Local Government Association of South Australia State Government of South Australia

Metropolitan Adelaide Stormwater Management Study

Part A

Audit of Existing Information **Final Report**

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LOCAL GOVERNMENT ASSOCIATION AND STATE GOVERNMENT OF SOUTH AUSTRALIA

Metropolitan Adelaide Stormwater Management Study

Part A – Audit of existing information

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INTRODUCTION

In 2003, the Local Government Association of South Australia prepared the 'Stormwater Management Strategy' dated 27 June 2003, and presented it to the State Government (Minister for Local Government).

The Strategy, targeted specifically at metropolitan Adelaide, was prepared to 'provide a constructive means to address the significant challenges and opportunities in relation to stormwater management in metropolitan Adelaide'. Endorsed unanimously by all metropolitan council Mayors and Chief Executive Officers, the strategy proposed a partnership approach to stormwater management with equal responsibility for funding between councils and the State Government.

'Step 1' of the proposed strategy – an independent study to clearly define 'The What' subsequently resulted in the preparation of the terms of reference brief for the 'Metropolitan Adelaide Stormwater Management Study' (MASMS). The MASMS is being undertaken in three distinct, although inter related parts:

- Part A—Audit of Existing Information
  - Component 1: Assessment of the current position
  - Component 2: Recommended actions/way forward
- Part B—Stormwater Harvesting and Use
- Part C—Apportionment of Council Costs.

This report presents the outcome of Part A: Audit of Existing Information.

CONTEXT

The assessment, conclusions drawn and recommendations presented in this report are based on a detailed examination of exiting drainage, flood mitigation and stormwater management reports, as well as an extensive consultation process involving all metropolitan councils within the study area, relevant State Government departments and other stakeholder groups.

The general perception of the significance of stormwater problems in Adelaide is highly varied, primarily due to the fact that Adelaide has long periods of time (often years) without significant rainfall events and associated flooding. Expenditure on stormwater infrastructure appears to be affected by this perception, often resulting in stormwater being a low priority for State Government and council spending, when compared to more 'visible' projects.

CONCLUSIONS

It is concluded that a number of metropolitan councils do not have significant stormwater related problems, largely as a result of the size and topography of the contributing catchments and the age and condition of infrastructure. These councils, however, can be contributors to downstream problems, and therefore should be part of the solution (refer also Study Part C Report).

There is a vast range in the standard of existing systems across metropolitan Adelaide, and most council areas have quite differing approaches to flood management including a combination of catchment based solutions (i.e. detention basins and underground drainage systems) and on-site management requirements for new developments. Detailed flood hazard and flood damage assessment has not been undertaken within the Study area, except for the Brown Hill and Keswick Creek and River Torrens catchments.

Water Sensitive Urban Design (WSUD) solutions are largely suitable only for new developments, where there is opportunity to incorporate open space into the planning and 'shaping' of the development. For projects in existing developed areas with no or inadequate drainage systems, apart from on-site methods, the lack of open space (unless private property is acquired) will largely prevent WSUD solutions due to the additional costs associated with significant land acquisition, channel widening etc.

Significant stormwater works required to be undertaken have been collated, categorised and costed. Based on historical cost estimates (adjusted to 2004 dollars), the estimated cost of identified significant stormwater flood mitigation works in metropolitan Adelaide is in the order of $160 million. This value excludes local level projects (catchment areas less than 40 ha) and land acquisition.

An output based procurement model has been considered as one mechanism for achieving the backlog of outstanding works. Such a model can be applied to specific individual projects on a catchment wide basis or on a metropolitan wide basis. This approach has the potential to provide more opportunity to incorporate 'innovative' and cost effective solutions to stormwater problems, addressing whole catchment/metropolitan wide benefits to the whole of water cycle under one contractual arrangement. One of the key issues associated with such a model is that hydrology and flooding is probabilistic, not an exact science, and hence will make it difficult to clearly and unambiguously define the outputs. In addition, potential legal and contractual complexities with such an arrangement are likely to be significant.

The notion that on-site detention (OSD) and on-site retention (OSR) will solve major system deficiencies is incorrect. Such devices are suited for consideration as part of the minor systems and would be overwhelmed during major events. The majority of metropolitan Adelaide is flat and will provide little opportunity to collect on-site surface flows from large events, and roofs are not designed to collect large storm events. The blanket approach of requiring OSD and OSR should be treated with caution as preliminary work has shown their effectiveness is very catchment specific and may actually be detrimental.

Local disposal methods into the shallow aquifer have been proven for small scale (i.e. residential) developments for flood mitigation purposes, however, given the current (and proposed) onerous and stringent requirements set by the EPA for sampling and testing, it is unlikely that these will be economically feasible.

As Adelaide's urban fringes approach a maximum level of growth and an increased trend to inner metropolitan living continues, urban consolidation will place further pressure on the existing stormwater infrastructure. The areas of highest potential for urban consolidation are considered to be within the western suburbs (Cities of West Torrens and Charles Sturt) and north eastern suburbs (Cities of Campbelltown and Tea Tree Gully). More specifically, these areas relate to the Meakin Terrace, Trimmer Parade, Port Road, Dry Creek and Third to Fifth Creek catchments. The impact on drainage systems due to urban consolidation metropolitan wide is yet to be quantified.

Policy and regulatory tools are an important aspect of stormwater management. The role of the Development Act is to establish a framework for making policy and provide for its implementation. A summary of the important aspects and limitations of the Development Act are outlined as follows:

- It is emphasised that it only controls development as defined by Section 4 of the Development Act 1993, being those activities such as land division, building works, changes in land use and certain prescribed works in floodplains.

- The application of the Development Plan largely refers to new development and it has no effect on existing buildings and land uses that are not contained within a particular development application.

- The State Government, through the Minister, can amend the Development Plan through a Ministerial Planning Amendment Report (PAR). However, this is an option warranted by justification of importance and coordination, and this is a strong possibility for stormwater management.

- Recent analysis of the floodplain areas in the established parts of the metropolitan area and the preparation of comprehensive floodplain inundation and hazard mapping have pointed to the necessity of significantly amending the Development Plan through a Ministerial PAR that will address this issue (Draft Brown Hill, Keswick, Parklands and Glen Osmond Creeks Flood Prone Areas PAR Statement of Investigations Extract Non-Complying Approach, 2003).

- It is also emphasised that the framework of planning in South Australia requires Development Plan changes to be based on the fundamentals within the Planning Strategy. It is therefore the case that the aims of long-term planning and development for sustainable stormwater management are tied into the adoption of these objectives at the implementation levels of government, particularly local government.

- There is a necessity for the State Government and councils to ensure that these objectives are incorporated in the revision of the Development Plans and the practices of local government.

RECOMMENDATIONS

It is important to highlight that innovative solutions to stormwater management at a strategic level are difficult to identify. Innovation for stormwater management is largely developed at a more detailed level with specific goals in mind. Significant innovation can be conceived and implemented at a catchment level, and is why Urban Stormwater Master Plans (USMPs) are so important and should continue to be developed and recognised.

Stormwater hazard management

The minor system standard is currently set by reference to accepted practice and community standards, coupled with appropriate engineering judgement. There is no reason to change this current philosophy.

The greatest opportunity to apply a more subjective qualitative approach is to major drainage systems based on a risk management approach rather than uniform ARI standard, particularly for larger projects warranting use of a more rigorous cost-benefit analysis. Such analysis requires better definition of tangible costs and further analysis of applying risk management processes to stormwater management. Additional flood hazard mapping must be undertaken on more catchments for such analysis to be performed.

WSUD should be embraced, with recognition that there are limitations, primarily with available open space. However, the vision of WSUD solutions needs to be assessed as part of the preparation of the USMP at a catchment level in collaboration with conventional stormwater management approaches. Strategic property acquisition should, nevertheless, be investigated as part of the preparing the USMP.

Stormwater discharge reduction

Detention basins historically have been successful in flow reduction and should continue, where possible (i.e. where space is available), to be a desirable form of relief for both the minor and major drainage system at a catchment or sub-catchment level.

It is recommended that councils undertake an immediate review of current requirements for on-site stormwater management and further analysis be undertaken to assess the following:

- determine which method (OSD or OSR), or combination thereof, is more beneficial for catchment flow reduction on a catchment by catchment basis;
- determine in which part of the catchment the devices are most beneficial including a review of the different release rates and detention requirements associated with its location within the catchment relative to outfall and travel time;
- what size devices are most beneficial and cost effective;
- for rainwater tanks (OSR) determine the demand coupled with storage that provides the most effective flow reduction;
- assess outfall conditions and determine the impacts of each of reduced runoff volume (OSR) and extended low flow periods (OSD).

The analysis must be incorporated into the preparation of the USMP on a catchment by catchment basis.

The issue of ownership and liability associated with on-site stormwater management must be addressed as maintenance is critical to the effectiveness of such systems.

For locations where large rainwater tanks with high demand are found to be beneficial, rebates should be incorporated as part of the 2006 mandate.

Developer contributions at the smaller scale in lieu of on-site stormwater management must be put towards the stormwater drainage works. The danger of financial contributions is that they can be put towards other (less critical) areas.

A review of minimum allotment sizes and private open space requirements must be undertaken, as this has a significant impact on the practicality of on-site solutions, particularly infiltration/soakage solutions and above ground tanks.

As the potential for future small scale OSR via direct aquifer disposal can achieve significant cost benefits, further work on a risk basis should be undertaken in this area to overcome currently proposed stringent EPA licencing requirements.

Assessment of outstanding projects

Given the large amount of outstanding work for significant projects (estimated in the order of $160 million) it is recommended that more objective analysis be used to allocate and prioritise future funding. It is recommended that detailed cost-benefit analysis be undertaken to assess the comparative merits of each project. This is not a new approach but is rarely done.

A 10 year timeframe should be adopted as a guide for addressing the outstanding significant projects and renegotiation the current funding arrangements as recommended by the 2002 Catchment Management Subsidy Scheme review.

Significant projects considered highest priority based on catchment size, potential for increased runoff and existing deficiencies have total works estimated at approximately $100 million. The remaining projects (estimated value of works $60 million) are considered a lessor priority and need further detailed cost-benefit assessment to determine their priority. The above figures exclude land acquisition costs and local level (catchment less than 40 ha) projects.

Output based specification

It is considered that the uncertain and inexact nature of stormwater management and flood mitigation, together with the high level of liability and litigious potential of flooding, poses more risks than likely beneficial outcomes of applying an output based contract model. In addition (as recently stated by the State Government), current appetite from the private sector with respect to public private partnership (PPP) approaches and investment in public infrastructure in Adelaide is poor.

Regulatory and policy tools

The following recommendations are made in relation to the proposed changes to the Development Plan and linkage with the State Infrastructure Plan:

- The intention to require local government to prepare strategic directions and infrastructure reports be strongly supported and that these reports be closely related to the State Infrastructure Plan.

- The State Infrastructure Plan be referred to in the Development (Sustainable Development) Amendment Bill 2004 and particularly the link between the Plan and the infrastructure reports of local government.

Statutory planning

The following recommendations are made:

- The module being prepared under the Better Development Plan process in relation to stormwater be reviewed in accordance with this study.
- The provisions within the Metropolitan Adelaide Planning Strategy that relate to the management of stormwater be considered as a priority in the amendment of the Development Plan within the Metropolitan Area of Adelaide. It is likely that this will require a particular programme and a Ministerial PAR in order to emphasise the imperative of this task.
- Urban Stormwater Master Plans be completed and better recognised by policy makers with the necessary detail at the local level to gain an accurate picture of the current network system and potential impacts of development, stormwater use opportunities and water quality/amenity issues, and be mandated in the Development Plan.
- A Ministerial PAR be prepared to address the issue of major flood concerns from existing development in established areas and that the State Government focus its resources to reach a solution and to make the Ministerial PAR work by minimising any risks such as the threat of litigation from aggrieved landowners.

It is imperative that there is a consistent approach to stormwater management issues in each Council Development Plan, whether the approach is deemed to require total control, some degree of control using development approval conditions or no regulatory requirements or control on development.

It is recommended that the review of the Development Plan and other policies and guidelines that will follow from a comprehensive incorporation of the 2004 Metropolitan Planning Strategy must involve all councils within the Metropolitan Area and include consideration of drainage systems and catchment wide outcomes, as well as specific local or site level concerns.

Private landowner responsibilities

Further work is required to examine how developer contributions can be put to best use, particularly where (and if) on-site management does not prove to provide benefit.

It is recommended that legal advice be sought as to who is responsible for maintenance and operation of on-site measures for stormwater flow reduction (and disposal) and how this relates to the coupling of captured on-site stormwater as a resource (i.e. use).

Further investigations

In addition to the above recommendations, the following work is required to fully quantify and understand the overall picture of Adelaide's stormwater management requirements:

- continued research into design methods, particularly design approach for major systems and large works
- condition of infrastructure needs to be accurately documented including remaining life and replacement cost profile
- magnitude of small projects (<40 ha contributing catchment area)
- magnitude of climate change effects on Adelaide's stormwater systems
- the impact that poor outfall conditions have on drainage capacity
- quantify the effect of full development, including urban consolidation
- an assessment of the magnitude of long-term (i.e. non-current) problem areas.

Glossary of Terms

Aquifer – a rock or sediment in a geological formation, group of formations or part of a formation which is capable of being permeated permanently or intermittently and can therefore hold and transmit water.

Aquifer Storage and Recovery (ASR) – the process of recharging water into an aquifer for the purpose of storage and subsequent withdrawals.

Average Recurrence Interval (ARI) – the expected or average interval between events of a rainfall intensity of a given magnitude being exceeded – refer Section 2.2.

Detention – the temporary storage of stormwater caused by a reduction in outflow capacity of a holding device (e.g. tank, basin) which results in a reduction in discharge.

Detention tank – a tank used to temporarily store or hold runoff directed off a surface (i.e. roof area). The outlet is sized to reduce the outflow rate from the device.

Ecologically Sustainable Development (ESD) – development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends.

Flash flooding – sudden and unexpected flooding caused by local heavy rainfall or rainfall from another area. Often defined as flooding which occurs within six hours of the commencement of a rainfall event.

Floodplain – an area of land adjacent a creek, river or other drainage system which is subject to periodic inundation.

Flood damage – damage occurring as a result of a flood event. Damage can be both tangible (i.e. financial) and intangible (i.e. distress, inconvenience).

Flood hazard – a measure of the impact due to the severity or size of a flood. The potential for loss of life, injury and economic loss caused by a flood.

'Greenfield' development – a broad acre development (i.e. housing, industrial, commercial) which occurs on a site previously open space, paddock etc.

Groundwater – water contained within the hydrological cycle below surface level.

Hydrograph –graphical representation of the variation with time of discharge (discharge hydrograph) or water level (stage hydrograph) during the course of a flood at a particular location.

Hydrologic analysis – the study of water and its constituents as they move through the natural process that constitute the hydrological cycle (i.e. rainfall, runoff, evaporation, infiltration).

'Major' system – the more subtle drainage system, comprising natural river and creek systems, constructed open channels, road systems and often large underground drainage systems which convey flows above that capable of being conveyed by the 'minor' system – refer Section 2.2.

'Minor' system – the formal 'in the street' drainage system normally consisting of kerb and gutter, side entry pits and underground pipe systems – refer Section 2.2.

Pollutant – any substance introduced into the environment that adversely affects the usefulness of a resource. Contaminants (heavy metals, hydrocarbons, organic matter, litter etc) contained within stormwater flows.

Probable Maximum Flood (PMF) – the largest flood that could physically occur at the location of interest. It is an extremely rare event and defines the extent of flood prone land.

Rainfall intensity – the rate at which rain falls, typically measured in mm/hour which varies throughout a storm.

Rainwater tank – a tank used to retain runoff directed off a surface (i.e. roof area) and used for irrigation, drinking, washing etc. The tank overflows only when the available storage is exceeded.

Retention – the permanent storage of stormwater due to a holding device (e.g. tank, basin). Can also be representative of soil infiltration or percolation which prevents stormwater from discharging into the 'minor' and 'major' drainage system. Water remains in the hydrological cycle but continues in a different process.

Runoff coefficient – a measure used to assess the ability a surface has in converting rainfall into runoff. A coefficient of 1.0 implies 100% of the rainfall is converted into runoff. A coefficient of 0 implies no rainfall is converted into runoff.

Storm duration – the length of a storm (i.e. rainfall event) that produces a flood discharge at a particular location.

Trunk drainage system – a large man made (i.e. artificial) drainage system, either open channel or large underground system, and often performs the purpose of both a 'minor' and 'major' drainage system. The term 'arterial' drainage system (likened to the road system) is also emerging as an alternative to 'trunk' drainage system.

