, including landscaping and increased grassed areas.

It is estimated that the cost of the channel upgrade works would be approximately **\$14.9 Million**.





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## 13. STORMWATER MANAGEMENT STRATEGIES

Flood mitigation works, as a discrete strategy of the SMP, are described in the following Sections 13.1 to 13.4. Other strategies of a non-structural nature are discussed in Sections 13.5 to 13.8.

### 13.1 FLOOD MITIGATION WORKS – PARTS A AND B

Determining the cost of works involved updating previous cost estimates prepared for the 2006 Master Plan to account for the effect of cost escalation, which has been determined according to building price indices for Adelaide documented in Rawlinson's Construction Handbook (2012) and also through consideration of relevant construction index numbers from the Australian Bureau of Statistics. The escalation rate for cost estimates was determined to be 31.2% between 2006 and January 2012.

The following **Table 13** summarises the estimated costs of the Part A Works (*refer Section 12*) and the alternatives identified for upper Brown Hill Creek upstream of Forestville Reserve (*refer Section 11*). Based on the full range of works (*Parts A and B*) identified in the 2011 Draft SMP, the estimated total cost is approximately **\$148 million** (*in 2012 \$*).

This does not include likely additional cost that may result from addressing the reduced channel capacity of the existing channel, as revealed in the Channel Capacity Assessment study (*AWE, 2012*).

Options 3 and 3A cost estimates have been taken from Table 5 of the Bypass Culvert Feasibility Assessment report (*WorleyParsons, 2012*).



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**Table 13 ESTIMATED COST OF STRUCTURAL WORKS COMPONENTS**

COMPONENT	CAPITAL COST (2012 \$ M)		
	2011 DRAFT SMP	OPTION 3 BYPASS CULVERT	OPTION 3A BYPASS CULVERT
<b>Part A Works</b>			
Detention basins in the South Park Lands / Glenside Campus	\$17.6		
Modify Mt Osmond Interchange Dam outlet.	Completed in 2008		
Inline flood detention system in Ridge Park Reserve and stream rehabilitation	\$1.1		
Bypass Culvert at Fisher Street	\$4.5		
Keswick Creek to Brown Hill Creek Diversions at Le Hunte Street and Anzac Highway	\$31.9		
Brown Hill Creek Channel Upgrades between Forestville Reserve and Anzac Highway	\$14.9		
Brown Hill Creek Channel Upgrade from Anzac Highway to the Confluence with Keswick Creek	\$49.1		
<b>Sub-Total Cost</b>	<b>\$119.1</b>	<b>\$119.1</b>	<b>\$119.1</b>
<b>Part B Works</b>			
Flood Control Dam at Brownhill Creek Recreation Park	\$10.8	-	-
Minor Channel Works in Mitcham	\$0.8	\$2.1	\$2.1
Channel upgrade between Hampton Street & Cross Road	\$2.8	\$2.8	\$2.8
Bypass Culvert between Malcolm Street and Forestville Reserve	\$14.1	\$19.0	\$18.1
Bypass Culvert between Hampton Street and Malcolm Street	-	\$11.0	\$8.5
<b>Sub-Total Cost</b>	<b>\$28.5</b>	<b>\$34.9</b>	<b>\$31.5</b>
<b>TOTAL CAPITAL COST</b>	<b>\$147.6</b>	<b>\$154.0</b>	<b>\$150.6</b>

\* Costs updated from 2011 dollars (2011 Draft SMP) to 2012 dollars.



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**13.2 LEVEL OF FLOOD PROTECTION AND RESIDUAL FLOOD RISK –  
FULL CATCHMENT (PART A AND PART B WORKS)**

Floodplain mapping (*extent and depth of inundation*) based on implementation of the full suite of structural works of the 2011 Draft SMP is provided in **Figures 29 to 32** for the 100, 50, 20 and 10 year ARI events, respectively. It is assumed that the Part B Works developed via the 2012 SMP Strategy will achieve flood mitigation benefits which are no less effective than those of the 2011 Draft SMP detailed below. Therefore, the mapping in these figures will be applicable for the final flood mitigation scheme that is ultimately agreed and implemented.

The number of properties affected by flooding following implementation of the structural works is provided in **Table 14**. There are expected to be about 1,300 properties still affected during a 100 year ARI event, although the number subject to over-floor flooding would be reduced to about 200.

Comparison of these numbers with that for existing Base Case conditions (*refer Table 1*) shows that the proposed works will reduce the number of affected properties in the 100 year ARI event by about 5,600. This represents a reduction of more than 80%. In terms of properties subject to over-floor flooding, the reduction is almost 90%.

**TABLE 14 PROPERTIES AFFECTED BY FLOODING FOR PROPOSED WORKS**

DESIGN FLOOD EVENT	NUMBER OF FLOOD AFFECTED PROPERTIES		
	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	TOTAL
10 Year ARI	42	238	280
20 Year ARI	102	473	575
50 Year ARI	142	747	889
<b>100 Year ARI</b>	<b>225</b>	<b>1,096</b>	<b>1,321*</b>
500 Year ARI	1,041	4,019	5,060

*\* Although not reflected in current flood mapping, the number of properties affected would be further reduced to approximately 500 if the Fisher St bypass is installed (refer Section 13.2.2 below).*

The level of flood protection varies across the catchment due to the varying capacity of the creek channels and differing flowpaths that originate from each creek system.

It is difficult to clearly define the level of protection on an area-by-area basis. Notwithstanding, a general assessment has been made on a sub-catchment scale and the results are presented in **Table 15**.



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**Table 15 INDICATIVE LEVEL OF FLOOD PROTECTION**

REACH	LEVEL OF FLOOD PROTECTION	
	BASE CASE	FLOOD MITIGATION SCHEME
Parklands Creek	10 year ARI	100 year ARI <sup>1</sup>
Glen Osmond Creek	10 year ARI	100 year ARI <sup>2</sup>
Keswick Creek to Le Hunte St	10 year ARI	50 year ARI <sup>3</sup>
Keswick Creek from Le Hunte St to Richmond Rd	10 year ARI	100 year ARI
Keswick Creek from Richmond Rd to South Rd	10 year ARI	50 year ARI <sup>4</sup>
Keswick Creek downstream from South Rd	10 year ARI	20 year ARI <sup>4</sup>
Brown Hill Creek upstream from Cross Rd	10 year ARI	100 year ARI <sup>5</sup>
Brown Hill Creek between Cross Rd and Anzac Hwy	10 year ARI	100 year ARI <sup>6</sup>
Brown Hill Creek downstream from Anzac Hwy	10 year ARI	100 year ARI

**Notes:**

1. Subject to confirmation that section downstream of King William Road has adequate capacity. Excluding breakout at Conyngham Street.
2. Residual extent shown in flood mapping (Figure 28) is expected to be removed if the Fisher Street bypass culvert is implemented. It is assumed that the Unley Road constriction (Section 2.2.2) will be rectified independently of the BHKC Project when the downstream works (diversions and lower BHC channel upgrade) are implemented
3. Localised flooding on floodplain mapping immediately downstream of Le Hunte Street will no longer occur due to diversion off-take from Le Hunte Street instead of at Goodwood Road (as per 2006 Master Plan)
4. Flooding is mainly due to local runoff rather than flow from upstream (which is diverted from Keswick Ck)
5. Some nuisance flooding is expected during events greater than 20 year ARI, but flooding would be limited to near the channel
6. Small number of properties could experience inundation during the 100 year ARI flood in the vicinity of Heywood Park, but there is unlikely to be significant damages.

Further details of the residual 100 year ARI flood risk along each of the major creeks are provided in the following sections (refer **Figure 29**).



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**13.2.1 Parklands Creek**

- The recent concept design for the South Park Lands detention system (*Tonkin Consulting, 2009*) incorporates measures to enlarge the detention basin at the Glenside Campus, thereby confining the 100 year ARI flood extent to areas within the campus. Some residual breakout will occur upstream at Conyngham Street.
- The detention system allows for the 100 year ARI flow to be passed through the existing culvert beneath the intersection of Fullarton and Greenhill Roads.
- Temporary storage in the South Park Lands controls flow through the area and reduces inundation mainly to the designated basin areas. The 100 year ARI flow out of the detention basins is reduced to about 8 m<sup>3</sup>/s. Capacity of the channel between Greenhill Road and the confluence with Glen Osmond Creek is considered to be at about this level or marginally less. Maintenance work is required on this section of channel to restore the channel capacity to 8 m<sup>3</sup>/s.

**13.2.2 Glen Osmond Creek**

- The reduction in flow from the upper reaches of Glen Osmond Creek provided by the modified outlet from the Mount Osmond interchange dam and the Ridge Park Reserve detention basin is expected to minimise the potential for breakouts from the channel upstream of Fisher Street.
- The proposed bypass culvert along Fisher Street (*refer Section 11.1.4*) has not been incorporated into the hydraulic model at this stage. However, the inclusion of the bypass culvert is expected to eliminate the flood extent emanating from the channel between Fullarton Road and Windsor Street (*refer Figure 28*).
- Therefore, it is estimated that the number of properties affected by 100 year ARI flooding would be reduced from about 1,300 (*refer Table 14*) to about 500, further reducing the residual flood damages following SMP works implementation.
- Further investigation is required as part of finalising the Part B works to confirm if sections of the channel or culverts downstream from Fisher Street have sufficient capacity to carry the peak 100 year ARI flow. This will need to consider the findings of the Channels Capacity Assessment study (*AWE, 2012*).

**13.2.3 Keswick Creek**

- From the confluence of Parklands and Glen Osmond Creeks to Le Hunte Street, localised flooding will continue to occur immediately upstream of the tramway crossing.
- No flooding will be experienced downstream from Le Hunte Street through to Anzac Highway due to the diversion of flow through the proposed Le Hunte Street diversion culvert.



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- Additional diversion of flow through the Anzac Highway diversion culvert reduces the flow even further downstream of Anzac Highway such that the flows are contained within the Keswick Creek channel downstream to Richmond Road (*and beyond*).
- A minor breakout is still expected at Manchester Street as flow builds up due to continuing local urban runoff. More significant breakouts will occur between South Road and Brooker Terrace, which will spread to the north and west into low lying areas of Cowandilla. However, the extent of inundation is expected to be significantly reduced compared with the Base Case floodplain. Floodwaters are not expected to enter the Adelaide Airport.

### **13.2.4 Brown Hill Creek**

#### ***Impact of Part B Works***

- The proposed flood control dam in the upper reaches of the Brown Hill Creek catchment is expected to reduce 100 year ARI 36 hour flows by between 6.6 and 8.5 m<sup>3</sup>/s for areas upstream from Cross Road. In many locations along the creek this reduction in flow will translate to a noticeable reduction in flood extent.
- However, there will still be some localised overtopping from the channel between Paisley Avenue and Mitcham shopping centre. As discussed in **Appendix K**, there are some additional minor works that can be undertaken through this area to further reduce the impact of flooding as part of the Part B Works.
- The 100 year ARI flood map indicates that there is a very minor breakout still at George Street. However, the depth of flow would be minimal (*i.e. less than 50 mm*) and it is expected that the currently proposed upgrade for the George Street bridge would eliminate the residual overtopping.
- The proposed channel upgrade between Hampton Street and Cross Road is expected to minimise the potential for significant breakouts and flow down adjacent streets, although there is still expected to be some localised overbank inundation across 2 or 3 properties along Denning Street.
- Some residual overbank flooding is expected to occur upstream from Heywood Avenue, which may affect the rear of up to 5 properties.
- The high-flow bypass culvert between Malcolm Street and the Glenelg Tramway will effectively eliminate any residual breakouts from the channel along this reach.

#### ***Impact of Part A Works***

- The channel upgrade between Forestville Reserve and the Anzac Highway will effectively eliminate breakouts from the channel along this reach.
- Likewise, for sections of the channel downstream from the Anzac Highway, the expected breakout and floodplain inundation will be minimal.



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**13.2.5 Summary**

The information presented in **Tables 14** and **15** and the mapping contained in **Figures 29** to **32** show that even with the implementation of the Part A and Part B engineering works, flooding is still expected to affect some localised areas.

While it would be technically possible to provide a higher level of flood protection at all locations, the social impacts and capital costs would likely outweigh the benefits. The proposed works components have been developed with a view to minimising social impacts (*to be further addressed through Part B investigations*) and ensuring the costs of works are largely balanced by the benefits.

In the case of Keswick Creek downstream from Richmond Road there is significant runoff from local urban areas which exceeds the existing channel capacity. Further investigation of how this flow is being conveyed to the creek will better define the local flood risk and identify local mitigation strategies.

Further reduction of the likelihood of flooding in these areas may require the acquisition of land to either increase the capacity of the channel or to provide enough open space to provide adequate flood storage. Such an approach cannot be justified economically nor is it considered likely to be socially acceptable.