Wetland – permanently or intermittently wet areas, shallow water, and land/water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions.

1 Introduction

In 2003, the Local Government Association of South Australia (LGA) prepared the 'Stormwater Management Strategy' dated 27 June 2003, and presented it to the State Government (Minister for Local Government).

The Strategy, targeted specifically at metropolitan Adelaide, was prepared to 'provide a constructive means to address the significant challenges and opportunities in relation to stormwater management in metropolitan Adelaide'. Endorsed unanimously by all metropolitan council Mayors and Chief Executive Officers, the strategy proposed a partnership approach to stormwater management with equal responsibility for funding between councils and the State Government.

'Step 1' of the proposed strategy, an independent study to clearly define 'The What', subsequently resulted in the preparation of the terms of reference brief for the 'Metropolitan Adelaide Stormwater Management Study' (MASMS) dated 6 October 2003. The MASMS is being undertaken in three distinct, although inter related parts:

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This report presents the outcome of Part A: Audit of Existing Information.

As noted above, Part A of the MASMS (Audit of Existing Information) has two components. Component 1 'Assessment of the Current Position' is the outcome of an extensive information gathering, review and consultation process. In brief, it is an assessment of the adequacy of stormwater infrastructure in metropolitan Adelaide, with particular emphasis on known existing and possible future problem areas.

For the purposes of this study, metropolitan Adelaide is defined by the Urban Growth Boundary (the study area) as depicted in Figure 1. Appendix A contains drainage network and catchment boundary plans.

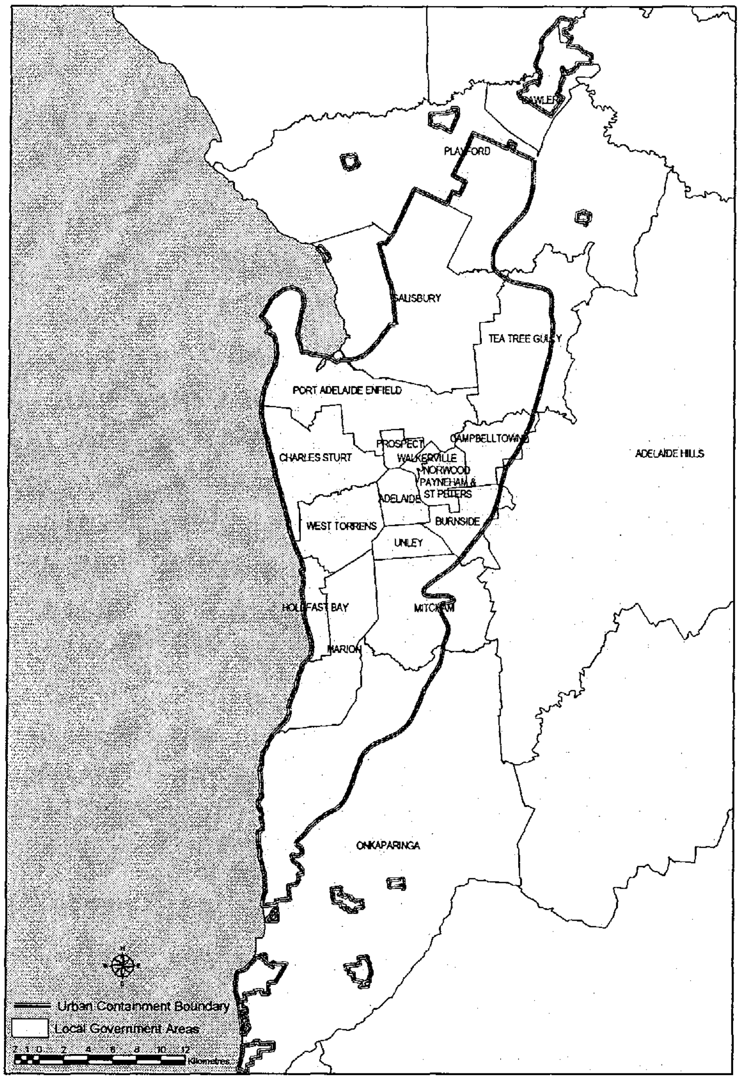


Figure 1
Study area

Component 1 of Part A included a detailed examination of drainage, flood mitigation and stormwater management reports, including:

- Urban Stormwater Master Plans (USMP) being prepared for a number of council areas;
- flood study and stormwater drainage study reports;
- stormwater use/Aquifer Storage and Recovery (ASR) studies;
- infrastructure studies/reports;
- development plan/planning strategy reports.

Consultation was also undertaken with the following stakeholders:

- staff from all metropolitan councils within the study area;
- Catchment Water Management Boards (CWMBs) including Torrens, Patawalonga, Onkaparinga and Northern Adelaide & Barossa;
- Transport SA; and
- Environment Protection Authority (EPA).

Component 2 of Part A – Recommended Actions/Way Forward covers the following areas:

- development of an appropriate risk management approach to stormwater management;
- identification of opportunities to reduce stormwater discharge and physical/biological damage to urban waterways and coastal waters;
- preparation of criteria to assess the importance of identified projects;
- provide estimates (as far as is reasonably practicable) of the costs of the projects identified and associated benefits;
- identification of regulatory and policy tools available to the State Government and councils to achieve public policy objectives;
- examination of the role of statutory planning processes so as to provide a sound basis to shape long-term planning and development for sustainable stormwater management;
- private landowner responsibilities;
- identification of information gaps.

Public policy objectives for stormwater management required to be observed in developing study outcomes included:

- hazard management to reduce the risk of property and arterial road flooding;
- environmentally sustainable development including the improvement of watercourses and open space assets;
- improving stormwater quality and reducing harmful discharges to water courses and the marine environment;
- the use of stormwater as a valued resource including the maximisation of stormwater use.

In addition, the work has regard to the following:

- identification of opportunities for possible private sector involvement and the associated pre-conditions;
- property owners and developers have responsibilities relating to stormwater management;
- the planned growth of Adelaide via infill or development intensification and the associated stormwater management and infrastructure implications;
- the need for clear and concise information to ensure a better understanding of the current situation and what needs to be done.

Consultation with a number of stakeholder groups relevant to Component 2 of Part A included discussions with the following agencies:

- Planning SA (Maureen Bartel, Ian McQueen, Malcolm Govett)
- Transport SA (Bill Lipp, David Kemp)
- SA Water (John Ringham, Kym Wallent, Robert Thomas)
- Department of Transport and Urban Planning (Tim O'Loughlin)
- Department of Water, Land and Biodiversity Conservation (Rob Freeman, Claus Schonfeldt, Peter O'Neill)
- Bureau of Meteorology (Lynton Johnston).

2 Component 1 - Assessment of the current position

2.1 BACKGROUND

The purpose of this section of the report is to provide a summary of the adequacy of stormwater infrastructure in metropolitan Adelaide as defined by Component 1 of Part A of the study brief.

The focus of this part of the study is on known existing and possible future problem areas, based on a comprehensive literature review of existing reports, studies, data and interviews with key staff from each of the councils responsible for managing stormwater and implementing new policies relating to stormwater.

Consultation was also undertaken with the relevant CWMBs to identify their philosophy on stormwater management, and with the EPA to determine their policies on stormwater quality issues.

A list of the key components of this part of the study is as follows:

- collection of existing data—drainage plans, stormwater studies/reports, geographical information system (GIS) data;
- review of existing data and identify information gaps;
- identification of known flooding locations and stormwater drainage 'hot spots';
- identification of likely areas of development and future problems;
- conduction of interviews with councils and other key stakeholders to validate the above findings;
- preparation of a consolidated report for submission to the Steering Committee.

Descriptions of the current legislative and policy drivers including the Water Resources Act 1997, the Development Act 1993 and the Environment Protection Act 1993 and how they are integrated for stormwater management in urban areas are also addressed further in this report.

The outcomes of Component 1 of Part A, the subject of this section, have been used to form the basis of Component 2, specifically focussing on recommending actions, strategies and methods of improving the process and policies used in stormwater management in metropolitan Adelaide.

2.2 STORMWATER MANAGEMENT TERMINOLOGY

This section refers to some of the commonly used terminology for drainage design and stormwater management and is to assist the reader with concepts relevant to Part A (Audit of Existing Information) of this study. Further assessment on strategies and methods for future flood mitigation hazard management are outlined in Section 3.

Design standard

In this report there is reference to the Average Recurrence Interval (ARI) as the standard of the drainage system. ARI is the probabilistic interval of time on average that the capacity of the system is equalled or exceeded. Being probabilistic, storms that produce flows in excess of the design standard may occur more than once in that period, but over a long period of time the average is maintained. For example it is possible that there is more than one 5 year ARI storm in one year but it would be expected that on average, there would be approximately 20 similar events in a period of 100 years.

Minor and major drainage systems

Stormwater infrastructure is often described in terms of 'minor' or 'major' systems, catering for the 'minor' or 'major' storm event. The minor system is the formal 'in the street' drainage system, normally consisting of kerb and gutter, side entry pits and underground pipe systems. The minor system generally caters for runoff collecting in streets and off adjacent property, and is normally designed to convey flows from frequent occurrence rainfall events up to approximately 5 to 10 year Average Recurrence Interval (ARI), i.e. a rainfall event with magnitude that on average only occurs once in every 5 or 10 years.

The major drainage system is often more subtle, comprising the natural river and creek systems, constructed open channels, road systems and often large (trunk) underground drainage systems which convey flows above that capable of being conveyed by the minor system. The function of the major drainage system is generally for flood mitigation, normally designed to or checked to ensure that it is conveying flows and preventing flooding during larger rainfall events, i.e. at a higher average recurrence interval often up to 100 year.

It should be noted that the minor drainage system also normally includes large underground trunk drains where stormwater enters via smaller upstream drains (e.g. South Western Suburb Drainage Scheme). Trunk drains only become part of the major system once they become open channels and large surface flows can flow into them, or in a few cases, it can be an underground drainage system where special provisions have been made to allow large surface flows beyond the normal 5 to 10 year ARI design standard to enter that drain.

Despite its name, the minor drainage system is a very important and integral part of the stormwater infrastructure and often represents a significant proportion of the costs associated with stormwater management.

Water sensitive urban design

The term 'water sensitive urban design' (WSUD) is relatively new terminology which is used to describe the integration of urban planning and development with the management, protection and conservation of water within the water cycle. It includes both structural and non-structural techniques to achieve a holistic approach to stormwater management. This report concentrates on urban stormwater from a flood management perspective and to a lessor extent on water quality issues. Part B of this study concentrates on urban stormwater management from a harvesting and use perspective and hence also includes water quality aspects. Further discussion on WSUD from a stormwater harvesting and use perspective is made in Part B of this study.

Stormwater drainage in Adelaide

The topography of metropolitan Adelaide has natural grade generally falling from east to west across the plains. Steeper gradients occur closer to the Adelaide Hills and gradients are generally very flat to the west and north of the city centre. Near the coastline, there is a slight rise to the sand hill remnants before reaching metropolitan beaches.

Although the majority of annual rainfall in Adelaide falls through the winter months, the infrequent high intensity storms which cause flooding problems generally occur during summer months.

Areas contributing to the upper reaches of the larger catchments in metropolitan Adelaide generally have steeper natural gradient and the resultant size and hence cost, of providing stormwater infrastructure, particularly underground systems, is often smaller than those flatter areas further down the catchment. Drainage from the eastern side of Adelaide generally discharges into channels and natural watercourses.

The areas on the north-western side of Adelaide generally cater for flows from 'self contained' catchments and do not have well defined topography. This leads to man made flow paths (underground systems, roadways, channels, etc.), resulting in a quite different infrastructure requirement than the eastern side.

Many areas south of the River Torrens have contributing catchments from the south-eastern Adelaide Hills, where steep undeveloped catchments drain through flatter built-up urban areas of the inner southern and south-eastern suburbs of metropolitan Adelaide.

2.3 DATA COLLECTION

A detailed examination of stormwater management reports and studies pertaining to councils areas within the study area was undertaken upon project commencement.

These reports related to the following broad categories:

- flood mitigation studies including floodplain mapping
- stormwater infrastructure studies
- urban stormwater master plans (USMPs)
- catchment water management plans
- infrastructure planning studies.

Some flood and drainage related studies in Adelaide are quite old and since that time, many changes (e.g. land use/catchment characteristics, technological advances in hydrologic and hydraulic modelling) have occurred, affecting the validity and accuracy of the findings and recommendations of these reports. For the purposes of this study only those reports prepared in the past 25–30 years have been considered for detailed review.

The majority of flood related study reports were available from Transport SA (Stormwater Group). Reports and studies held at Transport SA consisted of those relating to larger scale catchment water management plans (managed by the relevant Catchment Water Management Boards – Patawalonga, Torrens, Onkaparinga and Northern Adelaide & Barossa) as well as those directly relating to flood mitigation and drainage studies that were jointly funded by the State Government Catchment Management Subsidy Scheme (CMSS) and the applicable council(s). A more detailed description of the State Government Catchment Management Subsidy Scheme and its administration is discussed in Section 2.5.

The catchment water management plans are broad and cover a wide range of issues affecting the relevant catchment including water quality, water usage, biodiversity, groundwater, catchment health as well as floodplain management and mitigation (e.g. Sinclair Knight Merz 2001; PPK 1997; Tonkin Consulting 2002a; Tonkin Consulting 2002b).

Major contemporary floodplain mapping studies have recently been completed on the upper Onkaparinga River (Tonkin Consulting 2004), Brown Hill and Keswick Creeks (Hydro Tasmania 2003), River Sturt (BC Tonkin and Associates 1997), River Torrens provided in these reports to date. More detail is required within current USMPs to provide the catchment specific solutions to stormwater management.

The Initial USMPs undertaken to date include the following:

- Port Road Drain catchment (Tonkin Consulting 2002c)
- Trimmer Parade catchment (Tonkin Consulting 2003a)
- Meakin Terrace catchment (Tonkin Consulting 2003b)
- Torrens Road catchment (Tonkin Consulting 2003c)
- North Arm East catchment (Tonkin Consulting 2003d)
- Hart Street catchment (Tonkin Consulting 2003e)
- City of West Torrens (Draft only) (Tonkin Consulting 2003f)
- Hindmarsh–Enfield–Prospect (HEP) catchment—currently being prepared by Tonkin Consulting.

Stormwater infrastructure reports have also been prepared for City of Mitcham (Tonkin Consulting 2003g), City of Holdfast Bay (Tonkin Consulting 2001) and First Creek in the City of Burnside (Tonkin Consulting 2003h). It is understood that a similar study is currently being undertaken for the City of Onkaparinga.

Stormwater infrastructure reports are similar to the initial USMP except they focus primarily on the capacities of existing drainage infrastructure, highlighting future required upgrades and additional flood mitigation studies and strategies. Less strategic direction is provided on water harvesting opportunities and strategies at planning/development level for control of flows and general stormwater management than the USMPs.

Other major drainage infrastructure studies include the review of the South Western Suburbs Drainage Scheme (SWSDS) undertaken by Kinhill (now Kellogg Brown & Root Pty Ltd (KBR)) which provided a capacity assessment review of the minor and major drainage systems within a considerable portion of the Cities of Mitcham and Marion, as well as the Dry Creek Hydrology Review (KBR 2000).

In addition to reports, the GIS mapping of the entire piped drainage system of metropolitan Adelaide was obtained from the Environmental Protection Authority (EPA). The EPA in collaboration with the councils, the CWMBs, Transport SA and with assistance from the CMSS developed a drainage network map of metropolitan Adelaide, initially to assist in tracking of pollutant spills. One limitation with the work undertaken by the EPA was that it did not include a detailed catchment breakdown.

Major catchment and sub catchment boundaries were obtained digitally from the CWMBs and overlaid over the drainage infrastructure to produce an overall drainage base plan for the study area. A copy of these plans is provided in Appendix A.

2.4 CONSULTATION

2.4.1 Process

Interviews were conducted with each of the metropolitan councils within the study area to build on and clarify the information gathered in the data collection and review process. Interviews were directed at senior to middle management level, specifically to those staff with a direct involvement with stormwater management, planning issues and those with a knowledge of the existing stormwater infrastructure.

The primary focus of the interviews was to identify current stormwater management philosophies, ascertain the design standard of existing infrastructure and find out current and future stormwater drainage problems and strategies. Following the completion of the interview process summaries were produced to highlight significant differences between neighbouring councils, particularly those that share the same catchments.

Further interviews were held with the four CWMBs in order to ascertain their views and plans with respect to stormwater management, both from a flood mitigation and water quality/environmental and amenity perspective.