**13.3 PART B WORKS PROCESS**

The Part B Works process will be carried out in accordance with the strategy specified in Section 3.3.

The Part B Works process will be informed by the Supplementary Investigations (refer Section 3.2), including the Bypass Culvert Feasibility Assessment (*refer Section 11.3*) and the Channel Capacity Assessment study which is discussed in the following section. Other information obtained since the 2011 Draft SMP, as identified below, also will have a bearing on outcomes of the process.

Investigations will include a preliminary concept design and costing for the flood control dam option (*to enable a more detailed comparison with other options*) and measures to increase the conveyance capacity of Brown Hill Creek channel through Torrens Park, Hawthorn, Unley Park and Millswood.

**13.3.1 Implications of Channel Capacity Assessment**

Background to this investigation is given briefly in Section 3.2.

The AMLRNRMB commissioned consultant AWE in mid 2011 to assess the hydraulic capacity of the creek channels within the catchment. AWE delivered a report in April 2012.

The Channel Capacity Assessment study indicates that channel capacity has been reduced significantly in places since the time of the last assessment (*by WBCM*) in 1983, mainly along the privately owned sections of Brown Hill Creek (*upstream of Anzac Highway*), but also in Parklands Creek (*downstream from Greenhill Road*). Reduced channel capacity is not a factor along the lower Brown Hill and Keswick Creeks part of the catchment.





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Reasons for deterioration in capacity include encroachment of structures (*typically bridges and walls*) and increased trees and vegetation within the channel due to lack of maintenance.

The floodplain model produced by Hydro Tasmania for the 2006 Master Plan and used in subsequent modelling for the 2011 Draft SMP incorporates channel capacities that were verified by Hydro Tasmania against the 1983 capacities. It is therefore assumed that in terms of the channel capacity the model is based closely on the 1983 WBCM analysis.

From flood modelling for the 2011 Draft SMP, there was considered to be sufficient flow capacity (*subject to implementation of other flood mitigation measures*) along upper Brown Hill Creek to mitigate significant overbank flows. However, with respect to upper Brown Hill Creek the AWE results indicate that in many areas the previously accepted capacity of the existing channel and bridges/culverts could be overestimated.

Generally, along the length of upper Brown Hill Creek the Channel Capacity Assessment has revealed significant deterioration of channel capacity compared with WBCM and, by inference, more detailed analyses will have to be carried out of critical sections of channel for the purposes of floodplain mapping and works designs.

In the Part B Works process, options for consideration include:

- clear flow constraints to improve channel flow capacity;
- reduce peak flow to not exceed channel capacity (*e.g. by flood detention*);
- install bypass or diversion systems to accommodate high flows in excess of channel capacity; and
- accept a lower level of flood protection.

In respect of downstream impacts, the Channel Capacity Assessment report states:

*“It is apparent that the most affected sections of Brown Hill Creek with the lower post-1983 WBCM capacities are located in areas where the flooding is relatively localised and the floodplain path is confined to the vicinity of the channel. For this reason these lower capacities are not likely to significantly change the downstream extent, depths and hazard ratings of the overall Brown Hill and Keswick Creek Floodplain maps currently in use.”*

Despite the potential overestimation of channel capacity in flood modelling for this SMP, future flood mitigation works on upper Brown Hill Creek upstream of Forestville Reserve (*whatever the determined works are*) are not expected to impact on the effectiveness or viability of the Part A Works.

- For the section of Brown Hill Creek channel upgrade from Forestville Reserve to Anzac Highway it is expected that the design flow will be resolved before detailed design and construction are undertaken. However, in case the design flow is unresolved a ‘no dam’ (*undetained*) flow is assumed, as the difference in construction cost between the higher and lower flow capacities in this section is not excessive.



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- For the lower Brown Hill Creek channel upgrade, the critical design flow from upper Brown Hill Creek and diverted flow from Keswick Creek is governed by the 90 minute storm and therefore the upgrade sizing is not dependent on whether upper catchment detention is provided.
- Other Part A Works are relevant to Glen Osmond, Parklands and Keswick Creeks which are unaffected by flood or flood mitigation impacts along upper Brown Hill Creek.

**13.3.2 Goodwood Junction Rail Grade Separation Project**

It has been announced by the Federal Government that funding will be provided to allow the planned grade separation of the interstate Australian Rail Track Corporation (ARTC) railway line and the suburban Noarlunga Centre railway line at Goodwood Junction to proceed in 2012/13. The grade separation is at the same location where Brown Hill Creek crosses the railway, just south of Victoria Street, Goodwood.

It is proposed that the Noarlunga Centre railway line will be lowered to pass under both Victoria Street and the ARTC line. While it was originally intended that the Noarlunga Centre line be lowered sufficiently to allow Brown Hill Creek to pass over the lowered Noarlunga Centre line tracks, this has not proved feasible due to trunk sewer constraints.

Currently it is planned to relocate Brown Hill Creek (*away from the existing crossing point of the railway reserve*) to the north along Devon Street and then west along the southern side of the tramline overpass, crossing under the railway to re-enter the existing creek at the Brown Hill Creek culvert under the tramline overpass. While this arrangement is still subject to change, ensuring the continuity and flood flow capacity of the existing creek is one of the prime constraints on the Goodwood Junction Project.

Due to the uncertainty of timing, the impact of the railway project has not been fully investigated. As the railway project is now proceeding, its effect on the mitigation scenarios investigated as part of the Draft 2011 SMP has been considered, as follows:

- Smaller Dam at Site 1 + Supplementary Works: The proposed high-flow bypass route from Malcolm Street to the Glenelg Tramway would need to be changed to avoid the lowered Noarlunga Centre line. A possible route clear of the works to the south has been identified. Other routes may be possible depending on the final configuration of the Brown Hill Creek relocation works.
- Entire Channel Upgrade (*Muggs Hill road to Anzac Highway*): The planned Brown Hill Creek relocation would need to be increased in size.
- Generally, the other scenarios would be unaffected, except for the two scenarios which involve the Glenelg Tramway interceptor. A reconfiguration of the interceptor would be required, but the concept would still be viable.

The railway grade separation project does not render any scenario impracticable. It has most effect on the scenario involving the high-flow bypass culvert from Malcolm Street to the Glenelg Tramway (*Forestville Reserve*) and the entire channel upgrade scenario. For all other scenarios the railway project has little or no effect.



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The railway project will be constructed in the same timeframe as the proposed Part B Works process. As the scenario involving the high flow bypass (*or variations thereof*) will be investigated in more detail in the Part B investigations and an as-constructed railway project is likely to force an alternative to the current bypass route, the BHKC Project must be kept informed and be given opportunity to provide input to the final design of the railway project.

### **13.3.3 Unley Special Works**

In its response to the 2011 Draft SMP, Unley Council identified several additional flood mitigation works in its council area which it seeks to have included in the SMP (*refer Section 3.2*). Although these components are on Glen Osmond Creek (*and therefore outside the scope of upper Brown Hill Creek*) they will be considered within the Part B Works process for potential inclusion in the Final SMP. The Unley Special Works are:

- Windsor Street culvert to 100 year ARI flow capacity
- Unley Road culvert upgrade to 100 year ARI flow capacity
- King William Road culvert upgrade to 100 year ARI flow capacity

## **13.4 PART A WORKS IMPLEMENTATION**

In the context of risk assessment, the implications of having the Part A Works implemented without Part B Works have been considered as follows.

### **13.4.1 Viability**

Notwithstanding the Channel Capacity Assessment findings (*AWE, 2012*), the Part A Works will provide the related flood mitigation impacts of the 2011 Draft SMP on the basis that the hydrologic model (*which is critical in respect of the sizing and functionality of the diversions and lower Brown Hill Creek channel upgrade*) is unaffected by the findings, and that:

- Keswick Creek channel capacity is assessed to be unchanged since the 1983 WBCM assessment;
- Adverse changes along Parklands Creek identified can be corrected by relatively minor works which reasonably can be expected to be carried out within the timeframe of the Part A Works program;
- The findings confirm adverse changes along Glen Osmond Creek that in the 2011 Draft SMP were identified as being matters which in time should be rectified to alleviate localised flooding, but which still contribute to overall flood mitigation benefits of the SMP on a catchment-wide scale;
- The findings in respect of the Brown Hill Creek channel upgrade (*including bridge culverts*) between Leah Street and Anzac Highway confirm that the channel will have to be enlarged to accommodate the peak flow (*either 34 m<sup>3</sup>/s with dam or 39 m<sup>3</sup>/s without dam*); and



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- For the section of Brown Hill Creek channel between Forestville Reserve and Leah Street it is likely from the findings that channel enlarging will be required for either flow condition. However this section of channel is in public ownership and upgrading should not be problematic.

The Part A Works are effective either as a set of stand-alone flood mitigation measures or as integral elements of the overall SMP for the catchment including Part B Works (*when defined*).

#### **13.4.2 Level of Flood Protection and Residual Flood Risk**

Floodplain mapping (*extent and depth of inundation*) based on implementation of the Part A structural works only is provided in **Figures 33 to 36** for the 100, 50, 20 and 10 year ARI events, respectively.

Mapping for the 100 year ARI event is based on detailed computer modelling of the Part A works, while due to time constraints the mapping for the lesser design events has been developed using engineering judgement based on previous model results. This is considered appropriate due to the limited breakouts that are expected to occur during the lesser events. Flood modelling has been undertaken for the 500 year ARI event.

This analysis has been undertaken to determine the interim benefit of implementing the Part A works while the Part B works are being further investigated and constructed.

The number of properties affected by flooding following implementation of the Part A structural works is provided in **Table 16**. There are expected to be about 3,300 properties still affected during a 100 year ARI event, although the number subject to over-floor flooding would be reduced to about 720.

Comparison of these numbers with that for existing Base Case conditions (*refer Table 1*) shows that the proposed works will reduce the number of affected properties in the 100 year ARI event by about 1,000. This represents a reduction of more than 52%. In terms of properties subject to over-floor flooding, the reduction is almost 60%.



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**TABLE 16 PROPERTIES AFFECTED BY FLOODING FOR PART A WORKS ONLY**

DESIGN FLOOD EVENT	NUMBER OF FLOOD AFFECTED PROPERTIES		
	OVER-FLOOR FLOODING	UNDER-FLOOR FLOODING	TOTAL
10 Year ARI	44	242	286
20 Year ARI	127	584	711
50 Year ARI	239	1,124	1,363
100 Year ARI	717	2,578	3,295
500 Year ARI	1,906	7,528	9,434

It is difficult to clearly define the level of protection on an area-by-area basis. However, the following impact on the proposed SMP level of protection would be expected if only the Part A works are completed (*i.e., in the interim while Part B works are being further investigated*):

- The level of protection along Glen Osmond and Parklands Creeks would not be affected.
- As for the 2011 Draft SMP works flood mapping (*refer Figure 29*), the flood mapping for the Part A Works shown in **Figure 33** does not reflect the benefit of the proposed bypass culvert at Fisher Street. It is expected that the proposed culvert would remove the residual breakout of floodwaters between Fullarton Road and Windsor Street shown in **Figure 33**. Similarly, the above numbers in **Table 16** do not reflect the improved results produced by the inclusion of the proposed Fisher Street bypass culvert and correction to floodplain mapping in the vicinity. Corrections to the floodplain model will be carried out in the Part B Works process.
- The level of protection along Brown Hill Creek between Belair and Forestville Reserve will revert to Base Case existing conditions (*i.e. a 10 year ARI level of protection*).
- The level of protection along the Brown Hill Creek channel downstream from Forestville Reserve will generally be increased to the 100 year ARI level. However, breakouts from further upstream are expected to permeate down through the floodplain and cause low-depth inundation to the north of Brown Hill Creek between Anzac Highway and South Road (*refer Figure 33*).
- The overflow from upstream sections of Brown Hill Creek will continue to flow north through the Wayville Showgrounds area and also across the Anzac Highway, leading to inundation through Richmond and Mile End South in the 100 year ARI event. A portion of the flow would pass through the Keswick Rail Terminal and meet up with residual overflows from Keswick Creek near South Road.



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## **13.5 PLANNING POLICY AND DEVELOPMENT ASSESSMENT**

### **13.5.1 Improving Development Plans**

The Development Plans of each council within the Brown Hill and Keswick Creek catchment contain policies relating to stormwater management and flood risk mitigation; however, not all have adopted the South Australia Planning Policies Library (SAPPL).

The SAPPL is a set of Development Plan policies developed by DPTI that deal with issues common to most councils, including stormwater management and flood risk management. The policies that make up the Library are consistent with the current State Planning Strategy, and are considered to be current best practice.

Those councils within the catchment which have not adopted the SAPPL policies are required to do so in the future, and by doing so will incorporate standardised Development Plan policies which will include:

- A Development Plan overlay showing high and medium flood hazard areas and 100 year ARI flood levels;
- General policies that recommend all new development including land division, change of land use, and building works to incorporate WSUD techniques; and;
- Policies to ensure that new development does not reduce the capacity or functionality of the existing drainage network, or have any adverse impact on flooding across adjacent properties.

### **13.5.2 Assessment Guidelines**

Improved quality and consistency of planning policies can be assisted by the availability of guidelines for new development in flood prone areas.

A report prepared for the City of Unley in 2010 recommended that council consider a streamlined approach to assessment of development applications according to a classification of High, Mid or Low categories of flood risk. The categories relate to the predicted depth of flooding at the development site during a 100 year ARI storm event, and correspond to three levels of flood risk assessment:

- High Category
  - ⇒ Any part of the property is subject to 100 year ARI flood depths > 500 mm, or if the property is adjacent to or within a watercourse
  - ⇒ An engineering report is to be prepared by a suitably qualified chartered professional engineer with experience in floodplain management and hydraulic modelling, and is to include recommended minimum floor levels and an assessment of potential flood impacts.





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- Mid Category

- ⇒ The property is subject to 100 year ARI flood depths between 100 and 500 mm
- ⇒ A detailed engineering report is not required; however, the flood depth information provided by council is to be used to demonstrate that requirements for minimum floor levels have been met (*i.e., in terms of freeboard allowances*).

- Low Category

- ⇒ The property is subject to 100 year ARI flood depths < 100 mm
- ⇒ For properties higher than the adjacent road level, the floor level must be at least 150 mm higher than the top-of-kerb level.
- ⇒ For properties lower than the road level, the floor level must be at least 150 mm higher than the finished site levels around the perimeter of the proposed structure.

Other councils within the catchment may consider adoption of similar assessment guidelines to those under consideration by the City of Unley. In progressing the Unley guidelines or similar, consideration may be given to applying a merits-based approach to buildings located within significant flowpaths, even if depths are less than 500 mm (*amendment to the Mid Category above*).

In considering assessment guidelines it is important to recognize that the different categories do not represent different flood-related design standards, but rather represent differences in the approach to assessment.

### **13.5.3 Water Sensitive Urban Design**

Transitioning South Australia and Adelaide to a water sensitive State and city respectively is a key objective of Government and is articulated in the State's water security plan, Water for Good. It is also an inherent objective in the 30 Year Plan for Greater Adelaide and the regional volumes of the Planning Strategy, which guide South Australia's future urban and regional development (*Department for Water, 2012*).

Intensification of development increases the rate and quantity of stormwater runoff by increasing the area of impervious surface in the catchment. This can in turn increase the risk of flooding of downstream areas. WSUD provides an opportunity to manage the risk of flooding in the context of new development and urban consolidation.

WSUD is an approach to urban planning and design that integrates the management of the total water cycle into the urban development process (*DPLG, 2010*). Such a definition recognises WSUD as a valid approach for urban design for both 'development' (*as defined in South Australia's Development Act 1993*), and for other urban land uses such as streets and thoroughfares constructed or altered by the State, local council or other public authority.





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WSUD focuses on on-site and built environment scales such as allotment, sub-division, and precinct scales and includes:

- Integrated management of groundwater, surface runoff (*including stormwater*), drinking water and wastewater to protect water related environmental, recreational and cultural values;
- Storage, treatment and beneficial use of runoff;
- Treatment and reuse of wastewater;
- Using vegetation for treatment purposes, water efficient landscaping and enhancing biodiversity; and
- Utilising water saving measures within and outside domestic, commercial, industrial and institutional premises to minimise requirements for drinking and non drinking water supplies.

Within the context of this Stormwater Management Plan, there is the opportunity to consider how stormwater WSUD related elements can be implemented across the catchment in order to achieve the water quality and water reuse objectives of this Plan.

Implementing WSUD in neighbourhood level planning through a master planning process provides the opportunity to incorporate stormwater management at an early stage of neighbourhood design and development. Good management of stormwater at the neighbourhood level reduces the risk of flooding throughout the catchment, particularly in downstream areas of the floodplain.

In recent years catchment councils have been pro-active in adopting WSUD techniques and this trend is expected to continue. Mitcham and Unley Councils are particularly relevant in terms of stormwater runoff in the Brown Hill Creek part of the catchment.

Mitcham Council has nine operational applications in streets and open spaces (parks and ovals) within the catchment. Their primary function includes first flush infiltration, bioremediation, street tree irrigation (*or a combination*) and they involve techniques of infiltration trench, rainwater collection, rain garden and ASR. These applications harvest relatively small volumes, but indicate significant benefits if applied more generally.

Unley Council has implemented two significant WSUD applications – in Wattle Street (*east of Fullarton Road*) and Hamilton Boulevard, Wayville. Both projects were developed around other necessary infrastructure upgrades of road reconstruction (*Hamilton*) and a stormwater drainage system (*Wattle*). These applications are also identified as stormwater harvesting schemes in Section 12.10 because of the relatively large volumes of stormwater collected.

Other street level WSUD applications generally across the catchment are indicated in the plan at **Figure 37**.

In mid 2012 AMLRNRMB initiated development of a business case, in partnership with six other organisations including the Local Government Association, Department for Water and the EPA, to support implementation of a local WSUD capacity building program (*ie,*



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*knowledge and skills*). The BHKC catchment councils are potential stakeholder in the program and would seek to be involved.

Fundamental stormwater reuse activities including WSUD and the use of rainwater tanks remain important actions to promote and where possible mandate and regulate in planning and building policies. However, those measures will not have a measurable impact on reducing major flood risk and hazards in the Brown Hill Keswick Creek catchment.

### **13.5.4 Infill Development and On-site Detention**

**Figure 2** is an indicator of impervious area across the urban areas of the catchment. Jensen Planning in its SMP report on Marion and Holdfast Bay (2011) suggests that the impervious percentage is likely to increase to the order of 80% to 90% due to more intense development within each housing block. This effect is evident from inspections of the housing areas. It is also evident from higher discharge rates during recent storms. Increases in impervious area of the scale indicated would lead to greater peak flows than are currently estimated, particularly for the more frequent flood events, unless counter measures are taken.

As indicated in Section 4.3, the level of flood protection provided by the proposed works will be reduced over time if higher density redevelopment is permitted without appropriate controls in place. This reduction is potentially very large. Individual councils currently implement a variety of approaches to manage this issue, ranging from arbitrary property peak discharge limits, to no limitation on impervious site coverage.

It is necessary that a catchment-based on-site detention policy, or other policy providing a similar outcome, is applied to appropriately manage this issue. The policy will need to be tailored such that future development will have appropriate guidance on measures by which the peak flows within the creek system are maintained to those adopted for the design of the new works.

It should be noted that the policy may vary from council to council, and between areas within a council area, based on the different hydrological impacts of development in different areas. For example, the proposed South Parklands and Glenside detention storages would need to be taken into consideration in scoping a policy that would be relevant to the City of Adelaide and City of Burnside catchment areas, in order to achieve a balance between on-site retention and publicly funded stormwater infrastructure.

Further work is proposed to be undertaken, as part of a collaborative effort between the Planning and Infrastructure departments of the Councils, during the development of the Part B Stormwater Management Plan. This work would include:

- Identification of catchment development trends.
- Assessment of the likely catchment impervious site coverage levels at the end of the current planning period.
- Adoption of policies within each council to limit the discharge of stormwater from any new development (*large or small scale*) to pre-development volumes and peak discharges.



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- Verification of the effectiveness of the proposed policy response in managing future development.
- Policies(s) for inclusion in the Part B Stormwater Management Plan.

**13.6 COMMUNITY AWARENESS, FLOOD PREPAREDNESS AND EMERGENCY RESPONSE**

It is considered that the existing FloodSafe program implemented by SES and the councils is beneficial for raising community awareness of flooding and helping residents in planning for a flood emergency.

The program is designed to achieve the following:

- Provide people with an understanding of whether they live or work within a floodplain area;
- Provide information on ways landholders can flood-protect their houses and businesses;
- Provide information on effective ways to respond during a flood emergency; and
- Work with landholders at a neighbourhood level to provide advice on developing individual emergency response and recovery plans.

The current cost of the program is less than \$200,000 per annum, which covers a total of nine council areas around Adelaide (*Tonkin Consulting, 2011*). It is estimated that the cost for the Brown Hill Keswick Creek catchment would be about \$100,000 per year.

No work has been done to estimate the specific dollar value of the reduction in flood damages afforded by the program. However, it is considered that the program would be cost-effective if it provided a reduction in damages of just 1 or 2% (*Tonkin Consulting, 2011*). In other words, a saving in Average Annual Damages of this scale would be more than the annual cost for the program.

In addition to any financial benefits, there are significant intangible benefits to a flood preparedness program. It can increase the safety of residents during a flood and help them to be more resilient in the aftermath of a flood. It is considered that the FloodSafe program can be justified on the basis of personal safety alone (*Tonkin Consulting, 2011*).

Accordingly, it is recommended that the SES and the catchment councils continue to operate and develop the FloodSafe Program. In light of comments made by some residents affected by flooding in 2005, it is also recommended that the program consider a door-knock approach by SES volunteers for the most flood prone areas. The purpose would be to advertise any upcoming FloodSafe events or provide assistance and advice in preparing a household or business Emergency FloodSafe Plan.

It is understood that the SES is consulting the five catchment councils, the BOM and the AMLRNRMB as part of the development of a new Emergency Response Plan for the catchment. The plan is expected to be completed in 2011 and tested through desktop simulations and field exercises (*Tonkin Consulting, 2011*).



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**13.7 CREEK OWNERSHIP AND RESPONSIBILITIES FOR MAINTENANCE**

Creek maintenance is important for a number of reasons, including:

- Hydraulic (*stormwater conveyance*) capacity;
- Environmental, ecological and biodiversity features;
- Amenity and aesthetic attractions;
- Water quality and impacts on receiving waters (waterway health); and
- Public safety.

**13.7.1 Existing Water Quality**

Urban stormwater runoff contains common contaminants including suspended solids, nutrients, biological oxygen demand (*BOD*), chemical oxygen demand (*COD*) and bacteria which are usually considered to have the most significant ecological impact on receiving waters (*Engineers Australia, 2006*). Oils and surfactants, and litter have aesthetic impacts in addition to their ecological impacts, and are more renowned for generating community concern.

Contaminants within stormwater runoff are generally higher than nationally accepted levels (*ANZECC and ARMCANZ, 2000*) for discharge into marine environments, with respect to both aquatic ecosystems and recreational use.

The transfer of contaminants to Gulf St Vincent from metropolitan Adelaide has previously been described by the Adelaide Coastal Waters Study (*Wilkinson et al., 2004*). A brief summary of the median values for a range of physical and chemical parameters reported for Brown Hill Creek are presented below.

	EC <sup>1</sup> (µs/cm)	Suspended Sediments (mg/L)	Total nitrogen (mg/L)	TKN <sup>2</sup> (mg/L)	Nitrate (mg/L)	Total Phosphorous (mg/L)
Brown Hill Creek (1996-2005)	437	17	1.01	0.80	0.165	0.134
Urban Average <sup>3</sup>		150 (50-450)	2.5 (1.4-5)			0.35 (0.15-0.85)

Based on (*Wilkinson et al. 2004*)

<sup>1</sup> The EC unit microsiemen/cm (µs/cm) can be converted to mg/L by multiplying by 0.64.

<sup>2</sup> TKN – Total Kjeldahl Nitrogen is the sum of organic nitrogen; ammonia and ammonium.

<sup>3</sup> ‘All Urban’ mean value, (± 1 Standard Deviation) (*Duncan, 2005*)



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The AMLRNRNB operates a flow and water quality monitoring gauge on Brown Hill Creek (Site No A5040583), located immediately upstream of the Morphett Road sedimentation basin. This gauge records water quality data for a number of flow constituents listed in the table above, as well as copper, zinc and lead.

**13.7.2 Stormwater Marine Impacts**

Stormwater from the Study Area discharges directly into Gulf St Vincent within the Adelaide Coastal Waters Study (ACWS) zone. The ACWS determined that nutrients, particularly nitrogen from wastewater and stormwater are likely to be responsible for broad scale seagrass loss along the Adelaide metropolitan coast, with turbidity from sediments carried by stormwater possibly contributing, especially in the near-shore zone (Fox *et al.*, 2007). Nutrients and sediment loads are also implicated in the loss of large brown canopy algae from temperate reefs, and a shift to turf-dominated assemblages (Gorgula and Connell, 2004; Turner, 2004).

The Draft Adelaide Coastal Waters Quality Improvement Plan (ACWQIP) has adopted the targets recommended by the ACWS, specifically, a 50% reduction in sediment loads and a 75% reduction in N from 2003 levels (McDowell and Pfennig, 2011) from all flow inputs (wastewater, stormwater and industrial).