2.4.2 Interviews

Each of the interviews with councils within the study area was conducted by two senior staff from KBR including an engineer and planner. Interviews were arranged with council staff with the duration of the interview generally taking 1–2 hours depending on the size of the council and issues involved.

Prior to the interviews, a questionnaire proforma was prepared outlining a number of key issues. Each council was given at least one week to review the questionnaire prior to the interview. The questions were considered a generic representation of current and future stormwater management issues such that the responses could be summarised easily into a list that could be used for comparison purposes.

Copies of the questionnaire and responses for each of the councils are located in Appendix B. Summaries of the broader issues and key council opinions arising from each of the council interviews are provided below.

City of Adelaide

- capacity of existing underground system is very good (originally designed to a 20 year ARI standard);
- ability to convey major system flows is generally good, some problems in South Parklands, however nuisance only;
- Council area primarily drains to River Torrens;
- proposals have been put forward for developing formal detention sites in South and East Parklands;
- existing detention facilities are located in the West Parklands;
- a number of the proposed stormwater drainage infrastructure upgrade options for adjacent council areas rely on use of the South and/or East Parklands for flood detention;
- primary issue with respect to flood mitigation is agreement between councils on what should happen and cost apportionment with respect to development of a South Parklands flood detention facility.

Adelaide Hills Council

- only areas within study boundary are Teringie and Woodford;
- capacity of existing systems (minor and major) in these areas is considered very good;
- developed areas are relatively new (~10 years old) and are situated on hilly sites, hence have a good standard of flood protection.

City of Burnside

- capacity of existing underground system is reasonable, limited however by poor side entry pit capture capabilities in many areas;
- major systems generally comprise creek systems, which are difficult to manage where situated in private property;
- infill development is occurring, but as per other 'foothill' council areas, is not (yet) having a significant effect on the capacity of stormwater systems;
- constraints are related to knowledge of the systems and the location/magnitude of problem areas – currently being addressed with the completion of infrastructure studies being undertaken.

City of Campbelltown

- capacity of existing underground system is reasonably good;
- major systems generally consist of creek systems, which have been improved in recent years;
- infill development is significant, however, the council area has good gradient and stormwater drainage is not considered a significant problem;
- constraints to flood mitigation are primarily related to the capacity of the creek systems and the availability of land to undertake channel improvement works, particularly in sections through privately owned land.

City of Charles Sturt

- capacity of existing underground system is poor (largely around 1 year, but up to 8 year ARI standard);
- ability to convey major system flows is very poor;
- council area is flat and low lying with limited underground infrastructure in many parts of the council;
- considerable infill is likely to occur in the future which will further impact on current drainage infrastructure;
- major constraints to flood protection are cost of works (limited internal and external funding) and lack of suitable open space for detention basins;
- Council has given priority to road reconstruction/reseal programme for the next few years;
- USMPs have or are currently being prepared for many areas of the council to provide further direction on stormwater management strategies.

Town of Gawler

- capacity of existing underground system is poor (1 to 5 year ARI standard);
- ability to convey major system flows is poor;
- significant flooding issues are associated with Gawler River;
- local drainage issues relate to old, poorly planned areas with little drainage infrastructure, close to creeks and watercourses;
- future issues will relate to expanding residential development and lack of stormwater management control at source and downstream;
- plenty of open space available;

- significant constraint to flood protection is cost of works;
- no short-term drainage works are planned due to a lack of internal funding;
- the preparation of an USMP is being explored.

City of Holdfast Bay

- standard of existing drainage infrastructure very dependant on location. 'Brighton' area is considerably better than 'Glenelg';
- capacity of existing underground system is poor to good (1 to 5 year ARI standard);
- ability to convey major system flows is very poor (Glenelg) to good (Brighton);
- drainage issues relate to flat, low lying areas;
- significant constraints to flood protection are cost of works (limited internal and external funding), long-term sea level rises, sand movement along beaches (blocked drains), lack of education/awareness by public and possible upstream impacts caused by changes in Marion;
- stormwater infrastructure study has been prepared to identify drainage issues;
- Council has limited planning controls on stormwater management of both small and large scale developments.

City of Marion

- capacity of existing underground system is good (generally 5 year ARI standard);
- ability to convey major system flows is average;
- drainage issues occur in flatter areas due to insufficient inlets (side entry pits);
- in steep locations (Hallett Cove, Marino) problems are due to stormwater overtopping kerbs, one way cross fall roads and along steep escarpment gullies;
- most large residential developments are near completion;
- future problems likely to be caused by infill and development of South Australian Housing Trust (SAHT) land;
- significant constraints to flood protection are cost of works (limited internal and external funding);
- Council has strategies at a development level for residential sites, which are considered more advanced than other councils (e.g. detention tanks sized depending on location and extent of development) and is similar for large development.

City of Mitcham

- capacity of existing underground system is good (2 to 5 year ARI standard);
- ability to convey major system flows is average;
- significant drainage issues relate to flooding of significant watercourses (Brown Hill Creek, Sturt River and Minno Creek) and wide street flow widths (flatter areas);
- future infill development/consolidation is a significant concern as this will be more prevalent on the flatter areas;
- constraints to flood protection are cost of works and lack of public awareness (leading to council budgetary constraints) regarding stormwater problems;
- larger developments have open space set aside for detention basins;
- smaller infill locations require on-site control measures;
- stormwater infrastructure study is complete and consideration is being made to prepare a USMP;
- Council want to see a bigger importance placed on on-site stormwater management measures including more investigations done on detention tanks.

City of Norwood, Payneham & St Peters

- capacity of existing underground system is reasonably good, with a rolling 10 year works programme in place – based on infrastructure report prepared by Tonkin Consulting;
- ability to convey major system flows through existing creeks varies, with typically minimum 20 year ARI capacity which is considered reasonable/acceptable by council;
- constraints to flood protection are primarily related to creek systems running through private property, as well as low lying built-up areas through Norwood and Kensington;
- infill development is considered an 'emerging' problem and planning controls (such as minimum floor levels) are being implemented.

City of Onkaparinga

- standard of existing drainage infrastructure very dependant on location. Former council areas of Willunga and Happy Valley are considerably different to Noarlunga;

- Willunga and Happy Valley – Capacity of existing underground system is average (2 to 5 year ARI standard);
- Noarlunga – Capacity of existing underground system is very good (10 year ARI standard);
- most drainage issues are related to local creek issues (road crossings and lack of capacity);
- future problems likely to be due to large scale developments rather than infill;
- plenty of open space available;
- constraints to flood protection are cost of works (limited internal and external funding);
- stormwater management scoping study is currently being prepared to identify future problems and stormwater management issues.

City of Playford

- capacity of existing underground system is generally good – the council area comprises a significant amount of newer development, coupled with open space has resulted in generally a good standard of stormwater infrastructure;
- ability to convey major system flows is varied between eastern (higher) and western (flat) areas of the council;
- older Housing Trust areas need further investigation as to their condition and capacity;
- Council recognise the need for an USMP to consolidate the whole of council stormwater infrastructure planning;
- Council is actively looking at Water Sensitive Urban Design (WSUD) projects to couple flood mitigation with stormwater quality, harvesting and use opportunities.

City of Port Adelaide Enfield

- standard of existing drainage infrastructure very dependant on location. 'Enfield' area is considerably better than 'Port Adelaide';
- capacity of existing underground system is poor to good (1 to 5 year ARI standard);
- ability to convey major system flows is very poor to average;
- Port Adelaide area/western part of council is very flat and low lying;
- both infill development and large scale development planned for future will further impact on current drainage infrastructure;

- constraints to flood protection are cost of works and predicted long-term sea level rises associated with global warming;
- USMPs have or are currently being prepared for many areas of the council to provide further direction on stormwater management strategies;
- planning controls at an individual site level are difficult to implement and measure effectiveness—stormwater master plans are used successfully on larger residential development.

City of Prospect

- capacity of existing underground system is reasonable to good;
- ability to convey major system flows is poor to average;
- Council is currently undertaking an USMP for the Hindmarsh Enfield Prospect (HEP) catchment, covering a significant proportion of the council area;
- Council does not consider that is has any problem flooding hazard areas;
- Council is undertaking camera inspections of their stormwater systems to assess the condition of the infrastructure.

City of Salisbury

- capacity of the existing underground system is average;
- capacity of the larger systems (primarily open channel) is reasonably good;
- ability to convey major system flows is generally good where trunk drains are constructed, however problems occur in flat terrain where limited infrastructure is present;
- future development areas will require on-site detention to manage flooding;
- infill development has not been identified as being a concerning factor to date;
- future problem areas are likely to be in developing residential and industrial areas east of Port Wakefield Road;
- Salisbury is a recognised leader in innovative stormwater management, harvesting and use projects.

City of Tea Tree Gully

- capacity of the existing underground system is thought to be 'average' but has recognised that is has not really been tested since more recent development has occurred;
- capacity of newer areas (e.g. Golden Grove) is considered to be good;

- ability to convey major system flows is currently not well known or defined;
- Council has budgeted to undertake flood inundation and hazard mapping;
- previous council wide study undertaken in 1980 and is out-of-date;
- Dry Creek studies undertaken in 1980 and revisited in 2000;
- constraints to flood mitigation are primarily funding (cost) and land availability.

City of Unley

- capacity of the existing local underground system to convey minor events is generally reasonable to good;
- ability to convey major system flows through the council area (via the creek systems) is very poor, with significant flooding risks;
- Brown Hill, Glen Osmond and Parklands Creeks are the high flooding hazards;
- system capacity problems for high intensity/short duration events are experienced in areas of Parkside, Unley and Wayville.
- further piped stormwater works are required through Myrtle Bank and Fullarton, however, require a detention facility within the South Parklands;
- significant constraint to Council is gaining agreement from other stakeholders (councils) with respect to the standard of protection, cost sharing principles and priority of works.

City of West Torrens

- capacity of existing underground system varies – newer areas are designed to a 5 year ARI standard, whereas a number of older areas (Thebarton) have a lack of drainage infrastructure;
- ability to convey major system flows through the council area also varies – sections adjacent Brown Hill and Keswick Creek are very flood prone;
- infill development is impacting on Council's stormwater infrastructure, and Council requires detention measures to be undertaken by the developer/landowner;
- Council is undertaking an Initial USMP (draft Report issued);
- current stormwater works include the outfall upgrading for the Mile End/Cowandilla Drainage network – involving substantial system capacity enlargement from May Terrace through to the Barcoo Outlet and the replacement of failed box culverts along Sir Donald Bradman Drive.

2.4.3 Summary of outstanding works

A broad summary of the significant works required to improve drainage and protection of existing development from flooding within the study area (council by council basis) is outlined as follows:

- City of Adelaide – Nil identified
- Adelaide Hills Council – Nil identified
- City of Burnside – Nil identified
- City of Campbelltown – Nil identified
- City of Charles Sturt – commencement of work in Port Road, Meakin Terrace/Trimmer Parade catchments and branch drains in Torrens Road catchment
- Town of Gawler – completion of various township works
- City of Holdfast Bay – completion of numerous minor drainage systems, flood protection of Gilbertson Gully
- City of Marion – completion of subsidiary drains of SWSDS
- City of Mitcham – completion of subsidiary drains of SWSDS
- City of Norwood, Payneham and St Peters – Completion of various works in the old St Peters area
- City of Onkaparinga – completion of works in the old Happy Valley area, Seaford, Willunga, Aldinga, Sellicks and Maslins Beach area and flood control dams on upper reaches of Christies Creek
- City of Playford – completion of identified upgrading work in the developed parts and the major system outfall channel (development dependent)
- City of Port Adelaide Enfield – completion of work in North Arm East, HEP and local catchments to the Port River
- City of Prospect – completion of work in HEP catchment
- City of Salisbury – completion of drainage works on Dry Creek, Helps Road and Little Para River catchments
- City of Tea Tree Gully – completion of various identified works in the Dry Creek catchment
- City of Unley – completion of the upgrading of drainage works across the council
- City of Walkerville – Nil identified
- City of West Torrens – completion of the trunk drain network in the Cowandilla/Mile End area and upgrading of drain outfall down to Barcoo Outlet.

It should be noted that the above list comprises work from a range of catchment sizes which has been defined into categories as discussed in the following section.

2.5 KNOWN FLOOD MITIGATION PROJECTS

As part of the data collection and review of previous stormwater related studies and reports, a review of identified flood mitigation work within the study area has been undertaken and the projects grouped into a number of categories. The categories of projects used to identify the identified projects relevant to the study area as follows:

- known and quantified projects suitable for CMSS funding;
- projects suitable for CMSS funding but will only be required if development occurs;
- large scale flood mitigation projects with budgetary requirements much greater than the current subsidy funding;
- small catchment area projects (catchment areas of less than 40 ha).

Stormwater studies have not been completed in all areas within the study area. Floodplain mapping has so far been confined to the more significant rivers and creeks, with virtually nothing undertaken on the smaller creeks and escarpment watercourses.

A more detailed description of the outstanding drainage and flood mitigation projects is outlined in Appendix C on a catchment by catchment basis.

2.5.1 Catchment Management Subsidy Scheme

In 1967 the State Government created a non-statutory administrative arrangement called the State Government Stormwater Drainage Subsidy Scheme. The technical and financial administration was the responsibility of the Highways and Local Government Department utilising knowledge and expertise gained through the South Western Suburbs Drainage Scheme and road related drainage projects. Early work concentrated on the provision of trunk drainage systems (e.g. Salisbury) or the upgrading of under capacity natural systems (e.g. Second Creek).

The scheme expanded through the 1970s into country areas and flood mitigation projects as well as continuing to support the development or upgrading of trunk drainage systems in Metropolitan Adelaide. During the 1980s drainage and flood studies were encouraged, not only to identify current problems but to avoid future problems by providing information to enable better planning and if possible to set aside adequate land for more environmentally sensitive drainage features such as wetlands, detention basins and open swales/channels (as opposed to underground pipes).

In the 1990s wider stormwater management objectives (quality, use and amenity) achieved more prominence resulting in the old Stormwater Drainage Subsidy Scheme becoming the Catchment Management Subsidy Scheme in 1997. The Scheme is now the responsibility of the Department of Water, Land and Biodiversity Conservation, with technical and financial administration provided by the Department of Transport and Urban Planning (Transport SA).

State Government financial assistance is normally in the form of a dollar for dollar subsidy for eligible projects and covers studies, works and land acquisition. For drainage or flood mitigation works, a minimum catchment area of 40 ha applies to be eligible for a subsidy. For many years, the Catchment Management Subsidy Scheme (CMSS) has been an important funding tool for initiating and undertaking stormwater infrastructure projects and is well understood and accepted by local government. It has successfully assisted with the implementation of nearly $300 million worth of projects (in current dollars) since being implemented in 1967.

Expenditure by the State Government on the Scheme has generally varied between $3 million and $6 million per annum (in 2003 dollars). However expenditure has declined dramatically over the last few years in response to the reduction to $2 million per annum in the funding allocation to the Scheme in 2000/2001. In 2003/2004 this allocation was increased back to $4 million per annum.

The historical expenditure history of the CMSS in actual expenditure and real (2003) dollars as provided by Transport SA is contained in Appendix D.

A list of identified stormwater drainage and flood mitigation projects that are applicable for subsidy was prepared in 2002 as part of the CMSS Review Report, which covers both country and metropolitan locations. It was concluded that up to 30 years would be required to complete the projects (excluding development dependent projects and large scale projects i.e. Brown Hill and Keswick Creek flood mitigation) based on the funding available at that time ($2 million per annum of State Government funding, now increased back to $4 million per annum, matched by local government contribution).

The list of identified projects applicable to the CMSS and associated costs is included in Appendix E.

The estimated costs highlighted in this report are based on the actual quoted figures in the relevant reports and adjusted to 2004 figures using the Building Price Index for Adelaide (Rawlinsons 2004). Due to time and budgetary constraints, a detailed investigation has not been undertaken as part of this study to ascertain whether the parameters assumed in the previous studies are suitable in the long-term.

To our knowledge, the cost estimates do not include any allowance for land acquisition, as these generally are not known. KBR has not attempted to check or validate the costs quoted from the sourced reports as this is considered outside the scope of this study, and it is assumed that they have been adequately checked by the relevant authors of that particular study.

2.5.2 Development dependent projects applicable to CMSS

In addition to the projects that are identified in the previous section, there is one identified project that is suitable for CMSS funding, however, the funding requirement is subject to development occurring, this being:

- City of Onkaparinga – Sellicks/Aldinga drainage upgrades (current total costs estimated at $3 million).

2.5.3 Large scale projects

Two other large scale projects have been identified but the size and scale is outside the scope of the funding currently available in the CMSS.

These projects are:

- Brown Hill and Keswick Creek – Flood mitigation works (Tonkin Consulting, 2002d) – numerous options proposed but no firm recommendation with respect to a preferred option (informed opinion on possible cost ranges from $20 million to $150 million depending on the standard adopted and type of upgrading proposed);
- City of Playford – Construction of outfall drains from Smith Creek catchment (current total costs estimated at $24 million, required as further development occurs).

Funding splits for each of the above projects have not yet been determined. Flood mitigation options for the Brown Hill and Keswick Creek system are concept only and no detailed cost benefit analysis of the options or detailed community consultation have been undertaken to date. A more recent investigation on the Brown Hill and Keswick Creek system with extensive piped diversion drains indicates an estimated cost of $72 million for the lowest option.

2.5.4 Minor projects (<40 ha) – non CMSS

There are numerous small projects that are yet to be implemented throughout the majority of the council areas. A complete review and listing of these projects is considered outside the scope of this study.

For those catchments that have Initial USMPs or comprehensive infrastructure studies, a listing of these locations/projects is possible, however, for many of these locations the flooding problems have not been quantified or examined in any detail and may be based on limited anecdotal evidence. Other councils have limited staff with knowledge on drainage and flooding history, primarily due to increasing rates of staff turnover. It is therefore not possible to obtain an accurate listing of every known drainage problem.

2.6 PROCESS FOR PRIORITISING WORKS

As discussed in the previous section of this report, identified stormwater infrastructure projects have been categorised as follows:

- known and quantified projects suitable for CMSS funding;
- projects suitable for CMSS funding but are dependant on development occurring;
- large scale flood mitigation projects with budgetary requirements outside the currently available subsidy funding;
- small catchment area projects (catchment area of less than 40 ha).

Currently, works in the first category are part funded through the CMSS. Works in the second and third categories will only be considered if development commences or if sufficient funding is made available. The fourth category is usually dealt with by the individual council in which the required works occur.

The first category contains larger works and will form the basis of this discussion where priority is determined on an annual basis by the CMSS advisory committee comprising representatives from:

- Department of Water, Land and Biodiversity Conservation
- Department of Transport and Urban Planning
- Institute of Public Works Engineering Australia (SA Division)
- Local Government Association
- expert in water sensitive urban design.

Applications for funding are divided into three categories; construction works, studies and land acquisition and then ranked by members of the CMSS advisory committee.

The criteria currently used for ranking the applications are as follows.

Works

- works proposed are consistent with a previously subsidised study or other study document;
- involve flood mitigation or drainage upgrade work;
- involve water quality improvement;
- involve water harvesting and use;
- improve bio-diversity or conservation or aesthetic improvement;

- has community involvement;
- is a further stage of a previously subsidised project.

Studies

- provide information on improving water quality/catchment health
- provide information on improving stormwater drainage
- provide information on potential flooding and flood mitigation
- provide information on the potential for stormwater use
- provide information on improving amenity
- raises community awareness.

Land acquisition

- land is for work currently or previously subsidised
- is for flood protection/drainage improvement
- avoids the need to do work
- can improve water resources in a catchment
- can improve conservation/biodiversity improvement.

Once the list has been agreed by the CMSS advisory committee, the value of the projects is compiled and the amount that can be allocated to studies and land acquisition decided, with the remaining funds available normally allocated to construction works. The final agreed list and funding allocation is forwarded to the Minister for approval.

In June 2002, a review of the CMSS was undertaken to review key aspects and shortfalls of the scheme. The review has provided a number of key findings to assist in prioritising and funding future work. The review established the following key points:

- Prioritising works is a difficult task and is a function of 'significance and urgency' which is often difficult to define and compare between projects.
- Current level of funding is limited. Based on the current identified projects and funding, the estimated time for completion of the works will be approximately 30 years. This length of time is seen as being unacceptable and should be reduced to 10 years with additional funding.
- Significant projects such as Brown Hill and Keswick Creeks are large and cannot be staged practically over only a few years to fall within current funding

allocations. Even with CMSS funding restored to their highest historical levels (in current dollars about $7 million/annum), there would not be sufficient funding for this project to be completed in a reasonable timeframe.

- Large projects which are dependant on urban or residential development will only proceed when there is sufficient demand for the land. In each instance funding for drainage work will be high and will involve major stakeholders including private developers. There is obviously a benefit to the developer and the council from the expansion. Whilst the State Government has an interest in the economic activity and expansion, the CMSS should not be a significant source of funding for such projects.
- Additional funding should be sought from other sources such as Catchment Water Management Boards (increasing catchment levies), Local Government Disaster Fund, Community Emergency Services Fund and developer contributions due to infill developments. It should be noted that these sources have since been explored with no success.
- The preparation of USMPs (with support from the Catchment Water Management Boards) are the key mechanism for councils to address stormwater management issues in particular stormwater use, stormwater quality, environmental issues and management of infill development.
- Weighting in favour of projects that incorporate stormwater use should be encouraged. The cost of incorporating beneficial stormwater use into design adds initial cost to projects; however, the long-term benefits of such projects are high.

2.7 FLOOD HAZARD ASSESSMENT

Flood hazard is best described by the publication 'Floodplain Management in Australia – Best Practices Principles and Guidelines' (CSIRO 2000) which states that the factors affecting the hazard and disruption caused by a flood can be grouped into four categories:

- flood behaviour (e.g. severity, depth, velocity, rate of water rise, duration);
- topography (e.g. evacuation routes, islands);
- population at risk (e.g. number of people, number of developments, land use, flood awareness);
- emergency management (e.g. flood forecasting, flood warning, flood response plans, evacuation points, recovery plans).

The current guidelines (CSIRO 2000) for determining flood hazard provide four degrees of hazard:

- Low—there is no significant evacuation problems. If necessary, children and elderly people could wade to safety with little difficulty. Maximum flood depths and velocities are low. The warning time is long and allows evacuation routes to remain trafficable for at least twice as long as the time required for evacuation. Evacuation is possible by conventional vehicles.
- Medium—fit adults can wade to safety but children and the elderly may have difficulties. Maximum flood depths and velocities are greater and evacuation times are longer. Evacuation is possible by sedan type vehicles in the initial stages of the flood and later by 4WD vehicles or trucks only. Evacuation routes remain trafficable for at least 1.5 times as long as the necessary evacuation time.
- High—wading evacuation routes are longer again. Fit adults have difficulty in wading to safety. Maximum flood depths and velocities are greater (up to 1.0 m and 1.5 m/s respectively). Motor vehicle evacuation is possible only with 4WD vehicles or trucks and only in the early stages of flooding. Boats or helicopters may be required. Evacuation routes remain trafficable only for the minimum evacuation time.
- Extreme—boats or helicopters are required for evacuation. Wading is not an option because of the rate of rise and the depth and velocity of the flood waters. Maximum flood depths and velocities are over 1.0 m and 1.5 m/s respectively.

The only relevant flood hazard assessment based on current definitions within the study area is that undertaken for the Brown Hill and Keswick Creek systems (Hydro Tasmania, 2003). Flood hazard maps have been prepared for the various flood events considered in the flood study ranging from 1 in 10 year ARI up to and including the 1 in 500 year ARI and Probable Maximum Flood (PMF).

Flood hazard assessment has also been undertaken for the Torrens River (SMEC 1999) and the Torrens River is considered to have a 200 year ARI capacity. Only for events larger than a 200 year ARI do the flood hazard maps become applicable.

A summary of the flood hazard assessment for the Brown Hill and Keswick Creek catchment is as follows:

- Low:
  - most of the built up areas that are inundated (for all events) are classified as 'low hazard'. This is because depths are low (less than 0.35 m) and velocities are also low (less than 0.3 m/s). Streets can have 'medium' or 'high' hazard ratings because the low roughness can result in higher velocities.

- Medium:
  - large areas in the Southern Parklands due to depths greater than 0.3 m. The roughness of the areas makes the water slow down and get deeper;
  - some areas of the Royal Adelaide Showgrounds and Investigator Science and Technology Centre;
  - Keswick Rail Terminal and the industrial area near Scotland Road, Mile End South;
  - the suburb of Cowandilla as there is a major flow paths through the suburb;
  - Adelaide Airport – deep pools of water are formed in the airport.
- High:
  - small areas of the Parklands due to localised areas of deep water and/or high velocity;
  - Keswick Creek upstream of the Royal Adelaide Showgrounds and Park Lands Creek downstream of Greenhill Road including areas adjacent the creek channels;
  - some areas of the Royal Adelaide Showgrounds, Investigator Science and Technology Centre and Keswick Rail Terminal due to deep water passing through the area;
  - some parts of the suburb of Cowandilla;
  - part of the Adelaide Airport adjacent plane runways and taxiways.
- Extreme hazard:
  - the north west corner of the allotment on which the Glenside Hospital is built at the corner of Greenhill Road and Fullarton Road (within the detention basin);
  - North Unley Play Park;
  - Upper Brown Hill Creek in the area upstream of Devonshire Street, Hawthorn as this is very deep and of high velocity;
  - some parts of the Royal Adelaide Showgrounds.

The mapping used to present these results by Hydro Tasmania are detailed and of a technical nature. These maps have not been included in this report as they are publicly available.

2.8 FLOOD DAMAGE ASSESSMENT

Flood damage can involve direct and indirect financial costs and can be incurred by individuals, business establishments and infrastructure (e.g. government costs). In addition, there are economic costs which are those derived from changes to the community welfare and resource consumption, and for many cases this amount is considerable.

Examples of **direct financial costs** are as follows:

- residential buildings
- household contents
- retail, commercial and industrial structures including contents
- public buildings (schools, libraries, hospitals, council offices and depots, etc.)
- transport infrastructure (roads, rail, bridges and airports)
- utilities (water supply, wastewater, electricity, communications, gas etc).

Examples of **indirect financial costs** are as follows:

- disruption of trade
- transport disruptions (e.g. airport closure)
- disruptions to water, sewer, telecommunications, etc.
- temporary accommodation
- clean up.

Other **intangible economic costs** and losses would include the following:

- disease and illness caused by contamination of water and sewerage systems and personal stress;
- other emotional, physical and psychological health issues;
- loss of morale in sections of the community responsible for flood management.

As with the previous section on flood hazard, the only significant study that has assessed flood damages is the Brown Hill and Keswick Creek study. A summary of this follows.

In a major event (100 year ARI), it is estimated that approximately 2.3 km of the Adelaide-Melbourne railway line would undergo medium damage, approximately 12 km of road would be affected (e.g. require pavement rehabilitation) and a number of old bridges would be destroyed.

Minor damage would occur to underground services, however stormwater pipes would become blocked with silt and debris, and sewage pumping stations are likely to be affected by significant inundation.

Stormwater flow management can essentially be controlled on three levels:

- catchment level
- drainage system level
- site level.

At a catchment level, the social, environmental and economic elements of the stormwater system are investigated. A balance between economic development, flood protection and restoration of natural systems is considered. This may involve at source controls to limit quality and quantity changes and can be either structural (e.g. detention basins, wetlands etc) or non-structural (e.g. legislation, policy change, etc).

Management at a drainage level has been the traditional approach to flow control and undertaken by assessment of the 'minor' and 'major' flow systems. It is primarily a structural measure with the main aim to minimise flooding with limited respect to natural systems. Measures include upgrade of pipe infrastructure, detention basins and are often expensive with high capital costs.

On-site management relates to managing stormwater quality and quantity at source on the site of origin. On-site detention (OSD) and retention (OSR) are techniques with a number of issues that need consideration and assessment. Such methods are increasingly required by councils for new developments, particularly when there is no available open space. In doing so, councils have shifted the responsibilities onto developers and private owners with regard to installation, operation and maintenance of such devices. This is also due to limited council staff to undertake such duties, and an attempt to shift away from some of the liability issues associated with large constructed basins designed to fill with water.

Existing open space (e.g. ovals, parks, gardens, large trees) is often utilised for other purposes, such that it is difficult to reconfigure and construct large detention basins without considerable disruption and change. Within larger new developments, councils specify the minimum amount of public open space; however, often do not consider the possibility of stormwater detention requirements in this calculation. Any detention requirement is then required to be dealt with at an allotment level. There are some examples in metropolitan Adelaide (i.e. Westwood) where stormwater management provisions (detention basins) are incorporated as a portion of the open space provision.

Some of the important advantages of OSD schemes are:

- limit site flows to permissible levels by causing a flatter, elongated hydrograph
- may negate the need to upgrade downstream drainage infrastructure.

Some of the key disadvantages of OSD schemes are:

- difficult to maintain and therefore ensure continued function;
- provide little direct reduction in pollutants;
- extended lower flows from the catchment may damage downstream creek environments;
- parts of the catchment may be subjected to increased flow rates due to the flatter, elongated hydrograph.

The main advantage of OSR that is different to OSD is that OSR schemes reduce the total volume of water discharged off the site into the downstream drainage system, but do not necessarily reduce the peak flow off the site. OSR tanks operate quite differently to OSR, infiltration and soakage devices.

Further discussion and explanation of these issues are presented later in this section.

2.9.1 On-site management

Locally, OSD and OSR practices have recently become a requirement for new developments by a number of councils. It is outside the scope of this investigation to cover in detail all applications, however a few relevant examples are highlighted to gain an appreciation of the topic.

Detention

On-site detention (OSD) is essentially the temporary holding of stormwater runoff on-site and releasing it at lower rates. This can be in the form of rainwater detention tanks, underground tanks or other holding devices.

The City of Marion requires that all new buildings and building extensions of 40 m^2 or more incorporate sufficient detention/retention to limit stormwater runoff from the subject land so that flows do not exceed those calculated from equivalent runoff coefficients of 0.25 (5 year ARI event) and 0.45 (100 year ARI event)—refer Kinhill (1998b). Criteria for detention tanks sizes have been developed based on the allotment size and roof area as a percentage of the total allotment area. This methodology is developed for urban consolidation of residential areas north of Seacombe Road and does not apply to 'greenfield' type development. This approach involves the capture of events up to the 5 year ARI event only and also assessed the effect on the 100 year ARI event. Tanks are provided with an appropriately sized orifice plate and modular tanks are required.

The analysis considered the effect of delayed hydrographs at catchment level and recommended that the approach was only appropriate for levels of consolidation of 10% of the catchment. Should the level of consolidation exceed 10%, it was recommended that a more detailed approach be required across the catchments.

The City of Charles Sturt also has requirements for OSD and OSR. The requirements developed by the City of Charles Sturt are broadly split into small and large scale residential developments, and council also caters for commercial and industrial developments on a case by case basis. In small scale developments, the design event is 5 year ARI and the maximum permissible flow from the site is calculated on the peak pre development 5 year ARI flow. For large scale residential developments, the design event is 100 year ARI and the maximum permissible flow from the site is calculated on the peak 5 year ARI flow. Large scale development requires capture of flows up to the 100 year ARI event. These requirements are uniform across the council area.

The City of West Torrens has a general 'blanket' approach where the development (regardless of size and land usage) is required to incorporate detention to restrict flows from the site to 20 L/s in the 20 year ARI event. There was no sound or founding basis established, that 20 L/s is a 'reasonable' value to be used unilaterally for all development types and sizes.

The City of Tea Tree Gully has a similar arrangement to the City of Marion, in that for certain areas, detention tanks are required for both new development and extension to buildings. The sizing of tanks falls within two distinct areas and is based on not exceeding either 30 or 40 percent equivalent roof area site coverage. Outside of these two areas, the detention requirement is unclear; however, some sites require discharge from the site to be limited to as low as 4 L/s for residential developments.

Interstate, OSD practices have also been developed in New South Wales, in particular the Upper Parramatta River Catchment Trust (UPRCT) in the 1990s (UPRCT 1999) and more recently the City of Newcastle (2003) and Manly Council (2003) have developed similar requirements.

For the City of Newcastle, on-site detention is to be provided so that:

- the total post-development 20 year ARI flow for all storm durations is controlled to no greater than the peak pre-development 10 year ARI flow; and
- the total post-development flow for events from 20 year ARI to 100 year ARI for all storm duration event is controlled to no greater than the peak pre-development flow for the corresponding event.

Manly Council and UPRCT require that detention storage be calculated for all storms from 5 year ARI to 100 year ARI to ensure runoff from the site is restricted to the peak 5 year ARI pre-development flow. Manly Council have implemented a maximum discharge of 25 L/s off a site directly into the kerb and water table.

All of the above requirements are quite different with some detaining minor event flows (up to a 5 year ARI event) and some detaining up to the 100 year ARI event. Except for the UPRCT, and to a lessor extent City of Marion and City of Tea Tree Gully, no detailed assessment has been undertaken to quantify the flood mitigation benefits of such devices within the catchment. Capture of major flows is practical for steeper locations where allotments are large enough, however, for smaller, flatter sites this is almost impossible to achieve.