Heavy metals and other contaminants potentially carried in stormwater have periodically exceeded levels of concern in Adelaide waters; although not considered an important factor in historical seagrass decline (Fox *et al.*, 2007), these may pose a risk to receiving environments if present in sufficient concentrations (Mills and Williamson 2008; Gaylard, 2009).

**13.7.3 Existing Water Quality Treatment Measures**

The PCWMB (since merged to form the AMLRNRMB) was established in 1995 to responsibly manage the water resources of the catchment through the implementation of its comprehensive Catchment Water Management Plan. The focus of the Board in the first five years was water quality improvement, largely driven by the polluted and unsustainable condition of the Patawalonga Basin (PCWMB, 2002).

Up until the early 1970s waters of the Patawalonga Basin were used extensively for recreation – including water skiing, swimming and other water sports. These activities were banned when it became apparent from the results of testing that the quality of the water was unacceptable for primary contact. Water quality declined as the upstream stormwater drainage network was improved and local streets were kerbed and sealed (disappearance of roadside grassed swales resulting in more runoff and less local treatment), increased roadside vegetation (more leaf litter), increased use of motor vehicles (more oils, heavy metals etc) and increased commercial activity (more gross pollutants).

The PCWMB was active in promoting improved practices in the catchment and facilitating works such as wetlands and gross pollutant traps to improve water quality. It established an extensive network of gross pollutant traps that (across the broader Patawalonga catchment) are estimated to collect about 1,000 tonnes per annum of mainly organic (vegetation debris) and silt material. It is estimated that a total of up to 5,000 tonnes per annum (across the broader Patawalonga catchment) could be ultimately discharged from the catchment. Also,



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the existing (*off-stream*) Urrbrae wetlands serves the same purpose in respect of a significant source of stormwater inflow to upper Brown Hill Creek.

The AMLNRMB recently completed the rehabilitation of Brown Hill Creek below the junction with Keswick Creek, which allowed for the laying back of banks and establishment of appropriate vegetation. These works are likely to result in further water quality improvement through this creek section.

In recent years, individual Councils have begun incorporating Water Sensitive Urban Design (*WSUD*) measures into road reconstruction and drainage construction projects. This has taken a number of forms, including:

- Bioretention swales and ‘pods’;
- Tree pits, designed to receive street runoff; and
- Street verge stormwater ‘pods’.

Some of these works support small scale stormwater harvesting and reuse, for irrigation of local street trees.

Locations of these elements across the catchment are shown in **Figure 37**.

Other non-structural works that have been undertaken in the past by the PCWMB and AMLNRMB, in collaboration with the councils include:

- Public Awareness and Education Campaigns incorporating Waterwatch, Our Patch and best practice promotion;
- Stormwater Pollution Prevention Projects (*Mitcham, West Torrens, Adelaide, Unley and Eastern Health Authority – serving Burnside and other councils*);
- Modifications to work practices (*Service Authorities, councils*);
- Local Agenda 21 plans in conjunction with councils;
- Promotion of EPA Codes of Practice for Stormwater and Guidelines for Urban Stormwater Management; and
- Street sweeping, building site management, retail sector site management improvements.

The street sweeping programs of councils are considered to be a significant source control component. Data collected indicates that 10-20 kg/ha/month of material (mainly vegetation and sediment) is generated in urban areas. Trials and investigations have shown that the generation of gross pollutants, especially vegetation, is dominated by the urban sector over the rural sector by a ratio of around 25:1. The reason for this difference is the very efficient urban drainage network (*PCWMB, 2002*).





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Stormwater 'Pod' (City of Burnside)

#### **13.7.4 Water Quality Targets**

Preparation of this SMP has not included investigations that would enable specific runoff quality targets to be set. Management of the quality of runoff and its effect on receiving waters will be negotiated with the AMLRNRMB during the Part B Works process for inclusion of targets in the Final SMP.





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Glen Osmond Creek, Simpson Parade Trash Racks



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Brown Hill Creek, Watson Avenue Trash Rack, Floating Boom and Sediment Basin



Parklands Creek, Park 20 Trash Rack





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**13.7.5 Hydraulic Capacity**

As mentioned in Section 8.3.5 the flood capacity of the creek system is directly affected by maintenance factors, including overgrowth and unsuitable species of vegetation, channel erosion, deterioration of constructed channel walls and lining and placement or construction of other obstructions in or alongside channels.

The Channel Capacity Assessment (*AWE, 2012*) study has identified upper Brown Hill Creek as a major section of concern with channel capacities possibly reduced by about 20% since the early 1980s, with the worst problems being where the creek is in private ownership. It is recommended that specific locations should be the focus of upgrades and channel maintenance as part of the Part B Works process.

**13.7.6 Creek Ownership and Responsibilities for Maintenance**

Responsibility for maintenance of watercourses and the installation and maintenance of any flood mitigation works on private land, as between landowners and local and state public authorities, has been a contentious issue.

In most cases, and excluding those covered by the Metropolitan Drainage Act, responsibility for the care of the watercourse remains with the property owner. However, the significant cost of periodic erosion protection, vegetation control and flow capacity upgrades (*as development increases in the catchment*) has been and will continue to be outside most private owners' capacity to pay.

In conjunction with local councils, the AMLRNRMB provides brochures and information for private landowners so that they can better manage a watercourse that traverses their property. An example is the booklet titled '*Urban Creeks; A Property Owner's Guide to Managing Healthy Urban Creeks*', prepared in conjunction with the City of Burnside.

Some private land owners may take exception to any flood mitigation controls being exercised over their land, including powers of entry, even if actions are confined to the watercourse channel and banks. On the other hand, some landowners may expect public authority assistance in dealing with major problems of maintenance and associated costs.

Under Section 131 of the NRM Act, the AMLRNRMB has the power to direct the owner of land on which a watercourse is situated to take action to maintain the watercourse in good condition. There is currently no definition of 'good condition' in the NRM Act. Nevertheless, information is freely available which seeks to inform landowners on how to exercise proper care of a watercourse, and it has been suggested that a code of practice could be developed and given legal status by inclusion in a relevant Act (*Kelly, 2007*).

However, the Board does not use its section 131 powers lightly and only does so principally to uphold the objects of the Natural Resources Management Act, which are orientated essentially to natural resources management and ecological sustainability.



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In 2006 the Board developed an Urban Watercourse Landholders Assistance Policy, with objectives to:

- Stimulate the adoption of best practice for biodiversity and water quality improvement objectives;
- Encourage proactive maintenance regimes; and
- Encourage public ownership of major urban watercourses in the region.

The policy includes financial and technical assistance for watercourse rehabilitation as long as the principal objective is biodiversity or water quality improvement or protection.

In other powers available under the NRM Act, Section 31 gives the NRM Board power to enter onto private land for the purposes of stormwater management or flood mitigation. However, if the intention is to install permanent infrastructure or works, the Board must first acquire an easement (*or other appropriate interest*) over the land unless the landowner consents to undertake the necessary care, control and management of the works.

Similar land access and other powers exist for local government and the SMA under Section 21 of the Local Government (*Stormwater Management*) Amendment Act 2007. If the intention is to install permanent infrastructure or works, the council or the SMA must first acquire an easement or other appropriate interest over the land or acquire the land, unless the landowner consents to undertake the necessary care, control and management of the works.

Acquisition is required if the permanent infrastructure involves the constructing, maintenance or removal of infrastructure, excavation of any land, deepening, widening or changing the course of a watercourse, deepening or widening a lake, taking action to remove any obstruction to the flow of water and undertaking any form of work for the purposes of stormwater management or flood mitigation. However, it could be judged that deepening, widening a watercourse etc. does not involve permanent infrastructure, in which case the power could be exercised without the acquisition requirements.

The powers in Section 21 may only be exercised by councils or the Stormwater Management Authority where there is an approved stormwater management plan. However, councils have other powers to construct stormwater management works without having to rely on Section 21. The SMA can require a council to use the powers available under Section 21 by the issuing of an order under Section 16. Unfortunately, depending on the interpretation of the words in Section 16, there is some doubt as to whether such an order can apply to the maintenance of watercourses as distinct from infrastructure.

Compulsory acquisition of all private properties with urban watercourses is neither politically viable nor socially acceptable. At least one metropolitan council has purchased property along a watercourse, placed an easement on the title and then resold the property. However this is rare. More commonly councils have acquired or placed easements over parts of properties in order to obtain control of the watercourse.

One of the conditions of the previous schemes supplying financial assistance from state government to councils for major stormwater management (*flood mitigation*) work was the requirement to obtain reserves or easements over the land involved. This requirement is



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now reflected in Section 21 and it is expected that the SMA will require that reserves or easements be obtained for all locations where work contemplated by this SMP is undertaken and financial assistance from the Authority is sought, notwithstanding whether or not permanent infrastructure is involved.

However, relying on the purchase of properties when they come up for sale or where permanent works are to be undertaken as a means of exercising public control over the maintenance of watercourses would take many decades to fully implement based on the normal turnover of properties. Proactively approaching property owners with offers to buy or place an easement over the watercourse is another approach in terms of land required from individual properties and a more comprehensive approach in terms of coverage of the total watercourse.

The relevance of maintenance responsibility in catchment creeks is as follows:

- The SMP requires a section of the lower Brown Hill Creek channel to be upgraded to increase its capacity. How that will be achieved and potential impacts in respect of the privately owned sections and land adjoining the channel reserve will be the subject of a further detailed investigation of the BHKC Project.
- The SMP does not propose any mitigation measures on Keswick Creek (*except at the two bifurcation points where the diversion culverts transfer flow into Brown Hill Creek*). Therefore, except at one location, private ownership is not an immediate issue. Unlike parts of upper Brown Hill Creek, the privately owned sections generally do not improve the amenity of the land and, if tested, public acquisition may not prove to be a contentious issue.
- Similarly the works proposed on Glen Osmond Creek are in road or council reserve. Private ownership is not an immediate issue as regards implementing the structural recommendations of this SMP. However, one of the advantages of the proposed bypass culvert at Fisher Street is that it removes a poorly maintained section of creek from problematic access in private properties.
- The scope of any other creek upgrading (*and hence impact on private property*) of lengths of upper Brown Hill Creek is likely to be significant in light of the Channel Capacity Assessment study (*AWE, 2012*), whether the objective is to increase conveyance capacity for the full 100 year ARI storm (*full channel upgrade option*) or partial flow where there is a bypass system or for reduced flow as a result of implementing upstream detention.

It is noted that under the State Government's Stormwater Strategy there is an action to 'evaluate options for management of urban watercourses on public and private land to further minimise flooding risk.' The lead responsibility group to ensure appropriate governance arrangements are put in place on this action comprises the now Department of Environment, Water and Natural Resources in partnership with the Local Government Association, the AMLRNRMB and the State Emergency Services.

The councils will address creek maintenance responsibilities in the Part B Works process, in consultation with the above lead responsibility group, and an outcome will be included in the Final SMP.



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As part of that process the councils will consult with others and seek expert advice, as may be necessary, with the intention of clarifying legislative responsibilities for management and provision of funding resources (*as between the parties involved*) for routine maintenance.

**13.7.7 Maintenance**

Having an approved SMP in place presents an opportunity for the responsible entity (*which is intended to be a regional subsidiary in accordance with the Local Government Act*) to take a leadership role in seeking to achieve more effective maintenance of the Brown Hill Keswick Creek system, and particularly critical sections of upper Brown Hill Creek. A consultative strategic approach is recommended, with application of coercive powers as a last resort.

The approach could draw from a range of available options for which implementation details would be subject to extensive consultation and general support by watercourse landowners:

- Responsible entity to undertake regular surveys of watercourse condition and convey results directly to watercourse landowners – as the basis for consultation in identifying and recommending any necessary maintenance actions by landowners.
- Arrange with the landowner to have the watercourse restored to 'good condition', if necessary, and at no cost to the landowner.
- Acquire an easement over the watercourse in order that good practice controls and maintenance can be exercised by the responsible entity.
- In critical cases where channel capacity should be increased by significant works, apply Section 21 powers to deepen or widen the watercourse in conjunction with good practice measures and seeking to achieve a suitably landscaped form – at no expense to the landowner.

Typically, 'good condition' could be based on existing information such as that conveyed in the brochure '*Urban Creeks – A property owner's guide to managing healthy urban creeks*' produced by AMLRNRMB in conjunction with the City of Burnside. Generally, AMLRNRMB and local government provide brochures and information for private landowners so that they can better manage watercourses traversing their property. AMLRNRMB has advised that it is considering a code of practice which presumably would embody leading practice environmental principles.

A code of practice for maintenance of urban watercourses in terms of that proposed by Kelly and based on leading practice environmental principles is recommended. It is noted that at the time of preparing this SMP the initiative is being considered within the AMLRNRMB, and the BHKC Project would seek to be involved and provide assistance with any such initiative.