Retention

On-site retention (OSR) is essentially prevention of stormwater runoff from a site, causing the water to continue in the hydrological cycle either as infiltration, percolation or evapotranspiration. Such devices can be in the form of rainwater tanks or infiltration and soakage devices.

The use of infiltration and soakage devices is also promoted by various councils. The effectiveness is related to the infiltration capacity of the soil. Soil moisture changes adjacent to structures need careful consideration to ensure shrinkage and swelling of soils is kept to a minimum. Safe distances (i.e. at least 3 m clearance from footings, pavements etc) are recommended by Argue (1986). In areas of Adelaide with high clay content, the use of infiltration and soakage devices often becomes impractical. Other sites that are generally inappropriate are ones with shallow rock, areas of high water tables (less than 2 m deep) and where sites are steep.

Infiltration and soakage OSR devices are sensitive to blockage and require regular maintenance to operate effectively. Ownership of the maintenance regime is often debated and funding is limited to educate council staff and property owners about the pitfalls of poorly designed and maintained devices.

In September 2003, a Minister's specification (Planning SA 2003) was developed to provide cost-effective technical solutions to the requirements for on-site retention of roof runoff using infiltration principles. The design basis and underlying principles of this document are considered sound and valid.

The use of rainwater tanks (as opposed to detention tanks) within the home is currently widely promoted and in many cases subsidised (e.g. City of Adelaide and City of Mitcham). From July 2006, the state government has mandated that all new homes will require rainwater tanks and are to be plumbed into the household. Whilst the primary purpose of this initiative is to raise water conservation awareness and a reduction in water mains consumption, the rainwater tank can also provide flood mitigation benefits if allowed to be sufficiently empty.

2.9.2 Effectiveness of rainwater tanks (OSR) and detention tanks (OSD)

It has been shown (UPRCT 1999) that incorporation of OSD in some catchments and under certain hydrologic conditions, has led to lower parts of the catchment being subjected to increased flow rates due to the timing of the extended hydrograph from upstream areas. This effect may be magnified if a 'blanket' approach is applied across the whole catchment. This has been highlighted clearly in the Planning SA document 'Guidelines for Urban Stormwater Management', maintaining that a formal study of the entire catchment or sub-catchment be undertaken to assess this effect and comparisons made with other solutions (e.g. detention basins and pipe system upgrades at a catchment level).

Research by the Urban Water Resources Centre (UWRC) at the University of South Australia has demonstrated that rainwater tanks have little effect on reducing stormwater flooding if the tanks are small and maintained close to full as much as possible. The available storage within a rainwater tank at the start of a storm event is a very important factor in determining the effectiveness of the device.

Van der wel (1990) showed that a rainwater tank of 20 kL capacity is required in Adelaide in order for it to be a reliable source of storage for flood mitigation purposes (without a daily demand). Work by Coombes and Kuczera (2003) has investigated the average retention storages available prior to storm events in Adelaide, based on different roof areas, number of occupants and tank volume. A rainwater tank on the average family home of at least 2 kL in size will on average provide retention storage of between 70–80%.

Investigations by Coombes et al (2000) has provided further conclusions on rainwater tanks for flood mitigation purposes, in that whilst OSD tanks provide a reduction in peak flows from a site, they do not provide a reduction in the volume of the discharge. What is also important is a reduction in volume. A 10 kL rainwater tank (if partially empty) reduces the volume of runoff and not the peak, however the cumulative effect of the volume reduction provided by rainwater tanks may provide sufficient flood mitigation benefits when assessing the stormwater hydrograph from the larger catchment.

Work by Argue & Scott (2000) has also investigated this effect. It was concluded that in small catchments where the individual site represents the limiting case, peak flow reduction will favour the OSD option. In medium to large catchments, the cumulative effect of volume reduction provided by OSR can override the effect of peak discharge reduction in OSD. This suggests that the most effective device has a combination of both OSR/OSD.

The Urban Water Resources Centre (2003) has recently undertaken a study into the hydrological benefits of rainwater tanks on an urban catchment at Glenelg with a 2 year ARI minor system standard. The scenarios investigated were:

- an assessment of the catchment without tanks;
- an assessment of the catchment with one 2 kL rainwater tank per dwelling (tanks used for drinking and watering i.e. low demand);
- an assessment of the catchment with one 4.5 kL rainwater tank per dwelling (tanks used for higher demand uses 300 L/day);
- an assessment of having rainwater tanks in only partial areas of the catchment.

The main outcomes of this study was that the larger tanks (4.5 kL) with a higher daily demand were found to have a greater benefit on stormwater flow reduction on the catchment, than smaller tanks (2 kL) with a smaller daily demand. In addition, the placement of rainwater tanks (4.5 kL – demand of 300 L/day) in the top two thirds of the catchment provided the same benefit to the drainage capacity as if applied uniformly throughout the catchment.

The UWRC also undertook water balance analysis of rainwater tank storage using historical rainfall data and suggests that rainwater tanks may provide insignificant available storage capacity to reduce the impact on the downstream drainage system for storms of less than 90 minutes duration (i.e. peak flows from smaller catchments). This would indicate that detention tanks or combined detention/rainwater tanks may be more suitable on the smaller catchments. For the larger catchments with critical storm durations of greater than 90 minutes, rainwater tanks may provide more benefit to the downstream system.

In summary, the key outcomes of the research undertaken to date on detention tanks (OSD) and rainwater tanks (OSR) for flood mitigation purposes are as follows:

- rainwater tanks need to be large enough (>5 kL) to provide sufficient storage;
- rainwater tanks require sufficient daily demand, detention tanks do not;
- strategic placement within the catchment is essential for performance;
- their effect on total catchment flows is quite catchment specific:
  - larger catchments appear better suited to rainwater tanks
  - smaller catchments appear better suited to detention tanks;
- rainwater tanks can improve downstream water quality by reducing the volume and the number of small infrequent events resulting in more efficient pollutant removal at downstream locations if measures for pollution capture and removal are put in place;
- detention tanks do not reduce volumes and will extend duration of low flow periods possibly creating environmental problems (e.g. erosion);
- both are only beneficial for events less than 20 year ARI (i.e. maximum roof gutter capacity).

The recommendations by Coombes et al (2000) are essentially the same as those outlined in 'Guidelines for Urban Stormwater Management', recommending that the industry undertake studies to analyse the performance of catchments with respect to installing OSD and rainwater (OSR) tanks. In the case of Adelaide, this assessment should be undertaken as part of the development of the USMP.

2.10 ENVIRONMENTAL MANAGEMENT

As highlighted in the paper 'Stormwater in Adelaide – from SWS to WSUD, 'myths' and realities' (Lipp 2001) water quality and other environmental objectives have become increasingly recognised over the past decade.

The beneficial effects of incorporating environmentally friendly infrastructure such as grassed swales, wetlands and even detention basins in stormwater management strategies has been well documented (CRC for Catchment Hydrology – 1998). Opportunities for incorporating water quality improvement and stormwater harvesting and use schemes in existing built-up areas is limited due to the lack of suitable open space along or adjacent to trunk drainage systems. Opportunities in 'greenfield' developments are greater, and this is where much of the future Water Sensitive Urban Design (WSUD) principles are likely to be most effective.

Some recent schemes incorporating stormwater volume and pollutant load reduction strategies, as well as resulting in the production of a non potable water supply resource include the Parafield Airport and Morphettville Racecourse Aquifer Storage and Recovery (ASR) schemes.

These schemes, and those with only water quality function (wetlands), typically target the smaller, frequent events such as up to the 1 year ARI event. Those frequent events have been shown to contain the majority of pollutant loads (in excess of 95%) and can capture up to 70% of the average annual volumetric runoff of the upstream catchment (Australian Guidelines for Urban Stormwater Management 2000). Large events, however, are not catered for in these schemes, and as such, provision for flood protection (in terms of size of infrastructure) remains largely unchanged.

The City of Salisbury has been recognised nationally as pioneers in this field, initially developing detention basins and wetlands for flood mitigation and water quality objectives and more recently for developing innovative stormwater harvesting and ASR projects (refer Part B Report).

As previously noted, the combination of limited open space and the magnitude of large, infrequent flood events in metropolitan Adelaide are such that containment of all flows is not possible. A number of councils, and more recently the CWMBs, have initiated and implemented catchment wide water quality improvement programs such as installing gross pollutant traps and constructing urban wetlands. As noted above, treatment of the minor events (<1 year ARI) can achieve significant reductions in pollutant loads contained within stormwater prior to discharge to receiving waters.

In addition to the broader, wider scale catchment management approaches, site specific approaches are used to reduce discharge to receiving waters. The principal legislation addressing pollution in South Australia is the Environment Protection Act 1993.

The Environment Protection (Water Quality) Policy 2003 makes polluting stormwater an offence that can result in on-the spot fines or legal proceedings. The authorities who may enforce the Water Quality Policy include the EPA, councils and CWMBs.

In terms of environmental benefit, on-site detention and retention does little to reduce pollutant loads from the catchments as the majority of the pollutant loads are sourced from roadways (refer Section 2.9.2).

As also previously discussed, detention results in extended periods of lower flows and may result in downstream environmental consequences such as erosion in creek systems. Rainwater tanks of reasonable capacity and demand have the effect of reducing the number of frequent storm events and therefore have the potential to reduce the cost with regard to water quality management further downstream. Detention tanks do not have the effect of reducing the volume, therefore maintain the number of frequent smaller events and have no impact on water quality.

The combination of incorporating a detention facility with aquifer disposal has been trialled and implemented on a limited scale in Adelaide. Opportunities in some of Adelaide's western areas are known to exist, where shallow (Quaternary) aquifers exist and are suitable for stormwater injection. The most significant barrier to this is the stringent licensing requirements for aquifer disposal imposed by the EPA.

One example of this arrangement has been incorporated into the Westwood Development at Ferryden Park in Adelaide's inner northwest. At this site, a small (4 ha) residential catchment drains to a local detention basin, with the outfall being to a buried gravel trench connected via slotted pipe to a series of three disposal bores. The receiving aquifer in this instance is quite shallow (30 m) and considered highly degraded due to its high salinity level. The input of fresh stormwater improves the condition of the aquifer.

Cleansing of the stormwater occurs via settlement through the detention basin and filtration through sand layers into the buried gravel trench. A management plan has been developed and accepted by the EPA for this scheme, which involves being able to isolate the basin and associated filter trench from the disposal bores in case of contamination spill. Although considered acceptable at the time (in 2000), recent comments made by the EPA are that this type of system is unlikely to be approved in the future, due to concerns over potential contamination of the aquifer, and disinfection of the stormwater will be required prior to disposal. This is likely to be in the form of UV disinfection, as chemical (chlorine) is not permitted, which at present is cost prohibitive for such a scheme.

It should be noted that considering the condition and third party use (or lack thereof) of the degraded saline shallow aquifer in these areas, and given the risk management approach developed in the management plan, the stringent EPA conditions and current attitude toward the potential of this type of scheme would appear unwarranted.

2.11 REGULATORY AND POLICY FRAMEWORK

This section discusses the regulatory and policy tools available to the State Government and councils principally through the operation of the Development Act 1993 and the instruments of that Act – The Metropolitan Planning Strategy and the Development Plan. Whilst the components of this Act have been in place for some time there have been significant changes at the strategic and policy level within the past three years that provide for potential changes to stormwater management in the metropolitan area.

2.11.1 Stormwater infrastructure and resource management

The responsibility for stormwater drainage in South Australia is largely that of local government. Due to the multitude of councils involved, the State Government has assumed maintenance responsibilities for the bed of the River Torrens and the concrete lined sections of the River Sturt, Brown Hill Creek and Keswick Creek.

As discussed previously, funding for stormwater infrastructure is also generally the responsibility of local government; however, where a catchment exceeds 40 ha, contribution of 50% of costs may be made by the State Government is made under the CMSS.

In addition to the above, where 'strategic planning' and water quality improvement works are being undertaken, funding can also be contributed by the relevant CWMB. The role of the CWMB is to, *'implement planning measures, catchment works and community education and awareness programs primarily to improve catchment water quality and water source health'* (Torrens Catchment Water Management Board 2002).

The structure of the current CWMBs is changing, with the Natural Resource Management (NRM) Bill being passed through State Parliament. This Bill, if passed, will see the amalgamation of the current four metropolitan Adelaide CWMBs (Torrens, Patawalonga, Onkaparinga and Northern Adelaide Barossa), together with soil conservation and pest control boards. The CWMBs currently (and will continue to) operate strategically, not operationally.

Implementation of catchment wide strategies is outside the jurisdiction of the CWMBs and where council boundaries are crossed, the process can be stalled due to individual councils not agreeing on responsibilities for the problem, cost sharing principles and physical works to be undertaken.

Initially, implementation of these larger 'cross council border' stormwater drainage projects was undertaken by the authority of a special act of Parliament. A case in point is the South Western Suburbs Drainage Scheme (SWSDS), authorised by the South Western Suburbs Drainage Act 1959 and implemented by the Government (largely by the then Highways and Local Government Department).

This project saw the construction of a number of trunk drains, feeding into the River Sturt and direct to the sea. Also constructed was the River Sturt concrete lining to increase the capacity of the channel, the River Sturt Flood Control Dam to limit inflows from the rural areas and enhancements to the Patawalonga Basin and floodgates to ensure safe passage of flood waters to the sea (Lipp 2001).

The creation of the Stormwater Drainage Subsidy Scheme in 1967 was the alternative approach to the State Government acting on a problem under the authority of an Act of Parliament. The previous Stormwater Drainage Subsidy Scheme and the current CMSS are basically funding arrangements and the legal authority to undertake the work rests with the proponents of individual project (in the case of councils, the Local Government Act).

Under the Local Government Act, 'Regional Subsidiaries' (formerly Section 200 Authorities) are the preferred mechanism for such multi-council activities and are common especially for stormwater management and waste management (Barry 2000). A current example of this approach is the Gawler River Floodplain Management Project.

2.11.2 The Development Act 1993

The Development Act has been established to provide for proper, orderly and efficient planning and development within South Australia. The key objectives of the Development Act are:

- establishing objectives and principles of planning and development;
- establishing a system of strategic planning to guide development;
- providing for the creation of Development Plans;
- establishing and enforcing cost effective technical building requirements;
- providing for appropriate public participation in planning and the development assessment process;
- providing for the safety and health of people who use buildings; and
- facilitating the adoption and application of uniform national building standards.

The role of the Development Act is to establish a framework for making policy and provide for its implementation. Whilst the Act is a statute of State Parliament a large part of its operation and impact, particularly in regard to Policy and Development Assessment, is handled by local government.

Amendments are currently being undertaken to the Development Act 1993 (the Better Development Plan Programme).

These changes are aimed at improved policies and procedures which will improve all aspects of the planning system and in particular:

- a greater emphasis at the State and local level in regard to strategic and infrastructure planning and the enhancement of the role of the Strategic Plan (Stormwater infrastructure is a significant component of urban based infrastructure);
- a greater emphasis at the local level on desired future character statements.

2.11.3 Planning Strategy

Section 22 of the Development Act requires a Planning Strategy to be developed and maintained. The Planning Strategy is a vision for the development of the State and its regions and the Adelaide metropolitan area is specifically covered by a component of the Strategy. The Strategy covers social, economic and environmental issues and outlines State Government programs, processes and actions to achieve the vision. The Strategy applies to state, local and private development via the Development Plans and provides an overall government approach by incorporating key directions from a range of State level strategic plans and policies.

2.11.4 The management of Metropolitan Stormwater and the Metropolitan Adelaide Planning Strategy 2004

The revision of the Metropolitan Adelaide volume of the Planning Strategy—January 2004 (MAPS) which is in Draft format and soon to be released, contains significant implications for development that is based on Ecologically Sustainable Development (ESD) practises and the management of the metropolitan area. In particular the MAPS provides links to the Metropolitan Development Program (MDP) and the State Infrastructure Plan that is being produced by the newly formed Office of Infrastructure Development (OFID).

OFID is currently preparing the Metropolitan Section of the State Infrastructure Plan and water management and the stormwater component of the management cycle features prominently in the evaluation. The State Infrastructure Plan will detail the priorities for infrastructure works particularly if they relate to matters that will impede the proper development of the State. Significantly within the provisions of the Development (Sustainable Development) Amendment Bill 2004 it is proposed that local governments prepare a 'Strategic Directions and Infrastructure Report' (Sect 30 (1)) which will address the strategic issues within the area of the council with particular reference to the Planning Strategy and '(ii) Local infrastructure development.' Such a review must be cognisant of the State Infrastructure Plan and will address the significance of stormwater infrastructure. The State Infrastructure Plan is not yet referred to in the Draft Bill and this should be corrected.

ESD and the organisational elements of the MDP and OFID have significant implications for policy directions in regard to stormwater management at the highest level of State Government.

The Planning Strategy contains guiding principles that are based on ESD principles and these form the basis of the key overarching objectives of the Strategy. In particular the guiding principles are to:

- optimise the net benefit from development, use and management of resources and ensure the integrity of natural, social and economic capital;
- create integrated solutions with multiple benefits from sustainable development;
- enhance accessibility and ensure a fair distribution of resources throughout the urban area;
- provide both certainty to investors (taken to be a wide definition including the Adelaide community) and adaptability of policy to allow for innovation.'

The overarching objectives then follow as:

- urban containment
- integrated energy provision, transport planning and land use planning
- planning for integrated land and water use.

The implications for stormwater management, given these objectives, are significant and far reaching in the development of metropolitan Adelaide.

The concept of using alternative water sources in the urban environment is explored by Kathryn Bellette, Director Strategic Planning, Planning SA in her paper *'The Role of Planning in Advocating the Use of Alternative Water Sources in the Urban Environment'.*

Ms Bellette's paper highlights up front that 'the use of alternative water sources in urban areas has been demonstrated to be feasible both in theory and in practice'.

Combined with this she makes reference to the marked increase over the last 10 years in the knowledge, skills and interest in this area.

The paper outlines the role of planning in South Australia in advocating the use of alternative water resources in urban areas, and adjacent horticultural areas.

The clear aim is to 'increase the use of alternative water sources in an effective and efficient manner as an integral part of an overall strategy for ecologically sustainable development'.

In this, the State Planning Strategy for metropolitan Adelaide and water proofing Adelaide programs are adding value to one another, at administrative and ministerial levels to encourage and facilitate the use of alternative water resources by establishing a whole of metropolitan strategic planning framework.

Community awareness and acceptance will be a key step in delivering the cultural and regulatory change needed to embrace and make the best possible use of alternative water resources.

The creation of an urban growth boundary for Adelaide in 2002 places emphasis on higher levels of urban infill and consequent runoff and the necessary renewal of stormwater infrastructure. The emphasis in the Strategy is on the efficient provision of infrastructure and the integration of systems to better manage and utilise stormwater. The intention of the Strategy is to create a 'whole of water cycle' approach to water use and management and integrating this into the design of land development. It is therefore necessary to augment existing supplies of water that are of potable standard with the use of local stormwater supplies and from other sources such as treated waste water and grey water.

It is therefore important to note that significant detail has now been incorporated at the State Strategic level of the planning system in regard to stormwater management.

To achieve the overarching objectives the key direction of 'Water Resources Stewardship' in the Metropolitan Planning Strategy indicates the following major strategies.

Ensure the most efficient use of water based on the hierarchy principles of avoidance, reduction, use, recycle and appropriate disposal to assist in reducing Adelaide's dependency on the Mount Lofty Ranges and the River Murray for its water supply

- developments will take into account efficient and integrated on-site disposal and/or storage, treatment and use of local rainwater and stormwater;
- where stormwater use opportunities are available wetlands and/or other forms of treatment and storage of stormwater will be incorporated in subdivisions and other multi-building developments to facilitate aquifer storage and recover (ASR);
- make provision for rainwater storage into plumbing and general building design for use of rainwater in residential and non-residential buildings.

Minimise risk of flooding to persons and property

- undertake WSUD and associated infrastructure development in order to provide neutral drainage impact as a result of infill development (upstream and downstream).

Integrate the management, protection and use of water resources into the broader land use planning and management

- 'greenfield' development should, where possible, seek opportunities to integrate treated stormwater and wastewater disposal for irrigation;

- incorporate opportunities in development design and implementation to allow the active recharge of ground water e.g. ASR, with harvested stormwater of a suitable quality;
- design stormwater management infrastructure systems to incorporate a dual function of flood mitigation and water quality and where possible, biodiversity.

A coordinated multi-approach to the provision of infrastructure, from the perspective of stormwater as a resource as well as a potential hazard. Incorporating complementary functions related to water quality and flood management (stormwater) and also in relation to water supply needs

- prepare urban stormwater master plans at the local level to provide a framework for the assessment of appropriate measures to be incorporated into development to address stormwater runoff;
- prioritise stormwater collection and management at the catchment level, followed by an assessment of the requirement for on-site measures;
- ensure council and developers, in conjunction with relevant State Government infrastructure agencies, complete a local infrastructure provision plan for greenfield developments prior to development approval for subdivision. This should encompass:
  - WSUD at both site level and whole of subdivision level where one complements the other and on-site disposal, and/or collection, treatment and stormwater harvesting and use.
  - Ensure WSUD is incorporated at the site level, and development project level and/or sub-catchment or catchment level if appropriate, to provide (at least) a neutral drainage impact. This is to be consistent with both the council and catchment level stormwater management master plan. This may include on site disposal, and/or collection, treatment, harvesting and use of stormwater.

The Metropolitan Adelaide Planning Strategy 2004 identifies some key actions that are considered relevant to stormwater management. In particular:

- that the State Government, councils and the Mount Lofty Ranges/Greater Adelaide Natural Resource Management (NRM) Board jointly establish a staged plan to rehabilitate waterways across metropolitan Adelaide;
- establish a policy/legislative framework for water rights;
- develop performance criteria for WSUD for greenfield and infill developments at both site and catchment levels;
- councils to implement, in accordance with Planning SA Guidelines for Urban Stormwater Management, USMPs, consistent with catchment master plans;

- development plans require development proponents to deliver environmental water flows (ground water and surface water) for water dependent ecosystems impacted or influenced by the development;
- investigate changes to the Waterworks Act (1932) and Sewerage Act (1929) to achieve a whole of water cycle approach to water use and management;
- provide space to undertake WSUD.

The Planning Strategy indicates a very important link with maintaining and enhancing infrastructure and particularly the implementation and management role of the Metropolitan Development Program in this regard. The program details the requirements by new urban development for infrastructure and, with the growing pressures of urban infill, the added burden on the existing infrastructure assets. The issue in this regard becomes one of not only maintaining a depreciating asset but also renewing to cope with additional use at often higher standards.

The 2004 MAPS includes significant detail and direction for water stewardship and, of relevance to this study, stormwater management. The impact of MAPS is still in its formative stages and its full force has not yet filtered into direct action by the State and local government, or into regulatory and policy change particularly in the form of the Development Plans.

It is emphasised that in accordance with the Development Act the Planning Strategy is the fundamental direction for changes to Planning Policy and must guide the future direction. Without this lynch pin the policy can be fundamentally challenged and without the adoption of the key directions of the Strategy by State and local level policy there will be no fundamental change for such matters as stormwater management.

2.11.5 The Development Plan

The Planning Strategy is the 'blueprint' for the 'machinery' of the more detailed Development Plan. The Development Plan is comprised of detailed policy for areas of the State, usually formatted in council area groupings. The Development Plan provides a vision, objectives and principles for development under land use categories. The Development Plan is a spatial expression and activities are linked to location expressed as precincts and zones. The Development Plan provides the basis for making an assessment of individual development applications. In arriving at a decision in regard to a development the assessing authority has reference to desired character, preferred development, and the criteria to allow development to occur.

As indicated above, in regard to the recent changes to MAPS, the full force of the 2004 revision has not yet been fully felt in Development Plan changes.

It is the case however, that there have been a series of changes in recent years that been included some Development Plan changes (refer Figure 2.1). The release of the

'Stormwater Infrastructure Planning Package' in March 2001 covered a wide range of matters in regard to stormwater management. These initiatives included the 'Ministerial Stormwater in Urban Areas Amendment Report (PAR)', a 'Minister's Specification on On-Site Retention', 'Guidelines for Urban Stormwater Management' and the Planning Bulletin 'Urban Stormwater Infrastructure'.

The Ministerial PAR, 'Stormwater in Urban Areas', was established to better integrate strategic water resource policy with development policy and allows for a more comprehensive approach by local government to incorporate stormwater management into their plans.

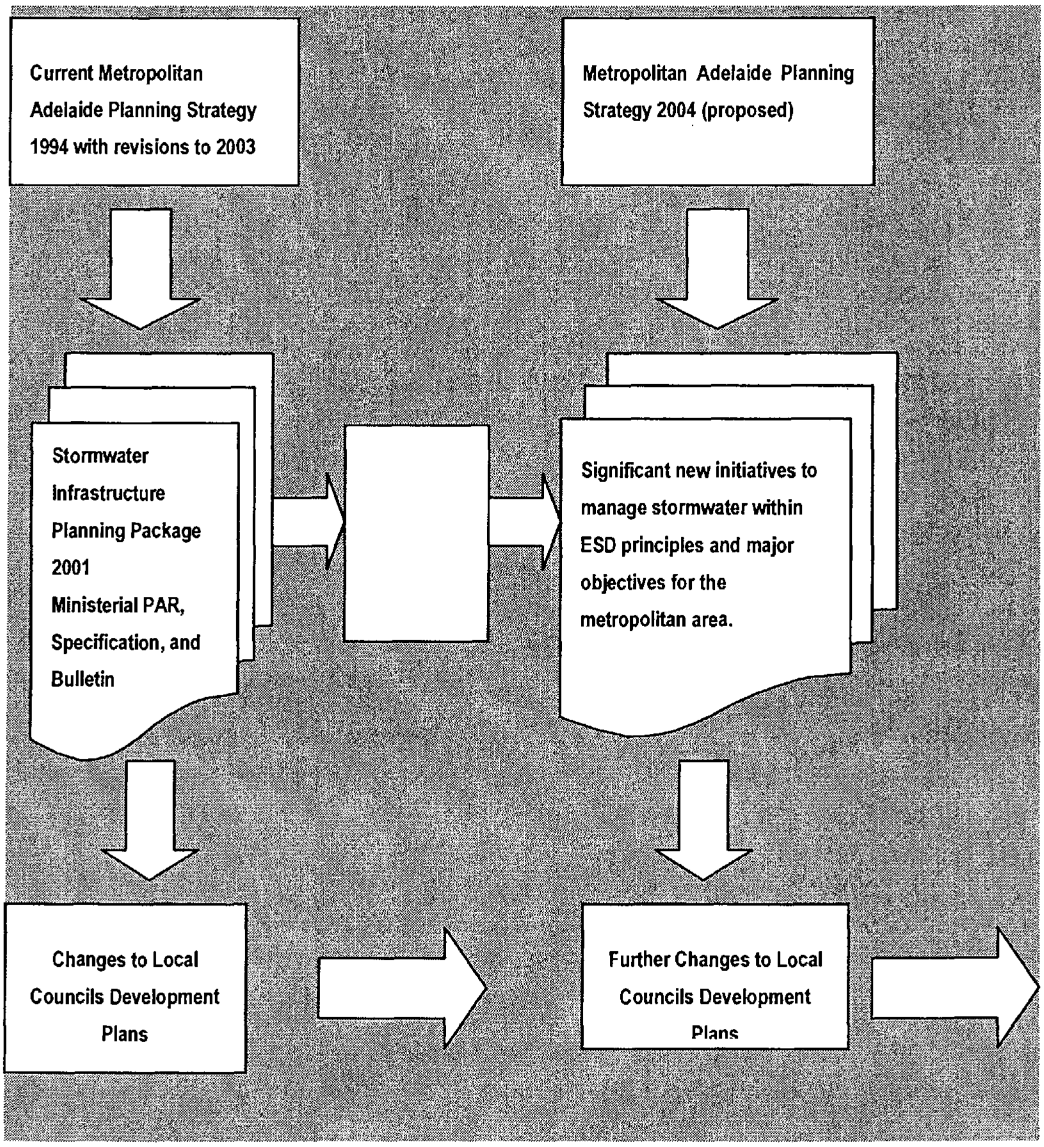


Figure 2.1—Changes to Development Plans

The release of the Planning Bulletin 'Urban Stormwater Infrastructure' specifically provides guidance to councils in formulating Development Plan policies at the local level to support the integrated management of urban stormwater in a manner that complements the relevant Catchment Water Management Plan. The Bulletin was produced as a result of collaboration by the Torrens and Patawalonga Catchment Water Management Boards aimed at promoting better Development Plan responses to urban stormwater management.

The draft PAR was approved by the Minister for Urban Development and Planning in November 2002 for incorporation into all Council Development Plans in the Torrens and Patawalonga catchment areas. The discussion below details the extent of changes at the local level in regard to the Development Plan and much of this change emanates from the Ministerial PAR.

The other Catchment Board areas that cover metropolitan Adelaide (e.g. Northern Adelaide & Barossa and Onkaparinga) are still in the process of incorporating the policy and therefore some councils in these areas have still not adopted the provisions. A concern at this stage may be that there is a danger that there will be variations in the content of the provisions adopted between the different catchment jurisdictions. This could be overcome if the metropolitan area falls under one overall catchment jurisdiction as is proposed by the single Natural Resource Management Board for Adelaide.

The intention of the Development Plan amendments is to deal with urban stormwater issues at three levels:

- catchment or regional level
- drainage system or neighbourhood/street level
- site or allotment level.

A weakness that has been observed in the current provisions is that it focuses on-site level provisions and not on a drainage system or catchment wide treatment level.

A full analysis of the Development Plan situation for each metropolitan council is given in Appendix F.

The revised MAPS and the significant emphasis on ESD and core guiding principles will impact on a greater consideration for water. This has been emphasised in the Strategy through a series of actions that relate to rehabilitation, new policy frameworks, performance criteria for urban design, master planning and further changes to the Development Plan and legislation that is related to water. It is likely that the Strategy, if allowed its full potential, will provide the basis for another comprehensive round of policy changes at the State and local level of government.

2.11.6 Australian standards and Building Code of Australia 2004

The Building Code of Australia (BCA) is produced on behalf of the Australian Government and each State and Territory, and is a uniform set of technical procedures for the design and construction of buildings and other structures throughout Australia. The BCA is given legal effect by the state; however, any provision may be overridden by other state legislation.

In regard to stormwater drainage, Part 3.1.2 of the BCA outlines the performance requirements. Where alternative solutions are proposed, the proposal must then comply with AS/NZS 3500.3.2 – Stormwater drainage or AS/NZS 3500.5-Domestic installations, Section 5 – Stormwater drainage.

The BCA does not require the installation of drainage systems, it is merely used where drainage systems are used. The need for a drainage system is obtained from the appropriate authority (i.e. council) as well as the legal discharge point from the building site.

The BCA deals with such issues as:

- design of roof areas
- sub-soil drainage requirements
- effects on adjoining land and adjacent buildings
- finished slab heights.

Some elements of the BCA are primarily to minimise flood hazard on individual sites, and are considered sound and are in no way detrimental to the management of stormwater on a wider catchment basis.

AS 3500 Part 3.2 is the standard that specifies acceptable solutions for materials and products, and design and installation of roof drainage systems, surface drainage systems and subsoil drainage systems to the point of connection to the external stormwater drainage system.

As with the BCA, the basis for the drainage solutions are well founded and technically sound.

Perhaps the only weakness is the lack of direction provided on the design of on-site stormwater detention and retention systems, although as discussed earlier the use of on-site management appears to be quite a local, catchment specific issue. As stated in Section 5.5.12 of AS 3500 Part 3.2:

> *'Note: An acceptable solution is not available for design of OSD systems because of the lack of consensus on requirements by network utility operators (i.e. councils)'*

2.12 URBAN DEVELOPMENT

2.12.1 Effects on stormwater infrastructure

As Adelaide's urban areas approach a maximum level of lateral growth and the increased trend towards inner suburban living continues, there will be a continued increase in urban consolidation. Urban consolidation is placing increased pressure on the existing stormwater infrastructure because of an increase in impervious area (roofs, paving, etc.) which causes an increase in stormwater runoff.

The potential for urban consolidation of residential areas throughout metropolitan Adelaide has recently been assessed by Planning SA for all metropolitan councils, except Adelaide City Council. This information was obtained from Planning SA spatially in GIS format as point references for every residential allotment. The number of potential new dwellings averaged across each sub-catchment in metropolitan Adelaide has been mapped to provide an indication of the ultimate residential development impact within the study area and is presented in Appendix G.

For example, an average new dwelling change of 2.0 means on average, an additional two dwellings can be created on every existing allotment (i.e. total of three allotments can be formed from one). It is understood that the potential for development has considered all areas currently zoned residential using the minimum allotment sizes allowed for the particular council.