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## 13.8 STORMWATER HARVESTING AND REUSE

### 13.8.1 AMLRNRMB Report

The AMLRNRMB produced a report '*Stormwater Harvesting Plan*' in 2010 to inform this SMP regarding stormwater harvesting and reuse actions and opportunities within the catchment and for the report to be regarded as a complementary component of the SMP.

Information for the report was provided by (*then*) recent supporting studies, including major opportunities identified by the *Urban Stormwater Harvesting Options Study (Wallbridge and Gilbert, 2009)* and the *Water for Good strategy* of the State Government, as well as examining reuse opportunities from any proposed upper Brown Hill Creek catchment flood detention storage and possible harvesting and reuse opportunities in the eastern suburbs.

The Stormwater Harvesting Plan concluded the following:

- Existing stormwater harvesting projects (*identified below*) should be considered part of the BHKC Project, even though their role in flood mitigation is minimal.
- Flood detention storage proposed for the upper reaches of Brown Hill Creek could be modified to provide a steady yield from the rural catchment of up to 1.5 GL/year. However, likely demand and water treatment / MAR options reveal that at present there is insufficient justification for such an option. Also, such flow is not regarded to be "stormwater", but rather rural runoff.
- Fundamental stormwater reuse activities including WSUD and the use of rainwater tanks remain important actions to promote and where possible mandate and regulate in planning and building policies. However, those measures will not have a measurable impact on reducing the flood risk and hazards in the Brown Hill Keswick Creek catchment in the medium to long term.
- In regard to water quality and watercourse amenity stormwater management objectives, significant measures have been implemented in the catchment. There is a network of trash racks and silt trap facilities that remove litter, debris and sediment from the system before discharging to the marine receiving waters. There are also rural and urban watercourse restoration sites established. In addition, as part of the catchment management plan, there has been an industry, community and local government stormwater pollution control awareness program implemented. Importantly, there will be opportunities to incorporate further water quality improvement measures (*e.g. gross pollutant traps and wetlands*) as part of the physical works associated with the SMP.
- A detailed review of all the potential MAR schemes, water demands and the key flood management requirements in the catchment has not revealed any stormwater harvesting options that would significantly change, improve or enhance the key components of the stormwater management plan.
- Stormwater harvesting opportunities are based on the regular stormwater flows that occur throughout the winter period. Flood management options are founded on addressing the very rare, large and potentially catastrophic events that might happen once or twice in a lifetime. Opportunities that meet both of these water management objectives may not be readily available or may involve uneconomically high cost.





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**13.8.2 Existing Schemes**

The current status of identified stormwater harvesting schemes in the catchment is summarised below, including discussion of six of the schemes. Several of these schemes have been advanced from their status at the time of the NRM report.

The total stormwater harvesting and reuse (800ML/yr) from existing schemes and those being developed represents approximately 16% of the runoff generated within the urban catchment.

SCHEME	STATUS	HARVEST CAPACITY (ML/a)	PROPONENTS
Urrbrae wetland / Heywood Park MAR *	Funding secured / concept design / MAR proving underway	60	Cities of Mitcham and Unley
Claremont dam	Operational	10	University of Adelaide / City of Mitcham
Orphanage Park	Not proceeding	30	City of Unley
Victoria Park / South Park Lands *	Investigation / limited potential	100	BHKC Project
Disused railway corridor Plympton *	Preliminary assessment / funding application pending	1500	BHKC Project
Glenelg Golf Club *	Operational	300	Glenelg Golf Club
Adelaide Airport *	Funding secured / detailed design / construction	300	SA Water / Adelaide Airport Ltd
Ridge Park *	Funding secured / detailed design / construction planned	60	City of Unley
Scotch College	Operational	60	Scotch College
Hamilton Boulevard WSUD	Operational	10	City of Unley
Wattle Street WSUD	Construction	3	City of Unley

\* Further description below



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**13.8.3 Scheme Descriptions**

South Park Lands:

Construction of wetlands in the South Park Lands as part of the proposed stormwater detention system presents an opportunity to harvest approximately 350 ML/annum of stormwater for reuse. However, the capacity of a reuse scheme is limited by the capacity of aquifers in the area to store water. The suitability of aquifers in the vicinity for MAR has been investigated and is considered to be of low potential from a hydrogeological perspective, with capacity to store and recover a maximum of 100 ML/annum.

Whilst 100 ML/annum would be sufficient to irrigate about 15 ha, which is about the area of playing fields proposed for the southern half of Victoria Park, the area is able to be irrigated much more economically using the existing Glenelg treated wastewater supply. An alternative demand and a potential owner and operator have not been identified at this stage.

Ridge Park:

The Ridge Park scheme is being designed as a MAR scheme based on harvesting average seasonal flow from Glen Osmond Creek. However, the facility is being designed to enable yield from the creek to be increased by temporary storage in the proposed Ridge Park flood control dam of the SMP.

Multi-purpose objectives include reduction of potable water irrigation demand, improvement of stormwater quality, encouragement of plant biodiversity, overall environmental improvement and enhanced recreational benefits at Ridge Park and other reserves, including Fraser Reserve, Ferguson Avenue Reserve, Scammell Reserve and Fullarton Park Community Centre.

Glenelg Golf Club:

The MAR scheme, which can harvest up to 300 ML/annum for golf course irrigation enables the club to demonstrate a 100% recycled water rating. It is beneficial in terms of maintaining sustainability of the aquifer by utilising stormwater in place of the natural underground supply and decreasing salinity in the aquifer by 'refreshing' with wetland filtered stormwater.

Adelaide Airport:

SA Water, in cooperation with Adelaide Airport Limited, is designing a MAR scheme for commencement of operation in 2012. The bulk of the initial harvest capacity of 300 ML/annum from Brown Hill Creek is identified for on-airport facilities.

Urrbrae Wetland / Heywood Park:

The Cities of Unley and Mitcham are collaborating in a stormwater harvesting scheme involving the diversion of up to 60 ML/year of stormwater from Urrbrae Wetlands. The wetland basin will require modifications to provide 250 ML of balancing storage.

Stormwater will then be filtered at Urrbrae Wetlands before being piped to Heywood Park, Unley Park (*pipeline down Cross Rd and along Grove St*) for injection into bores. Recharge will involve ultra violet disinfection before pumping via a borehole well to the underlying



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aquifer. The stored groundwater is then to be extracted for parks irrigation via an adjacent borehole well in Heywood Park.

Consultation with interested parties is underway along with investigations into water licensing requirements and associated water and property rights that may affect a project of this nature. The project is to be completed by 31 May 2013.

Plympton railway corridor:

Biofiltration has been proposed by Wallbridge and Gilbert in the Urban Stormwater Harvesting Options Study (2009) to minimise the footprint needed for a wetlands system to service the size of a stormwater harvesting and reuse system proposed.

The land is owned by the Commissioner of Highways and is licensed to the West Torrens Council for open space purposes, with restrictions currently in place for certain activities which might prejudice future access for transport purposes.

Meetings with DPTI officials have revealed that there are no current plans for use of the land for transport purposes, but the intention is to investigate likely future needs prior to agreeing to release the land.

Agency officials appreciate that the proposed use of the land has significant community, business and resource use benefits and that the proposed use may not preclude its use for transport purposes. However its use as proposed is subject to formal approval by the state government.

In December 2011 the BHKC Project applied to the Commonwealth Government for funding assistance of \$20 million under the *National Urban Water and Desalination Plan: Stormwater Harvesting and Reuse Grants (Round 3)* to develop an MAR scheme in the disused railway corridor in proximity to lower Brown Hill Creek. The project concept was supported in-principle by key stakeholders including DPTI.

#### **13.8.4 Brown Hill Creek Flood Control Dam**

Further to the *Stormwater Harvesting Plan*, the consultant Wallbridge and Gilbert (W&G) was engaged by the AMLRNRMB in 2011 to review the practical opportunities of optimising stormwater harvesting from the proposed Brown Hill Creek flood control dams as identified in the 2006 Master Plan.

Wallbridge and Gilbert considered the following stormwater harvesting options for flood control dams:

1. Direct harvest from an active / permanent storage in the dams:

This option would require additional storage to be added to the dams in order to achieve the same flood mitigation potential. Height of dam is a critical factor in order to minimise visual impact, which detracts from this option.



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2. Diversion of flows to a local MAR using a small active storage:

This option is not envisaged to have any impact on flood mitigation effectiveness of the dams. However, the MAR potential in the upper catchment is poor to moderate and extremely variable. Due to the lower yield and recovery efficiency of fractured rock aquifers the scheme establishment costs in the upper catchment are likely to be double of an equivalent scheme in the lower catchment.

3. Temporary detention of water:

This would provide a slow release to increase yields at downstream sites and may require an increase in the volume of the dams to achieve the same flood mitigation potential.

Modelling indicates that total catchment yield is only marginally increased by harvesting at the dam sites. Throttling of flows from the dams provides an increased yield at the downstream sites in the order of 5%. Furthermore, harvesting in the lower catchment provides water supply closer to the demand points and hence at decreased reticulation cost.

Wallbridge and Gilbert concluded that:

- Approximately 1.5 – 1.7 GL/annum of median flow is generated from the rural part of the Brown Hill Keswick Creek catchment, compared with 6.5 GL/annum for the whole catchment.
- Approximately 75% of the identified potential yield is from the lower end of the catchment, where MAR potential in the aquifer is high.
- It is not recommended that large scale harvesting be undertaken at the proposed dam sites – subject to local demand for non-potable water in the region.
- If early throttling of flow rates from dams increases the required storage volumes of dams then it is unlikely to be worthwhile due to the relatively small increase that this achieves in total catchment yield.

Flood detention storage proposed for the upper reaches of Brown Hill Creek could be modified to provide a steady yield from the rural catchment of up to 1.5 GL/year. However, likely demand and water treatment / MAR options reveal that at present there is insufficient justification for such an option. Also, such flow is not regarded to be “stormwater”, but rather rural runoff.

### **13.8.5 Stormwater Reuse Goals**

As outlined in the *Stormwater Management Planning Guidelines*, a stormwater management plan objective is to set goals for the “extent of beneficial use of stormwater runoff”.

A detailed review of all the potential MAR schemes, water demands and the key flood management requirements in the catchment has not revealed any stormwater harvesting options that would significantly change, improve or enhance the key flood mitigation components of the stormwater management plan.



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Stormwater harvesting opportunities are based on the regular stormwater flows that occur throughout the winter period. Flood management options are founded on addressing the very rare, large and potentially catastrophic events that might happen once or twice in a lifetime. Opportunities that meet both of these water management objectives may not be readily available or may involve uneconomically high cost.

The *Stormwater Strategy* (refer Section 2.3) states that “*harvesting for reuse contributes to our water security....however, the end use, location of schemes, amounts harvested, storage options and prevailing hydro-geological conditions must be carefully considered when proposing harvesting schemes, as other sources of water may be available to better fit the need*”.

Fundamental stormwater reuse activities including water sensitive urban design and the use of rainwater tanks remain important actions to promote and where possible mandate and regulate in planning and building policies. However, those measures will not have a measurable impact on reducing the flood risk and hazards in the Brown Hill Keswick Creek catchment in the medium to long term.

It should be noted that the recently constructed GAP (*Glenelg to Adelaide Parklands*) pipeline, with lateral connections in the Cities of Unley and West Torrens, provides non-potable water to a number of areas within the catchment area that could otherwise be considered for supply via recycled stormwater. As a consequence, the remaining opportunities (*or customers*) for stormwater harvesting and reuse are more likely to be identified at a smaller scale.

Preparation of this SMP has not included investigations that would enable specific strategies or targets for increasing the volume of reuse to be established. Such strategies and targets will be negotiated with the AMLRNRMB during the Part B Works process for inclusion in the Final SMP.

### **13.9 SUMMARY OF OBJECTIVES AND OUTCOMES**

This section summarises how the objectives of the SMP (refer Section 5) are addressed with reference to the six strategies outlined in Sections 12.1 to 12.9.

#### **Objective 1.1**

*Provide an acceptable level of protection for the community and both private and public assets from flooding. Subject to economic justification, the objective is to provide a standard of flood protection for development equivalent to the 100 year ARI standard or better.*

Strategy: Structural Flood Mitigation Works

- At the whole of catchment scale, works (*Parts A and B*) are planned to mitigate the 100 year ARI flood conditions over approximately 90% of the catchment as outlined in **Table 15**. Over the remaining area the standard of protection would be at an acceptably higher level than is current.
- The Part A Works, covering all of the catchment except for upper Brown Hill Creek above Forestville Reserve, are defined to the stage where they can be implemented at an estimated cost of approximately \$119 million.



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- The Part A Works are considered effective either as a stand-alone flood mitigation scheme or as integral elements of the overall Plan for the catchment including Part B Works (*when defined*).
- Options have been considered for upper Brown Hill Creek (*Part B Works*) but the final works will be defined following further investigation which will be carried out within the defined Part B Works process.
- The full mitigation scheme (*effective for Part A and B works*) is estimated to have a benefit-cost ratio of approximately 0.65 based on tangible flooding impacts (*refer next section*). The benefit-cost ratio for the Part A works alone is estimated to be 0.65. Economic ratios of this order, for flood mitigation infrastructure, can be considered favourable in terms of project justification given that intangible factors are not included.

Strategy: Creek Ownership and Responsibilities for Maintenance

- Improved management of creek channels, including planned on-going maintenance will contribute to the overall effectiveness of conveying large stormwater flows.

**Objective 1.2**

*Enhance flood mitigation infrastructure with multi-purpose outcomes including visual, aesthetic and amenity improvements for the benefit of the wider community, where it is economically and socially feasible.*

Strategy: Structural Flood Mitigation Works

- The South Park Lands detention basins will incorporate a wetland which will provide enhanced amenity and recreational opportunities in the southern end of Victoria Park.
- Similarly, the detention basin in Ridge Park (*including MAR storage*) will incorporate recreational and aesthetic improvements along the creek in the vicinity of the works.
- For the upgrade of Brown Hill Creek channel between Forestville Reserve and Anzac Highway there is potential to enhance the public reserve area which adjoins or contains the creek channel (*including Wilberforce Walk*).
- For the lower Brown Hill Creek channel upgrade (*downstream of Anzac Highway*), there is potential to incorporate amenity features and environmental enhancements generally along the channel reserve for most of its length.

**Objective 1.3**

*Provide flood forecasting and warnings, and flood preparedness measures to help the community reduce any residual damages to property and risk to life during major flood events, particularly in high hazard areas.*

Strategy: Community Awareness, Flood Preparedness and Emergency Response

- There is evidence that the program is beneficial in raising awareness of the impacts of flooding and mitigation measures that individuals and community groups can take, particularly in respect of protecting private property.





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- Councils continue to support the Floodsafe program and recommend that it be enhanced by State Emergency Services. Councils will continue to work with State Emergency Services in developing and implementing a new Emergency Response Plan for Brown Hill and Keswick Creeks.

**Objective 1.4**

*Ensure that new stormwater infrastructure does not increase the risk of flooding in downstream areas.*

Strategy: Structural Flood Mitigation Works

- The project has been designed such that all the infrastructure elements including upgraded channels will enable the full stormwater flow to be conveyed through the system with minimal risk of localised downstream flooding.

**Objective 2.1**

*Stormwater discharged to the marine environment should meet targets that are set from time to time including targets in the EPA's Adelaide Coastal Water Quality Improvement Plan.*

Strategy: Structural Flood Mitigation Works

- Flood detention basins in the South Park Lands (*Parklands Creek*) and in Ridge Park (*Glen Osmond Creek*) have been designed to improve the water quality of normal stream flow through the sites. The South Park Lands project incorporates a wetland in Victoria Park preceded by the Glenside silt trap.
- A flood control dam in the rural catchment of upper Brown Hill Creek if it were to be included in the Part B Works would be beneficial in reducing the adverse impact of high stormwater flows transporting sediments potentially into receiving waters.
- For the lower Brown Hill Creek channel upgrade, there is potential to reduce stream bed and bank erosion and consequent transport of sediments into the lower sections of Brown Hill Creek including the receiving waters in the gulf.

Strategy: Creek Ownership and Responsibilities for Maintenance

- Gross Pollutant Traps (*GPTs*) and silt traps have already been established along the creek channels by the AMLRNRMB and its predecessor to reduce contamination and pollution from entering the catchment receiving waters. Also, the existing (*off-stream*) Urrbrae wetlands serves the same purpose in respect of significant stormwater inflow to upper Brown Hill Creek.
- Preparation of this SMP has not included investigations that would enable specific runoff quality targets to be set. Management of the quality of runoff and its effect on receiving waters will be negotiated with the AMLRNRMB during the Part B Works process for inclusion of targets in the Final SMP.



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Strategy: Stormwater Harvesting and Reuse

- Proposed stormwater harvesting initiatives at Ridge Park and Heywood Park (*and the potential offered by South Park Lands*) together with other stormwater harvesting schemes already established in the catchment provide significant reduction in the volume of stormwater discharged into marine receiving waters

**Objective 3.1**

*Maximise the reuse of stormwater for beneficial purposes including watering of community and private open spaces where feasible.*

Strategy: Structural Flood Mitigation Works

- A stormwater harvesting scheme utilising a MAR system is being developed by Unley Council in conjunction with the Ridge Park detention basin.
- The South Park Lands detention basins are being designed to enable retrofitting of a stormwater harvesting facility (*such as MAR*) should the water demand in the immediate area eventuate and prove to be of value.
- A flood control dam in the rural catchment of upper Brown Hill Creek if it were to be included in the Part B Works could be configured to provide a significant yield of runoff from the catchment (*albeit such flow would not be classified as stormwater*). However, at this stage there is insufficient justification for such facility.

Strategy: Stormwater Harvesting and Reuse

- Total stormwater harvesting and reuse from existing schemes in the catchment represents approximately 16% of the runoff generated within the urban part of the catchment.
- Additional stormwater harvesting opportunities provided by certain proposed flood mitigation works at Ridge Park, Heywood Park and South Park Lands are identified.
- The project has applied to the Commonwealth Government for funding assistance under the National Urban Water and Desalination Plan to develop an MAR scheme in the disused railway corridor in proximity to lower Brown Hill Creek (*supported in-principle by key stakeholders including DPTI*).
- Preparation of this SMP has not included investigations into specific strategies or targets for increasing the volume of reuse to that already established. Such strategies and targets will be negotiated with the AMLRNRMB during the Part B Works process for inclusion in the Final SMP.

**Objective 3.2**

*Where possible the drainage network should incorporate WSUD systems that aim to capture road runoff to replenish soil moisture for maintenance of street trees and plantings.*



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Strategy: Planning Policy and Development Assessment

- WSUD systems are being incorporated into refurbished and new streetscape developments within the catchment, mainly by councils, and it is proposed that such systems continue to be installed as opportunities arise.

**Objective 3.3**

*Encourage on-site use of stormwater by installation of rainwater tanks, detention and retention systems in order to minimise the adverse runoff impacts of urban infill.*

Strategy: Planning Policy and Development Assessment

- Councils will endeavour to incorporate/mandate WSUD in neighbourhood level planning.
- Councils will implement planning policy measures which seek to limit stormwater discharge from new developments to predevelopment volumes and peak rates of discharge.

**Objective 4.1**

*Watercourses and creeks in public and private ownership should be managed to an acceptable standard.*

Strategy: Structural Flood Mitigation Works

- In undertaking further studies for the Part B Works it will be necessary to consider restoration of channel flow conveyance capacity along upper Brown Hill Creek to levels which were estimated in the 1980s. This presents an opportunity to improve the condition of the creek including removal of obstructions and overgrowth of vegetation, particularly exotic and pest species.

Strategy: Creek Ownership and Responsibilities for Maintenance

- A code of practice for maintenance of urban watercourses in terms of that proposed by Kelly is recommended. It is noted that at the time of preparing this SMP a code of practice is being considered within the AMLNRMB, and the BHKC Project would seek to be involved and provide assistance with any such initiative.

**Objective 4.2**

*Where practicable and economically feasible, watercourses should be preserved in as natural condition as possible and should be revegetated and managed to maximise their ecological values and functions and to minimize any potential for stream erosion.*

Strategy: Structural Flood Mitigation Works

- With the South Park Lands detention basins a more natural ephemeral creek system will be created through the reintroduction of a range of aquatic macrophytes and riparian species, as well as the conditions for replenishing soil moisture stores for terrestrial plants.
- In the South Park Lands project there will be an improvement in the biodiversity of each site through the inclusion of native vegetation and habitat opportunities. The wetlands will slow down



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water flow and provide further treatment prior to returning water back into Parklands Creek, thereby improving water quality.

- As part of the Ridge Park detention basin and MAR works there will be stream rehabilitation and biodiversity improvements.
- Works along the channel of upper Brown Hill Creek (*both in Part A and potentially in Part B*) would incorporate removal of exotic vegetation, thereby providing ecological benefits.

Strategy: Creek Ownership and Responsibilities for Maintenance

- It is recommended that any creek maintenance be carried out in accordance with leading practice environmental principles and that any code of practice for maintenance of urban watercourses being considered (*Objective 4.1*) should embody such principles.

**Objective 4.3**

*Allow sufficient environmental flows to maintain water dependent ecosystems.*

Strategy: Structural Flood Mitigation Works

- Works which involve detention of stormwater flows (*South Park Lands and Ridge Park*) are being designed to accommodate environmental flows in accordance with advice from the Department of Environment, Water and Natural Resources. Any flood control dam in the rural catchment of upper Brown Hill Creek would be designed to enable the passage of normal creek flows.

**Objective 5.1**

*Open space should be utilised to achieve maximisation of permeable surfaces, on site retention and infiltration and stormwater reuse wherever possible.*

Strategy: Planning Policy and Development Assessment

- Councils recognise that WSUD provides an opportunity to assist in the management of flooding risk in the context of new development and urban consolidation. WSUD includes integrating stormwater treatment into the landscape and minimising runoff and peak flow through local retention and detention.
- Councils will undertake investigations during the Part B Works process to obtain greater understanding of potential impacts of infill development on generation of stormwater runoff and propose improved planning policies or controls for addressing the risks.
- The above strategies in respect of Objective 3.3 are also relevant to this objective.

**Objective 5.2**

*All new development must be built at a level that ensures buildings are not subject to inundation during a 100 year ARI flood.*



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Strategy: Planning Policy and Development Assessment

- Councils will adopt Development Plans that are in accordance with SAPPL policies which include a Development Plan overlay showing high and medium flood hazard areas and 100 year ARI flood levels.
- Councils will consider, in respect of flood prone areas, the adoption of development assessment guidelines similar to those which were the subject of a (2010) report to Unley Council.
- Councils generally will prohibit new development that would obstruct or interfere with a watercourse or is at high risk of flooding.

**Objective 5.3**

*New development should be constructed so as to not cause an increase in 5 year ARI flow rates or volumes.*

Strategy: Planning Policy and Development Assessment

- Councils will consider adopting Development Plans that are in accordance with SAPPL policies which seek to ensure that new development does not reduce the capacity or functionality of the existing stormwater drainage network.
- The above strategies in respect of Objective 5.1 are also relevant to this objective.

**Objective 6.1**

*Stormwater infrastructure should be managed sustainably by development of asset management and other necessary plans for on-going management, operation and maintenance.*

Refer to Section 15 (*Implementation*) that addresses management planning.

Strategy: Creek Ownership and Responsibilities for Maintenance

- There is lack of agreement and understanding between landowners, local government (*catchment councils*) and state government (*through the AMLRNRMB*) concerning responsibilities for maintenance of urban creeks in private property.
- It is noted that under the State Government's Stormwater Strategy there is a Lead Responsibility group of agencies to 'evaluate options for management of urban watercourses on public and private land to further minimise flooding risk.'
- The councils will address creek maintenance responsibilities in the Part B Works process, in consultation with the lead responsibility group, and include an outcome in the Final SMP.
- As part of that process the councils will consult with others and seek expert advice, as may be necessary, with the intention of clarifying legislative responsibilities for management and provision of funding resources (*as between the parties*) for routine maintenance.



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**Objective 6.2**

*A governance framework will be established based on having a single entity (nominally a regional subsidiary in terms of the Local Government Act) responsible for management of project infrastructure.*

Refer to Section 15 (*Implementation*) that addresses governance over the SMP.

- A charter is being prepared which will form the basis of a legal agreement between the councils for the formation and operation of a regional subsidiary in terms of the Local Government Act. The regional subsidiary would be responsible for construction and on-going maintenance of the flood mitigation infrastructure and management of the SMP

**Objective 6.3**

*Financial budgeting and funding arrangements (as between councils and other potential funding contributors) necessary for the timely and effective implementation of the SMP (including construction and maintenance of infrastructure) will be established.*

Refer to Section 15 (*Implementation*) that addresses financial and budgetary planning for the SMP.

- The councils have agreed on the cost apportionments between themselves in respect of the local government share of the overall project costs (*capital, maintenance and administration*).
- Councils' preferred funding model is based on each sphere of government (*Commonwealth, State and local*) contributing a one third share of the overall project capital cost.
- A ten year design and construction program for all the works comprising Parts A and B is planned.





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## 14. BENEFIT-COST ANALYSIS

As outlined above in **Section 9**, benefit-cost analysis is undertaken to assess the economic viability of implementing flood mitigation works. It involves the comparison of the cost of the works with the expected benefit that will result from their implementation.

The benefit is typically estimated as the reduction in flood damages that will be provided by constructing the proposed works. This is the approach that has been adopted during preparation of the SMP.