The assessment is an indication of the ultimate development potential and does not consider the rate of current or future urban consolidation. The current rate of consolidation has not been quantified, except to note that currently there is considerable consolidation occurring in a number of inner metropolitan areas, particularly the western suburbs (i.e. Cities of West Torrens and Charles Sturt) and north eastern suburbs (i.e. Cities of Campbelltown and Tea Tree Gully). Such consolidation has extensively involved converting large individual allotments into multiple allotments or unit sites. More specifically, these more significant areas relate to the Meakin Terrace, Trimmer Parade, Port Road, Dry Creek and Third to Fifth Creek catchments.

In addition to smaller developments, there have been more intensive urban renewal projects involving South Australian Housing Trust (SAHT) at Mitchell Park, Salisbury North, Ferryden Park, Kilburn and Gilles Plains. Other proposed projects will be located in Seaton, Royal Park, Angle Park, Mansfield Park, Athol Park and Woodville Gardens.

Local government is currently responsible for managing the effects of urban consolidation and infill, including stormwater management. Stormwater master plans are usually required for the larger urban renewal projects as part of the land division design and approval process (e.g. Kinhill 1995; Brown & Root 2001 and KBR 2004b).

For smaller infill development, stormwater management is handled on-site and approved as part of the council building application process.

The Westwood Urban Renewal Project started in 1999 and covers the redevelopment of five of the suburbs mentioned above (Ferryden Park, Angle Park, Mansfield Park, Athol Park and Woodville Gardens). It is a fifteen year project where 2,500 new private allotments will be created and the proportion of SAHT dwellings will reduce from 58% to approximately 23%. It is the largest residential urban renewal project in Australia.

Average allotment sizes in the project area are expected to reduce from approximately 550 m^2 to 490 m^2 and the average impervious area is expected to increase from 27% to 60%. Pre-development properties in the project have approximately 20–25% of the impervious area draining to pervious area (gardens, etc.) which do not contribute to runoff in minor events, whereas all runoff is now required by council to be directed directly into the street (minor) stormwater system.

Based on an assessment of the North Arm West Drain 4 (NAW4) drainage system (Brown & Root 2000) which covers Mansfield Park, Angle Park and parts of Woodville Gardens, it is expected that sub-catchment flows will increase by up to 50% due to the Westwood project. To date, large community based detention basin facilities have been constructed and more are proposed to reduce peak flows to manageable levels.

A similar but smaller project is proposed for the Seaton and Royal Park areas where the percent impervious is expected to change from approximately 36% to 47%, resulting in an increase in peak sub-catchment flows of up to 20% (KBR 2004b). It is proposed that community based detention basin facilities will be incorporated into the project to limit flows from the project area to pre-development levels.

A major stormwater investigation was undertaken to determine the current capacity of the South Western Suburbs Drainage Scheme (SWSDS) incorporating much of Cities of Mitcham, Marion and Holdfast Bay (Kinhill 1997 and Kinhill 1998a). The study indicated that the majority of the drainage systems were running at about a 5 year ARI standard or are slightly overloaded with a few drains having a capacity greater than a 5 year ARI standard. Those catchments which had a capacity at or near the 5 year ARI standard were found to have an overall runoff coefficient of 0.25. Given that the maximum allowable site coverage (or percent impervious) under current planning considerations for a residential development can be 60% (effectively equivalent to 0.60 runoff coefficient), urban consolidation would have a detrimental effect on stormwater management. The quantitative effect of full urban consolidation has not been established on these catchments, except to confirm that the majority of the catchments cannot accept urban consolidation without complementary flood control measures applied.

Major rainfall events also need consideration in terms of controlling runoff as a result of urban consolidation. During minor events, runoff is generally a contribution of impervious areas only. Pervious areas (i.e. gardens) do not contribute due to the higher losses associated with these surface types. During large events, runoff from pervious areas begins to contribute as soil storage capacities are exceeded, further exacerbating the potential problem.

The report on the SWSDS showed that older areas with larger allotments have a higher percentage of houses with roofs that drain to the garden. These areas currently have a lower potential for runoff to the street system during minor events. New developments, including urban consolidation, are increasingly requiring houses (roofs and paved areas) to connect directly to the street and therefore have a higher potential for increased runoff, particularly in smaller events compared with allotments in older established suburbs. The additional connectivity does significantly increase the impact on the 'major' system as the internal drainage system is not designed to capture large events. The factor that affects the 'major' system capacity is the additional runoff sourced from the additional impervious area in new developments.

2.12.2 Roles and responsibilities

Today, developers in most cases are required to contribute toward controlling or addressing the impact of increased run-off, either by on-site means (being a detention facility on either a neighbourhood development scale or individual allotment scale) or by monetary contribution towards downstream works (augmentation/detention) as discussed previously. The implementation of WSUD principles is beginning to become a requirement for new developments (e.g. City of Onkaparinga).

The burden of responsibility for stormwater infrastructure outside of the immediate development area has been argued to be not solely that of the developer, but also the responsibility of council. Additional rates generated by infill and new development is an income source for local government for the purpose of being applied to community infrastructure, such as maintaining roads and the provision of adequate stormwater drainage.

In recent times, partnership (cost sharing) arrangements between developer and council have been successfully demonstrated. The Westwood Urban Renewal project in Adelaide's inner north-west is a partnership housing development project between private sector, the State and local government. The area was considered to have a poor standard of stormwater infrastructure prior to redevelopment and would be even further strained with the significant increase in housing proposed. The development now comprises numerous detention basins, significant infrastructure upgrades and WSUD principles being adopted, funded in partnership primarily between the developer and Council. Similar experiences are also found at Mawson Lakes where stormwater harvesting, WSUD and dual reticulation form a significant component of this development (refer Part B report).

2.13 INFORMATION GAPS

Condition of infrastructure

An issue which is currently emerging is the age, condition and remaining life of the existing stormwater infrastructure.

For example, a number of councils (Cities of Port Adelaide Enfield – Murchison Street, West Torrens – Sir Donald Bradman Drive) have experienced large scale structural failure of reinforced concrete box culverts which are used in the flatter areas to convey large flows and are often considered as trunk drains. This form of failure is sudden and cannot be predicted unless inspected with cameras. The failure is primarily due to the age of the infrastructure (40 years old +) as well as the design and construction standards of the time being less than that considered to be acceptable at present (current standards are considerably higher and design life significantly greater).

As a result, there are issues which require consideration.

Firstly, the sudden failures result in immediate unexpected costs not included in council budgets. The rectification of these failures is usually urgent and therefore takes priority over other drainage (and other) works already identified.

Secondly, documented upgrades to existing drainage infrastructure have not fully considered this design life issue. More cost effective long-term solutions to drainage problems can be produced with knowledge of the age and deterioration of the existing systems. To date, little information is available on the condition of the drainage systems throughout most of metropolitan Adelaide.

In relation to the two locations listed above, the Murchison Street system in Woodville Gardens/Mansfield Park was due to be upgraded within the next 10 years as part of a large residential infill development (Westwood). The timing of the failure and identification of the deterioration was fortunate in that new and larger box culverts were constructed in advance to allow for the future development and increased runoff.

The replacement of the Sir Donald Bradman Drive system was not as fortunate, in that construction had already commenced on a separate diversion drain to alleviate demand on the existing Sir Donald Bradman Drive system as part of the Mile End/Cowandilla drainage review. The diversion drain was constructed along an alternative route as opposed to upgrading the existing Sir Donald Bradman Drive drainage system. Had the condition of the existing Sir Donald Bradman Drive system been taken into account, the existing drain could have been replaced and upsized more cost effectively than constructing a new diversion drain (personal communication, Kemp D).

To put the above into perspective, the Local Government Infrastructure Management Group prepared a report (Burns et al 2001) on the infrastructure asset management process of local government in South Australia. The estimated replacement value of stormwater drainage in metropolitan councils is $1.4 billion (19% of the total assets worth $7.5 billion). Currently, councils are spending in the order of 8% ($15.1 million) of their annual budget on stormwater works and this would include construction of new infrastructure as well as replacement costs.

Extent of small projects

As discussed previously, there are many small projects which have not yet been quantified. Despite their perceived small size, these projects are numerous, often important in terms of their function in the catchment and their impact on council infrastructure budgets are likely to be significant. Some drainage projects can be undertaken as part of road reconstruction works and can therefore be undertaken in a more cost effective manner. This issue is also very much linked to the need for an accurate and up-to-date asset register database for stormwater infrastructure.

Flood hazard

As discussed in Section 2.7, flood hazard identification has not been undertaken to any significant detail except for the Brown Hill and Keswick Creek catchment.

A number of current drainage issues have been identified based on anecdotal evidence, limited survey and no detailed assessment. In many locations there is no knowledge of what will happen in large storm events.

Identification of localised sags, low points and overflow paths throughout catchments is currently not possible for many of the flatter areas due to a lack of detailed survey. In the majority of areas, the most detailed form of topographic mapping available is a 1:2,500 scale with 2 m contour intervals.

Flood damage

As discussed in Section 2.8, flood damage quantification has not been undertaken to any significant detail except for the Brown Hill and Keswick Creek catchment.

This is a significant oversight in that decision makers are largely unaware of the consequences of flooding in Adelaide.

Flood damage data across all areas of Adelaide from historical events has never been compiled.

Effect of climate change

The long-term predication for Adelaide's weather is that it will become wetter and warmer, generally more sub-tropical. This is likely to cause changes to rainfall patterns (storm durations and intensity).

Predictions of long-term sea level rise will become a significant cause of flooding in the future unless properly planned for now. The effect of sea level rise on stormwater infrastructure capacity has yet to be explored. In low lying areas of Adelaide, sea water inundation will become an issue regardless of stormwater issues.

The City of Port Adelaide Enfield is currently undertaking a study looking at the Port River, Le Fevre Peninsula, Gillman and other low lying areas to assess the effect of sea water inundation based on projected sea level rises. The study is yet to progress to the prediction of risks for scenarios of high tides and rainfall events.

Short-term sea level rises (i.e. storm surge) has generally not been considered or quantified in the majority of the catchments as part of stormwater system analysis.

Changes to rainfall intensities will also affect the way in which drainage systems perform and needs to be considered in updates of future Australian Rainfall and Runoff editions.

Outfall conditions

The state and condition of a drainage system outfall is a very important part of the system that is often neglected. A blocked outlet will reduce the capacity of the drainage system regardless of the capacity of the upstream network. No attempt has been made to quantify the effect of blocked outlets on upstream pipe capacity and performance.

Interviews with councils along the coast indicate that the councils are aware of the importance of the outfall and at a number of locations undertake regular maintenance to remove sand blockages.

Future problem areas

The study has concentrated on those areas where known or identified flooding problems exist and works are proposed, with an emphasis on the larger scale works (catchments > 40 ha). Such works are likely to take into consideration a 20–30 year planning horizon. Beyond this period, significant changes may occur. Infrastructure will reach the end of its life (as discussed earlier) and further changes and modifications will occur to catchments and drainage characteristics. No quantitative assessment can be made on additional problems beyond a 20–30 year period.

3 Component 2 – Recommended actions and ways forward

3.1 FLOOD HAZARD MANAGEMENT

As briefly discussed and introduced in Section 2.2, the traditional approach to provision of an 'acceptable' level of stormwater management is to provide a minimum average recurrence interval (ARI) standard for the 'minor' and 'major' stormwater systems.

Further to previous descriptions, Argue (1986) defines 'minor and 'major' stormwater systems as follows:

*'**Minor Drainage System** – the arrangement of soakage wells, kerbs, gutters, roadside channels, swales, sumps, inlets and underground pipes and junction pits designed to fully contain and convey to disposal a design minor stormwater flow of specified frequency.'*

*'**Major Drainage System** – the arrangement of pavements, roadway reserves, open space, floodway channels, detention basins, lagoons, etc planned to convey to disposal a design rare flood of specified frequency.'*

The current accepted level of standard within metropolitan Adelaide for the minor system varies between 2 year and 10 year ARI, with 5 year ARI generally being the minimum desirable standard. The major system design standard is typically 100 year ARI (refer council consultation – Section 2). The generally accepted standard for natural watercourses (creek systems) within metropolitan Adelaide is at least 20 year ARI and the River Torrens has a 200 year ARI capacity.

Australian Rainfall and Runoff (AR&R, 1998) Book 8 Section 1.3 outlines the following in support of the above conventions:

> Past practice has often been based on one level of operation, but it is usually appropriate to design for several performance levels, which may include:
>
> - a maintenance requirement (frequent event) related to a short design ARI, perhaps less than one year;
> - a convenience or nuisance-reduction requirement (infrequent event) possibly 1 to 10 years ARI;

- a flood damage prevention requirement (severe or rare event) of about 100 years ARI; and
- a disaster management requirement (extreme event) related to extreme events such as probable maximum floods.

The first two or three are relevant to street drainage, and all but the second to trunk drains.

The above 'minimum standard' approach usually does not take into consideration the hazard or consequence effect of the particular rain event which is being designed for the specific location under consideration, i.e. it does not identify the hazard and apply a 'risk management' approach.

With respect to the minor system, the standard adopted is normally set by reference to accepted practice and community standards, coupled with appropriate engineering judgement. Risk management and rigorous cost-benefit analysis are generally not undertaken and is generally not warranted for the local system. As previously noted, the minor system generally caters for the 2 to 5 year ARI, with 5 year ARI being a desirable minimum target standard. There is no reason to suggest that this approach change for the minor system.

The opportunity to apply a more qualitative approach to the assessment of major drainage systems is likely to have benefit, as the outcome has the potential to produce a more 'efficient' design – based on a 'risk management' and 'considered effect' approach rather than a minimum ARI standard approach.

In recent times, flood inundation mapping has been coupled with flood hazard mapping. The flood hazard maps being produced map flow depth versus velocity as well as identify 'high risk' facilities such as emergency services, hospitals and the like. This form of mapping is qualitative rather than quantitative based, and functions in a similar way to the Modified Mercalli (MM) scale for the analysis of earthquakes. The MM scale is an intensity based method which considers the practical effects that a seismic event causes on infrastructure and dwellings.

The hazard mapping approach in Adelaide has to date been limited to larger flood studies of watercourses (Brown Hill and Keswick Creeks, Upper and Lower Onkaparinga, River Torrens, River Sturt and Little Para River). This modelling forms a sound basis for undertaking a risk management approach in assessing the costs and benefits of various flood mitigation options.

This methodology would need to be further developed if applied to the 'artificial' major drainage network, to the point where the outcomes could be quantified and agreed by all stakeholders, including the community and interests such as the insurance and housing sectors.

A weighted priority with respect to major event flooding would need to be developed and agreed, considering the functions of services and infrastructure such as:

- emergency services (including access to hospitals, etc);
- inhabited dwellings;
- proximity to industrial sites (contamination potential);
- commercial premises;
- uninhabited buildings;
- public infrastructure (where it does not adversely affect emergency services functions).

The risk management approach will need to include sufficient detailed cost/benefit analysis, such that consequences of agreed scenarios are defined, understood and appropriately communicated to all stakeholders. It has previously been identified (CMSS Review Report 2002) that rigorous cost/benefit analysis is not currently being sufficiency undertaken in stormwater infrastructure studies and should form the basis for determining the appropriate (structural) solution.

It is likely that the 'up-front' costs of such an approach (analysis, consultation, agreement and design) would be higher than the current standard approach, however, these costs are only a small percentage of the overall project cost (typically less than 10%). Potential resultant savings in capital cost may significantly outweigh the additional 'up-front' costs. This approach, however, may actually result in some areas requiring a level of service greater than 100-year ARI flood protection.

This approach is not different than the intent described by AR&R and similar to the flood security hierarchy set out in Argue (1986). However, as noted above, further work is required to better define the tangible outcomes and process of a more thorough 'risk management' approach.

Water Sensitive Urban Design (WSUD)

The conventional approach to urban drainage design embedded in Australian Rainfall & Runoff (1987) does not incorporate the vision of WSUD. The WSUD principles suggest that all facets of the drainage cycle can be dealt with including minor and major drainage systems. A fair proportion of outstanding work identified is the provision of or upgrading of minor drainage systems (e.g. Port Road catchment requires significant 'minor system' upgrade).

Apart from on-site management techniques (discussed in detail in Section 2) one of the general requirements of WSUD is availability of open space. In many of the catchments identified as requiring stormwater works, sufficient and suitably located open space is not available unless land acquisition occurs. Other factors such as making roads and footpaths narrower may assist in providing possible solutions to such problems, but are generally not desirable. The Port Road catchment is an example where WSUD solutions could be explored in more depth due to the large open corridor running along Port Road (although existing major services are likely to be the biggest inhibitor along this route).