It should be recognised that the additional multi-purpose benefits associated with the works are difficult to quantify (*e.g. increased recreational and visual amenity*) and therefore, these have not been incorporated into the benefit-cost analysis for the SMP.

Furthermore, the benefit associated with any potential overlap of the proposed management options with other stormwater management benefits, such as stormwater harvesting, has also been omitted from the analysis due to the difficulties in quantifying the benefit in dollar terms.

Accordingly, it is considered that the benefit-cost analysis outlined in the following provides a conservative indication of whether the proposed works are worthwhile from an economic perspective.

The benefit-cost methodology has been independently reviewed (*Evans & Peck, 2011*).

### 14.1 REDUCTION IN FLOOD DAMAGES (CATCHMENT-WIDE WORKS)

The tangible flood damages for the 2011 Draft SMP floodplain maps shown in **Figures 29 to 32** were calculated using the *waterRIDE* GIS software in accordance with the method outlined in **Section 7.4**.

The 100, 50 and 20, 10 and 500 year ARI damages for the proposed works flood mapping are presented in **Table 17**. These damages estimates were compared with the existing conditions Base Case damages documented in Section 7.4 to determine the reduction in damages afforded by the works. The analysis has not included any estimate of the reduction in intangible flood damages (*e.g. trauma, stress and anxiety of flood victims*), which may be as high as the tangible damages amount.

Non-structural floodplain management measures such as flood preparedness and emergency response could be expected to further reduce overall flood damages.

As shown in **Table 17**, the reduction in 100 year ARI damages is expected to be more than **\$168M**, which is equivalent to a reduction of more than 90%. This result is a reflection of the comprehensive scheme of works that is recommended, which is expected to both reduce the peak flow from the upstream catchment areas and also minimise any residual overtopping from the channels as water passes down through the floodplain.



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**TABLE 17 REDUCTION IN FLOOD DAMAGES (CATCHMENT-WIDE WORKS)**

DESIGN FLOOD MAP	FLOOD DAMAGES (\$ 2012)		
	BASE CASE	STORMWATER MANAGEMENT PLAN WORKS	REDUCTION
10 Year ARI	\$12,929,000	\$3,448,000	\$9,481,000
20 Year ARI	\$71,839,000	\$7,754,000	\$64,085,000
50 Year ARI	\$141,581,000	\$11,163,000	\$130,418,000
100 Year ARI	\$186,587,000	\$17,802,000	\$168,785,000
500 Year ARI	\$424,713,000	\$111,497,000	\$313,216,000
Probable Maximum Flood (PMF)	\$1,000,000,000 *	\$1,000,000,000	\$0
Average Annual Damages	\$11,478,000	\$2,510,000	\$8,968,000

\* Note – Base Case PMF damages are a rough estimate based on original estimates contained in the Floodplain Mapping Study (Hydro Tasmania, 2003)

As shown in the table, the calculation of Average Annual Damages (AAD) for the Stormwater Management Plan works has assumed that there will be no impact on damages for the Probable Maximum Flood (PMF), which is a conservative approach for lack of any model results. In reality, there would be expected to be a certain level of protection offered by the mitigation works.

**14.2 BENEFIT-COST ANALYSIS (CATCHMENT-WIDE WORKS)**

A detailed benefit-cost analysis was undertaken as part of the *Stage 1 Technical Report* during development of the 2006 Master Plan. This work involved undertaking sensitivity analyses for various parameters in the benefit-cost evaluation, such as discount rates and timeframes for implementation of the structural works.

As expected, the results showed that implementation of the structural works (*and hence realisation of the flood damages reduction*) as soon as possible provides a more favourable benefit-cost outcome. However, this requirement is likely to be constrained by the limits of council and government funding budgets.

It is proposed that the structural works components be undertaken according to a ten year build program. Further information on the scheduling of work is provided in Section 14.

The capital costs for the proposed works are summarised above in **Table 13**. The costs for non-structural options are also documented above in Section 12.6 to 12.9 (*where applicable, beyond the normal operational cost for councils*).



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In terms of ongoing costs for the Stormwater Management Plan, an allowance has been made up to 0.2% of the CAPEX value of works for the previous 2 years for specific maintenance of the proposed mitigation works. This is separate to the regular maintenance of the channel, the cost of which is expected to be borne by councils' budgets individually.

The total costs over a 30 year period have been brought back to an estimate of present cost using a 7% real discount rate.

The benefit-cost calculations for the SMP are provided in **Appendix L** for the recommended build program of ten years for the complete suite of structural works. A summary of the analysis is provided in **Table 18**.

**Table 18 SUMMARY OF BENEFIT-COST ANALYSIS (CATCHMENT-WIDE WORKS)**

	BASE CASE <i>(No Works)</i>	STORMWATER MANAGEMENT PLAN 10 YEAR BUILD PROGRAM
Average Annual Damages	\$11.5M	\$2.51M *
Present Value Damage Reduction	0	\$68.8M
Present Value Costs	-	\$106.1M
Benefit Cost Ratio	-	0.65
Net Present Value	-	-\$37.3M

*Note: Calculated over a 30-year period at a real discount rate of 7% per annum. Costs and benefits increase over the 10 year implementation period according to analysis provided in Appendix L.*

*\* Following completion of structural works (i.e. after 10 year build program)*

The Benefit-Cost Ratio (BCR) is approximately **0.65**, which is considered to be a conservative estimate in light of the following:

- Intangible damages, such as long-term social impacts and trauma experienced by flood victims, have not been quantified and therefore, the benefit of the stormwater management strategy in reducing these damages has not been assessed. As discussed above, it is possible that the intangible damages could at least match the tangible damages amount. If this is the case, then it is expected that the BCR could be increased to at least 1.2 to 1.5.
- The multi-purpose benefits, such as improved recreational amenity, biodiversity and stormwater reuse, have not been quantified in dollar terms. Consideration of these benefits would increase the BCR.

As discussed in Section 12.4, the reduction in flooding provided by the proposed bypass culvert at Fisher Street has not been tested using the hydraulic model. However, it has been determined that



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if the breakout from Glen Osmond Creek is removed between Fullarton Road and Windsor Street, then the residual 100 year ARI flood damages (refer **Table 17**) would be reduced by a further **\$10M**.

**14.3 BENEFIT-COST ANALYSIS (COMPLETION OF PART A WORKS ONLY)**

The tangible flood damages for the Part A works floodplain maps shown in **Figures 33 to 36** were calculated using the *waterRIDE* GIS software.

The 100, 50 and 20, 10 and 500 year ARI damages for the proposed Part A works flood mapping are presented in **Table 19**. These damages estimates were compared with the existing conditions Base Case damages documented in Section 7.4 to determine the reduction in damages afforded by the works.

**TABLE 19 REDUCTION IN FLOOD DAMAGES (PART A WORKS)**

DESIGN FLOOD MAP	FLOOD DAMAGES (\$ 2012)		
	BASE CASE	STORMWATER MANAGEMENT PLAN PART A WORKS	REDUCTION
10 Year ARI	\$12,929,000	\$3,492,000	\$9,437,000
20 Year ARI	\$71,839,000	\$9,509,000	\$62,330,000
50 Year ARI	\$141,581,000	\$18,698,000	\$122,883,000
<b>100 Year ARI</b>	<b>\$186,587,000</b>	<b>\$63,204,000</b>	<b>\$123,383,000</b>
500 Year ARI	\$424,713,000	\$233,143,000	\$191,570,000
Probable Maximum Flood (PMF)	\$1,000,000,000 *	\$1,000,000,000	\$0
Average Annual Damages	\$11,478,000	\$3,751,000	\$7,727,000

\* Note – Base Case PMF damages are a rough estimate based on original estimates contained in the Floodplain Mapping Study (Hydro Tasmania, 2003)

As shown in the table, the reduction in 100 year ARI damages is expected to be approximately **\$120M**, which is equivalent to a reduction of about 65%. This indicates that there is expected to be significant interim benefit in undertaking only the proposed Part A works; i.e., while the Part B component of works is being further investigated.

The benefit-cost calculations if only the Part A works are completed are provided in **Appendix M** for a build program of nine years. A summary of the analysis is provided in **Table 20**.



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**Table 20 SUMMARY OF BENEFIT-COST ANALYSIS (PART A WORKS ONLY)**

	BASE CASE <i>(No Works)</i>	PART A WORKS 9 YEAR BUILD PROGRAM
Average Annual Damages	\$11.5M	\$3.75M *
Present Value Damage Reduction	0	\$58.5M
Present Value Costs	-	\$89.8M
Benefit Cost Ratio	-	0.65
Net Present Value	-	-\$31.3M

*Note: Calculated over a 30-year period at a real discount rate of 7% per annum. Costs and benefits increase over the 9 year implementation period according to analysis provided in Appendix M.*

*\* Following completion of structural works (i.e. after 9 year build program)*

The Benefit-Cost Ratio (BCR) for the Part A Works is approximately **0.65**, which is similar to the BCR for implementation of the full flood mitigation scheme. This indicates that the reduced flood damages benefit associated with the Part A works is somewhat balanced by the reduced cost of the works (i.e., excluding the cost of works such as bypass culverts and flood control dams on upper Brown Hill Creek).

While the BCR for the Part A Works is similar to the full SMP works, it should be recognised that under this scenario there would be no flood mitigation benefit provided to residents along Brown Hill Creek upstream from Forestville Reserve.



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## **15. IMPLEMENTATION OF THE SMP**

### **15.1 PRIORITIES AND TIMEFRAMES**

The proposed structural works components have been developed as a package of works that collectively are required to achieve the flood management outcomes of the SMP.

There is a logical progression in which works need to be undertaken. This progression is not established according to the effectiveness of the individual works, but rather the requirement to ensure that the staging of the works does not result in the temporary transfer of the flood problem elsewhere. The timing of works has also considered that the total cost in any one year is not excessive in respect of budgetary requirements of catchment councils and other spheres of government.

An additional constraint in the project build program is the 2012 SMP Strategy, which allows the program to proceed with Part A works first while Part B works on upper Brown Hill Creek are being further investigated.

Further details of the logical progression of works are as follows:

- Non-structural initiatives, such as planning measures and the flood awareness program, will have immediate benefits and therefore, should be implemented at the earliest opportunity.
- Works involving temporary detention of flood waters can proceed at any time. They will provide benefit even if other works are not completed, and therefore, it is recommended that they commence as soon as possible.
  - ⇒ In the case of Ridge Park detention dam the works are planned to be constructed in early 2013 in order for the detention storage to be operational in conjunction with the MAR component of the project for which there is a operations commencement deadline of June 2013 under the funding assistance agreement between Unley Council and the Commonwealth.
  - ⇒ In the case of South Park Lands the Glenside campus detention basin of the project is planned to be constructed in the latter half of 2013 in order to be coordinated with the program of site development works being undertaken by the Department of Health. Coordination of basin construction with the development works will result in a financial saving to the BHKC Project.
- Major channel upgrades should progress from downstream to upstream and ideally should follow the construction of flood detention systems, because the channel upgrades have typically been sized to cater for reduced outflows from the detention systems.
  - ⇒ In the case of proposed channel upgrades along lower Brown Hill Creek, the critical design flow is governed by 90 minute storm and therefore, the sizing of channel upgrades is not dependent on whether upper catchment detention is provided.
  - ⇒ For the short section of Brown Hill Creek from Anzac Highway to Forestville Reserve it is expected that the design flow will be resolved before the time that this section is





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programmed for detailed design and construction. In the event that the design flow is unresolved a 'no dam' (*undetained*) flow could be assumed, as this is not significantly greater than the detained flow and the cost to upgrade to the higher flow capacity in this section is not excessive.

- Works involving flow transfer between creek systems must be staged to follow downstream channel upgrades.
- Works involving localised channel capacity improvements can also proceed at any time, provided the increased capacity does not transfer flooding problems to downstream locations. To ensure that this does not happen, these works should take place after associated detention systems and downstream channel capacity upgrades have been completed.

The proposed 10 year implementation program for the structural works is provided overleaf.

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Works Program

Year	1	2	3	4	5	6	7	8	9	10
	2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22
<b>Works</b>										
Ridge Park Detention System	Works									
South Park Lands Detention System	Design	Works								
Lower Brown Hill Creek Channel Upgrade	Design		Works							
Keswick Creek Diversion Culverts			Design		Works					
Anzac Hwy to Forestville Reserve Channel Upgrade				Design		Works				
Bypass Culvert at Fisher St							Design	Works		
Part B Works (1)						Design	Works			
Part B Works (2)							Design	Works		
Part B Works (3)								Design	Works	

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**15.2 FUNDING PROGRAM**

The proposed 10 year funding program for the Stormwater Management Plan is provided below.

Values in \$ '000 (Real Terms)	Year	1	2	3	4	5	6	7	8	9	10	Totals
		2012/13	2013/14	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	
<b>Part A Works</b>	<b>Previous</b>											
Ridge Park Detention System	30	972	57	-	-	-	-	-	-	-	-	1,059
South Park Lands Detention System	373	175	7,600	7,600	1,889	-	-	-	-	-	-	17,637
Lower Brown Hill Creek Channel Upgrade		435	500	12,500	17,500	15,000	3,197	-	-	-	-	49,132
Keswick Creek Diversion Culverts	131	-	-	100	650	5,500	12,000	10,000	3,470	-	-	31,851
Anzac Hwy to Forestville Reserve Channel Upgrade		-	-	-	50	300	5,500	7,500	1,530	-	-	14,880
Bypass Culvert at Fisher St		-	-	-	-	-	-	200	3,000	1,345	-	4,545
<b>Sub-Totals</b>	<b>534</b>	<b>1,582</b>	<b>8,157</b>	<b>20,200</b>	<b>20,089</b>	<b>20,800</b>	<b>20,697</b>	<b>17,700</b>	<b>8,000</b>	<b>1,345</b>	<b>-</b>	<b>119,104</b>
<b>Part B Works</b>	<b>160</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>500</b>	<b>2,500</b>	<b>10,500</b>	<b>8,700</b>	<b>6,109</b>	<b>28,469</b>
<b>Total Works Costs</b>	<b>694</b>	<b>1,582</b>	<b>8,157</b>	<b>20,200</b>	<b>20,089</b>	<b>20,800</b>	<b>21,197</b>	<b>20,200</b>	<b>18,500</b>	<b>10,045</b>	<b>6,109</b>	<b>147,573</b>
Maintenance (0.2% of CAPEX to previous 2 yrs)		-	-	5	21	61	102	143	186	226	263	
SMP Administration Costs	915	230	230	230	230	230	230	230	200	150	150	
SMP Study and Consultation	730	125	50									
<b>Total Costs</b>	<b>2,339</b>	<b>1,937</b>	<b>8,437</b>	<b>20,435</b>	<b>20,340</b>	<b>21,091</b>	<b>21,529</b>	<b>20,573</b>	<b>18,886</b>	<b>10,421</b>	<b>6,522</b>	

Notes

1. Program assumes construction of Ridge Park commences in about January 2013, South Park Lands in about June 2013, and Lower BHC upgrade in approx. mid 2014.
2. Ridge Park is timed to coordinate with MAR works at the site by Unley Council.
3. Diversions necessarily follow Lower Brown Hill Creek upgrade. They could be brought forward, but are delayed to lessen expenditure peak in 2014/15 and 2015/16.
4. Annual maintenance cost, at 0.2% of capital cost to the previous 2 years, would peak at approximately \$290,000 per annum.



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**15.3 IMPLEMENTATION RESPONSIBILITIES**

This SMP has been developed, in the main, to address major catchment wide flooding issues as distinct from local drainage issues, and reflects the following principles:

- All spheres of government have an interest in reducing the flood risk;
- The planning, construction and maintenance of a major regional flood mitigation scheme should be managed and funded cooperatively by all spheres of government;
- The proposed works are the type of works covered by the 2006 Stormwater Management Agreement between the State of South Australia and the South Australian Local Government Association;
- Cost sharing between Commonwealth, State and Local Government should reflect their commitment to investing in and maintaining an effective, integrated flood mitigation scheme and should avoid cost shifting;
- Cost sharing between councils should reflect both the extent of their contribution to the problem and the benefits that they each receive from any flood management actions and not be related to the specific location where those actions are implemented; and
- The approach should be as simple and transparent as is reasonably possible.

For example, it is contemplated that ongoing maintenance and management of the scheme would involve State and Local Government, working in terms of the Natural Resource Management Act and the Local Government Act respectively.

It is assumed that the management of internal council drainage systems that feed stormwater into the major trunk drains and watercourses and transfer stormwater through the catchment and across council boundaries remains the responsibility of individual councils.

It is noted that the BHKC Project will upgrade certain existing stormwater mitigation assets along lower Brown Hill Creek which currently are maintained by the state. It is expected that general maintenance of such assets will continue to be a state responsibility.

Local Government cooperation will be achieved through a regional subsidiary of the catchment councils which will be established to manage Local Government's responsibilities under the SMP.

As part of the 2012 SMP strategy (*Section 3.3*) there is commitment to prepare a charter as the basis of a legal agreement between the councils defining the creation and operation of the regional subsidiary for governance of the project and responsibility for proper management of the SMP including construction, operation and maintenance of assets owned by the BHKC Project through the regional subsidiary and on-going management of other flood mitigation strategies, in partnership with or with the support of state government agencies.



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The charter is being prepared through a working group of senior representatives of each of the councils. Key matters being addressed in the charter include:

- Board governance
- Management, administration and technical assistance
- Financial contributions by constituent councils for capital and on-going maintenance and operational costs
- Business, financial and asset management planning
- The ambit for construction, maintenance and operational matters
- Conditions for withdrawal by a constituent council
- Dissolution of the regional subsidiary
- Use of catchment stormwater

It is planned that final negotiations and legal due diligence for charter preparation will be undertaken subject to gazettal of the SMP and execution of the charter completed before major construction is commenced.

It is also planned to seek agreements with other stakeholders in respect of funding and other obligations and responsibilities in which there is mutual interest or for which performance by the regional subsidiary may depend.

The regional subsidiary would need to work with the SMA to secure state and Commonwealth funding and to manage on-going maintenance and operation of assets which broadly encompass the watercourses in addition to the stormwater mitigation structural components.

This SMP also recommends increased commitment in flood preparedness which may be best implemented at the local level without need for the Regional Subsidiary to oversee these actions (*because the benefits are received directly by the people involved*). Local councils should therefore be encouraged to implement these actions for their own areas, in conjunction with assistance from the State Emergency Services. However, there may be a role for the Regional Subsidiary to coordinate and ensure a consistent approach between councils.

This SMP also proposes opportunities for councils to improve their approach to managing new development to reduce flood risk and to achieve multi-benefit outcomes. Implementation of these opportunities should be the responsibility of councils.



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## 15.4 FUNDING ARRANGEMENTS AND COST SHARING

### 15.4.1 Cost Sharing between Councils

The proposed cost sharing arrangement for the SMP is based on the following principles:

- That the proposed works are the type of works covered by the 2006 agreement between the State of South Australia and the South Australian Local Government Association on Stormwater Management and in particular, both spheres of government each have interest in reducing flood risk;
- Cost sharing between councils should reflect both the extent of their contribution to the problem and the benefits that they each receive from any flood management actions and not be related to the specific location where those actions are implemented; and,
- The approach should be as simple and transparent as is reasonably possible.

The starting point for proposed local government cost apportionment is based on the benefits that each council will receive from the proposed mitigation works. These benefits are considered in two forms:

1. Benefit from the reduction in flood damages; and,
2. Benefits from urban development that has already or may take place in the future that will contribute to the flooding problem downstream.

Consideration of both of these benefits is consistent with the preferred cost sharing approach outlined in by the Urban Stormwater Initiative (2005, 2006), which is based on a study by KBR (2004) and Lipp & Kemp (2002). It is proposed that equal weighting be given to these two types of benefits. The benefit in terms of flood damage reductions has been estimated by reviewing flood damages on a council by council basis for both the Base Case (*existing conditions*) floodplain mapping and the Stormwater Management Plan floodplain mapping (*full suite of works including Part A works and Part B works*).

As discussed above, the Average Annual Damages have been calculated for floods up to and including the 500 year ARI flood. The reduction in damages across each council area is shown in **Table 21**.

This analysis was completed as part of investigations for the 2011 Draft SMP and therefore, the dollar values in the table reflect 2011 dollars. Notwithstanding this, the analysis is considered relevant and appropriate in terms of estimating the relative proportion of the damages provided to each council area (*refer Table 22*).





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**Table 21 REDUCTION IN AVERAGE ANNUAL DAMAGES**

COUNCIL AREA	AVERAGE ANNUAL DAMAGES <i>(up to 500 Year ARI event)</i>		
	BASE CASE <i>(No Works)</i>	FLOOD MITIGATION SCHEME <i>(PART A + B)</i>	REDUCTION
Burnside	\$142,000	\$67,000	\$75,000
Adelaide	\$53,000	\$26,000	\$27,000
Unley	\$2,645,000	\$1,082,000	\$1,563,000
Mitcham	\$129,000	\$72,000	\$57,000
West Torrens <i>(including the airport)</i>	\$7,458,000	\$1,189,000	\$6,269,000

\* All values are in 2011 \$

**Table 22 SHARE OF REDUCTION IN DAMAGES BY COUNCIL AREA**

COUNCIL AREA	PERCENTAGE SHARE OF FLOOD DAMAGE REDUCTION
Burnside	0.9%
Adelaide	0.3%
Unley	19.6%
Mitcham	0.7%
West Torrens <i>(including the airport)</i>	78.5%

The benefits from past and future urban development and their contribution to increased flows have been apportioned based on the impervious areas within each council area using a projected infill development case. These areas were estimated during development of the 2006 Master Plan and are primary inputs to the hydrologic model on which the testing of the various mitigation scenarios was based.



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The share of impervious catchment area between the councils is presented in **Table 23**.

**Table 23 SHARE OF IMPERVIOUS AREA BY COUNCIL AREA**

COUNCIL AREA	IMPERVIOUS AREA OF CATCHMENT WITHIN EACH COUNCIL AREA <i>(Hectares)</i>	PERCENTAGE OF CATCHMENT-WIDE IMPERVIOUS AREA
Burnside	190	17.1%
Adelaide	138	12.4%
Unley	238	21.3%
Mitcham	184	16.5%
West Torrens <i>(including the airport)</i>	364	32.7%

The share of impervious area and of flood damages reduction were both considered in determining an average apportionment of cost between the councils (*i.e. a 50% weighting is applied to both benefits, refer Table 24*).

**Table 24 CALCULATED SHARE OF LOCAL GOVERNMENT COSTS**

COUNCIL AREA	PERCENTAGE SHARE OF COSTS
Burnside	9.0%
Adelaide	6.35%
Unley	20.45%
Mitcham	8.6%
West Torrens	55.6%

In reality such a cost sharing arrangement unfairly penalises West Torrens as some of its impervious area contributes very little to the flood problem due to its location near the base of the catchment.



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Negotiation between councils has resulted in cost shares as follows in **Table 25**. Those figures are not markedly different from the percentages determined above and it has been agreed to retain the **Table 25** percentages based on the benchmark cost and any subsequent adjustments approved by the councils as referred to in paragraph 10 of the Proposed Strategy (*refer Section 3.3*). The table also confirms the agreed cost sharing in respect of maintenance and administration costs.

**Table 25 PROPOSED SHARE OF LOCAL GOVERNMENT COSTS**

COUNCIL AREA	PERCENTAGE SHARE OF COSTS <i>(Construction and Maintenance)</i>	PERCENTAGE SHARE OF COSTS <i>(Administration)</i>
Burnside	12%	20%
Adelaide	8%	20%
Unley	21%	20%
Mitcham	10%	20%
West Torrens	49%	20%

The benchmark cost is the total estimated cost of the structural works for Parts A and B given in **Table 13** (*refer Section 12.3*) in addition to adjustments that all the councils approve for correcting any design deficiencies (including cost estimates) which would be necessary to enable the Part B Works (*as in the 2011 Draft SMP*) to meet the stormwater mitigation outcomes described in the 2011 Draft SMP.

In respect of any Unley Special Works (*refer Section 12.2.5*) that may be included in the SMP as a result of investigations in the Part B Works process, the Unley Council cost share will be 100% of the local government component.

**15.4.2 Cost Sharing between Spheres of Government**

Works approved under a SMP are eligible for state funding assistance channeled through the SMA. Whilst stormwater infrastructure projects generally have been jointly funded by state and local government, most of those projects have been on a relatively smaller scale compared with the BHKC Project.

The preferred funding model is that each of the three spheres of government – Commonwealth and SA State Governments and local government (comprising the five catchment councils) each contribute one third of the capital cost based on the ten year construction program.

Even on that basis, the one third share of cost by local government places a significant financial burden on the individual councils, and if the councils' share has to be increased it



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may result in the program being extended by a number of years, thereby reducing its potential economic and social effectiveness.

At the time of preparing this SMP the councils, recognising the limited opportunities of current Commonwealth funding programs, are planning a medium term strategy for seeking Commonwealth Government financial assistance in time to meet the major budgetary impact commencing in 2013/14. That timeframe would also be convenient for any updated cost sharing arrangements to be incorporated in the Final SMP.

In respect of the assets notionally owned by the BHKC Project through a regional subsidiary it is noted that life cycle cost, including liability for depreciation expenses and renewal cost is an issue that is not settled. As between the councils, this issue will be addressed in the charter. However, it is also regarded as an issue that should be considered in terms of partnership with or with the support of State Government.

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