WSUD methods can be used along existing drainage corridors (e.g. concrete lined sections of Sturt Creek, Keswick Creek, Brown Hill Creek, etc.), where insufficient capacity has been observed. One of the options explored to date to upgrade the Brown Hill and Keswick Creek systems is a 'riverine' system where the 'natural' creek line is restored through channel widening and property acquisition. Another example is the 'Breakout Creek wetland' on the lower River Torrens. Although not considered a true wetland, improvements have been made by widening of the river to achieve adequate flow capacity whilst maintaining natural amenity.

With regard to smaller systems, WSUD techniques are likely to be more suitable for new developments (i.e. 'greenfield' land developments); however, it should not be discounted for other projects where development has already occurred. An assessment of WSUD options need to be explored early in the design phase of any project in order to make adequate provision and maximise its potential.

Flood proofing

It has been recognised (Wright 1999; CSIRO 2000) that flood damage can be reduced by measures such as flood proofing buildings, particularly businesses and factories where valuable high risk items are present in large numbers, and this includes retrofitting existing buildings and in the design of new buildings.

A discussion paper into issues in floodplain management was prepared for the National Landcare Program (Department of Primary Industries and Energy 1996) and proposed that a National Building Code for Flooding be prepared, not unlike the National Codes for wind and earthquakes.

Whilst it is understood that a code has not been produced, the production of the 'Floodplain Management in Australia – Best Practices Principles and Guidelines' by the CSIRO has provided national flood management guidelines.

It is considered pertinent that building guidelines be included into the national Building Code which should incorporate information on compatible materials and building methods for flood damage reduction and other flood proofing retrofitting measures for the building industry. One of the issues with this approach; however, is that it could be seen as being negligent in that a flooding problem is acknowledged and relevant authorities should be responsible to solve the source of the problem.

3.2 STORMWATER FLOW REDUCTION

Stormwater flow reduction in the past has commonly been undertaken at the catchment scale primarily using detention basins. Detention basins have generally been the responsibility of council and their operation and function rarely debated. Apart from the cost of land, the biggest issues are generally safety—associated with a large water body being created for a short period of time during a rain event; and on-going maintenance costs not unlike any other park or reserve. The design of detention basins normally incorporates an analysis of the entire catchment to ensure that flooding problems are not being transferred elsewhere.

More recently, there has been a shift towards dealing with stormwater flow reduction at a local allotment level primarily because of the lack of public open space within urban areas (refer discussion in Section 2).

The following issues have been identified with regard to on-site management and require recommendations on the way forward:

- does on-site flow reduction work;
- what are its limitations, particularly in the context of the nature of stormwater in Adelaide;
- can it be used as an alternative to conventional pit and pipe system upgrades;
- ownership and responsibility.

As outlined in Section 2, on-site methods for the reduction of flows do work and are technically feasible in Adelaide. The main issue with respect to technical feasibility and level of effectiveness is catchment specific. The effectiveness of OSD methods is very much dependent on the size and hydrologic characteristics of the catchment. Likewise, the effectiveness of OSR tanks (i.e. rainwater tanks) for flow control is also dependent on the hydrologic characteristics of the catchment as well as the tank size and demand. OSR infiltration and soakage methods are also very dependent on the soil type, another catchment specific issue.

The 'blanket' approach of uniformly applying on-site retention or detention methods using criteria with no sound engineering basis to all new developments can have a detrimental effect on flood mitigation. Whilst there may be no immediate (short-term) problems, if such criteria are maintained in the long-term, becoming wide spread, it has been demonstrated to have detrimental effects on flooding in the catchment. This applies primarily to OSD methods but also rainwater tanks with insufficient storage at the commencement of a storm event. Work by KBR on the SWSDS for the City of Marion recommends OSD measures based on a maximum 10% consolidation as previously noted.

Analysis across the full catchment to assess the impacts of on-site management is required prior to applying a blanket approach across an entire catchment or council area. The ideal mechanism for such analysis is the USMP, but this has not yet been carried out as part of any of the USMPs undertaken to date. Where currently in place, or proposed to be mandated, it is recommended that such analysis be undertaken as soon as possible. This applies to the infiltration and soakage devices for OSR, which are very dependant on soil conditions. To some extent, this issue has been covered in the September 2003 Ministers specification prepared by Planning SA; however, this document is general in nature and not catchment specific.

The mandate that all new houses from July 2006 are to have a rainwater tank plumbed to the house currently does not specify the size of the tanks. The use of large tanks (>5 kL) may also have a beneficial impact on downstream stormwater flows whereas smaller tanks (2–5 kL) will have little or no impact. The use of larger tanks should therefore be promoted and rebates applied due to the additional advantage of potentially providing flow reduction, and hence to some extent, flood mitigation as well as a reduction in mains water consumption.

Some work has been undertaken in investigating the cost and benefits of on-site flow management as opposed to detention basins and/or pipe system upgrades. It has been found that in some cases, on-site management is more cost effective. It is not possible to conclude, however, that for all situations on-site management will be more cost effective. As such, it is recommended that this analysis form part of future stormwater studies (i.e. USMPs).

The potential for on-site management to significantly reduce stormwater flows from large infrequent events is limited and likely to be cost prohibitive. Criteria by some councils to detain and reduce on-site flows for the larger less frequent events down to much smaller pre-development levels is somewhat ambitious. The collection and detention of large flows is difficult on flat sites and requires a well maintained, on-site management program. A more practical approach would be to use on-site management techniques for minor system benefits (e.g. up to 5 or 10 year ARI events) and use smaller sized detention basins placed at strategic locations (assuming land availability or acquisition) in a catchment to reduce the major event flows.

From an environmental aspect, the use of OSR is more beneficial than OSD because it reduces the volume of water discharged downstream. On an overall catchment basis, both OSD and OSR do little to reduce pollutants as it is primarily the roadways and other external sources that contribute to stormwater pollution. A far better approach to pollutant reduction is to treat them at a catchment or sub catchment level with the use of gross pollutant traps and wetlands, not on an individual site level, except where special industries exist or when construction activities occur (then covered under the Environment Protection Act).

OSD often creates the problem of extended low flow periods from a catchment. Consideration is required to those catchments which have particularly sensitive outfalls (e.g. Barker Inlet and other wetland environments) as OSD may cause a significant extension of flow periods. Again, this needs to be considered on a catchment basis as part of the USMP process.

The responsibility of on-site management needs to be addressed. Satisfactory on-going maintenance is essential to the effectiveness of on-site management measures. This includes short-term and long-term plans, however to date very little planning has been undertaken on this crucial aspect of the strategy.

As highlighted by Dyson (2004), the responsibility of a landowner to drain land and dispose of stormwater is complex. The Local Government Act contains only broad references to the duties of councils in relation to the provision of infrastructure, and that includes stormwater drainage. Liability to drain land and dispose of stormwater will therefore be governed by common law of negligence. If the purpose of on-site management is to control flows with the aim of alleviating the pressure on council stormwater infrastructure downstream, the question of whether the land owner or the council is responsible for its maintenance and installation needs to be answered. It is recommended that legal advice be sought to resolve the roles and responsibilities of on-site management. This may be facilitated at a State, LGA or industry based (HIA or UDIA) level.

As has been discussed, the ability to manage minor system flows via on-site measures can be demonstrated and is technically feasible. The experiences of the UPRCT have adopted the OSD principles for both minor and major system flow control by on-site measures from the whole site (roofs and surface drainage) – refer Section 2.

Adelaide's topography creates limitations in controlling site flows, as much of the area is flat and it is very difficult to grade a site and collect the flows without significant filling and regrading, which generally is not practical. This effectively excludes major flow control except where grades are greater than say 1.0% (e.g. eastern suburbs) and sufficient space is available.

The UPRCT approach assumes that there is a suitable discharge point at depth (i.e. adjacent creek, pipe system) which in many locations in Adelaide does not exist.

In new developments (small and large), there is generally a mandatory approach that all roof drainage must be connected to the street (e.g. pipe system, kerb and water) or other drainage system, regardless of any detention or retention requirements. There currently is limited incentive and opportunity to discharge directly onto the property. Councils now require connection directly into their system because it guarantees better control of discharge and assists in reducing complaints and maintenance issues.

This is compounded by the decreasing allotment sizes and increased site coverage allowed by councils which have reduced the available space for on-site (particularly infiltration and soakage) measures. Whilst soakage and infiltration methods are very much location dependant, the applicability of these and other on-site management devices is governed by the allotment size. Minimum allotment sizes (including minimum private open space requirements) combined with stormwater connectivity needs to be addressed. There is no point in mandating rainwater tanks or other OSD/OSR measures if there is insufficient private open space available on which to place them.

3.3 ASSESSMENT OF OUTSTANDING PROJECTS

3.3.1 Cost-benefit analysis

In the past, cost-benefit analyses are not afforded sufficient weighting for assessing options and the allocation and prioritisation of funding for stormwater works. This is partly due to the cost of preparing such analysis and the difficulties in measuring intangible and social benefits in economic terms. As noted previously, the CMSS 2002 review has highlighted that due to the large backlog of identified works and limited funding, more emphasis should be given to such analyses.

Cost-benefit analysis is often undertaken to assess the merits of various options. For example, we understand that a cost/benefit analysis is soon to be undertaken for flood mitigation options for the Brown Hill and Keswick Creeks. A preliminary scoping study has been undertaken to assess flood mitigation options by Tonkin Consulting (Tonkin 2002d) however, one of the recommendations is for a cost-benefit analysis to justify a target standard level of flood protection, with consideration given to flood protection as well as environmental, ecological, recreational and amenity values associated with a riverine upgrade as opposed to an fully 'engineered' upgrade consisting of underground pipes and concrete channels.

Cost/benefit analysis is sometimes undertaken to determine the most appropriate option for a specific project or problem, however no evidence points to it having been undertaken to compare the importance and prioritise different projects or components within a larger project.

Other factors and parameters need to be considered when comparing the benefits of different projects. The relative importance of each factor needs careful consideration and it is considered outside the scope of this project to prepare such criteria and importance on specific projects. Such factors may include but are not limited to the following examples.

Current level of flood protection

As an example, the Port Road system currently has flood protection as low as a 1 year ARI, whereas the majority of the Brown Hill and Keswick Creek catchment has at least a 10 year ARI standard. Based on these criteria, the upgrade to the Port Road drainage system would be considered more important than Brown Hill and Keswick Creeks.

Flood hazard

As discussed in Section 2, the common measure of flood hazard is the product of velocity and depth. Areas in the western suburbs are flatter, have a larger effective ponding area during major floods and are therefore likely to result in shallower depths, lower velocities and potentially lower flood hazard than in the escarpment or hilly areas. Whilst much of the western areas of the Brown Hill and Keswick Creek catchment is flat, low lying and subject to inundation, these areas are generally of low flood hazard because of the low velocities. As an example, flood mitigation projects in the City of Tea Tree Gully along Dry Creek and other flash flood prone areas may be given higher priority than flatter areas because of potentially greater hazard.

Proximity to key infrastructure

Areas along key transport routes, close proximity to emergency services should be given higher priority. For example the Adelaide Airport is at the downstream end of the Brown Hill and Keswick Creek catchment and flood plain mapping has shown parts of the airport will undergo significant inundation during larger rainfall events.

Number of dwellings, people, properties directly affected by flooding

The number of people and residential dwellings in close proximity to the flood zone should be measured and quantified. For example, one of the primary driving factors for the Hart Street drainage upgrade in Ethelton was a single low spot in the catchment which causes inundation to only a few private properties on a frequent basis. This is an example of a project where the aim of directly improving one street and to a lessor extent the remainder of the catchment and subsidiary systems is incurring high costs.

Potential for urban development (consolidation and infill) within the catchment

Catchments with high potential for urban consolidation, to directly impact significantly on the risk of flooding, should require higher priority drainage works. For example the Port Road, Meakin Terrace and Trimmer Parade catchments would be of high priority based on the data provided by Planning SA on potential for urban consolidation, coupled with knowledge regarding the current flood risks associated with these catchments.

Average annual flood damage

Whilst this is a component of flooding that has generally not been assessed in Adelaide (due to its complexity), the flooding in many locations is often significant, regular and causes damage and financial loss. For most flood prone locations in the metropolitan area, a measurable damage figure has never been estimated and as such to produce a summary of such information is considered outside the scope of this project.

3.3.2 Prioritised list of outstanding projects

In relation to the list of identified CMSS works as provided in Appendix C, it is a subjective and considerable task to prioritise the work using rigorous cost-benefit analysis.

As outlined previously in this section, there are a number of considerations that need to be made in order to accurately assess the benefits, consequences, frequency and costs in a tangible and comparable format. Without intricate knowledge of each of the projects, particularly the technical aspects, it is beyond the capability of this study to formulate a prioritised list.

It is recommended that a prioritised works program be explored based on consequence versus frequency and cost versus benefit via a further study. This is considered important due to the large backlog of work and the limited funding currently available, as it will enable a more subjective method of prioritising the identified work.

Based on the cost of outstanding works, which is a function of the magnitude of the current drainage problems, number of people affected on a regular basis and location (e.g. flat versus graded areas) the following list has been produced as a preliminary guide to prioritised works.

High priority projects

- Brown Hill and Keswick Creek Catchments—major system channel upgrades, detention storage, flood control dams and flow diversions into adjacent catchments, minor system pipe upgrades ($72 million lowest cost option estimated to date)
- Port Road Catchment—major and minor pipe system and open channel infrastructure upgrade ($13.2 million)
- Airport Drain, Cowandilla – Mile End Outfall—major system trunk drainage and outfall channel works ($8 million in outstanding works—note works planned for commencement with $2 million allocated funding)
- Trimmer Parade/Meakin Terrace Catchments—minor system diversion pipe works ($5 million).

Medium priority projects

- Hindmarsh Enfield Prospect (HEP) Drain Catchment—major system outfall channel upgrade and minor system pipe upgrades ($6 million)
- North Arm East (NAE) Catchment—major system outfall channel upgrade and minor pipe upgrades ($5.5 million)
- Smith Creek/Helps Road Catchments—both minor and major system pipe infrastructure and channel upgrades to service developing areas ($5 million)

- Hargrave Street Catchment (Birkenhead)—minor system pipe upgrade (outstanding works $2.5 million with $0.8 million allocated for 2004/2005)
- Wellington Street Catchment (Port Adelaide)—minor pipe capacity improvements (outstanding works $2.5 million with $0.8 million allocated for 2004/2005)
- Hart Street Catchment (Ethelton)—minor system pipe upgrade and pumping station upgrade (project commenced outstanding works $2 million)
- Airport Drain/Cowandilla – Mile End—major and minor system trunk drainage works ($1.2 million)
- Torrens Road/Grey Terrace Catchment—minor system pipe upgrades ($1.2 million)
- Gawler River Catchment, Gawler Township—minor system pipe upgrades and detention basins ($1.1 million)
- Brown Hill and Keswick Creek Catchments (City of Unley)—minor system pipe upgrades ($0.9 million).

Low priority projects

- Munno Para Outfall Drain ($24 million—works dependent upon future development)
- Sellicks/Aldinga—major and minor system upgrades ($3 million – works dependent upon future development)
- Dry Creek Catchment—numerous major system culvert upgrades and channel improvement works ($3 million)
- Sellicks, Aldinga, Maslins Beach, Silver Sands and Willunga—various minor system pipe and major system channel upgrades ($1.5 million)
- Field River Catchment—major system culvert upgrades and channel works ($1.2 million)
- Torrens River Catchment—numerous minor system pipe upgrades in St Peters and First and Second Creek systems ($1.1 million)
- Pedlar Creek Catchment—minor system pipe upgrades and channel works ($1 million)
- Christie Creek Catchment—major system channel works ($0.8 million)
- Little Para River Catchment—major system channel upgrades and channel works ($0.5 million).

The estimated value of unallocated funding for high, medium and low priority works are $96.2 million, $26.3 million and $36.1 million respectively, totalling approximately $158.6 million. As discussed earlier, it should be noted that in the majority of the above estimates, land acquisition costs have not been included, as these generally are not known.

The location of the above works is summarised in Figure 3.1. The locations of problem areas are numerous and cannot be shown on a plan of this scale. The detail required to show exact locations should be highlighted in USMPs and is considered outside the scope of this study.

3.4 OUTPUT BASED SPECIFICATIONS

Opportunities for private sector ownership of what traditionally has been public sector infrastructure have occurred in Australia over the past decade or so. Various models with varying degrees of private 'ownership' have been demonstrated, these models include:

- Build, Own, Operate (BOO) or Build, Own, Operate Transfer (BOOT)
- Public Private Partnerships (PPP)
- Privatisation (partial or full).

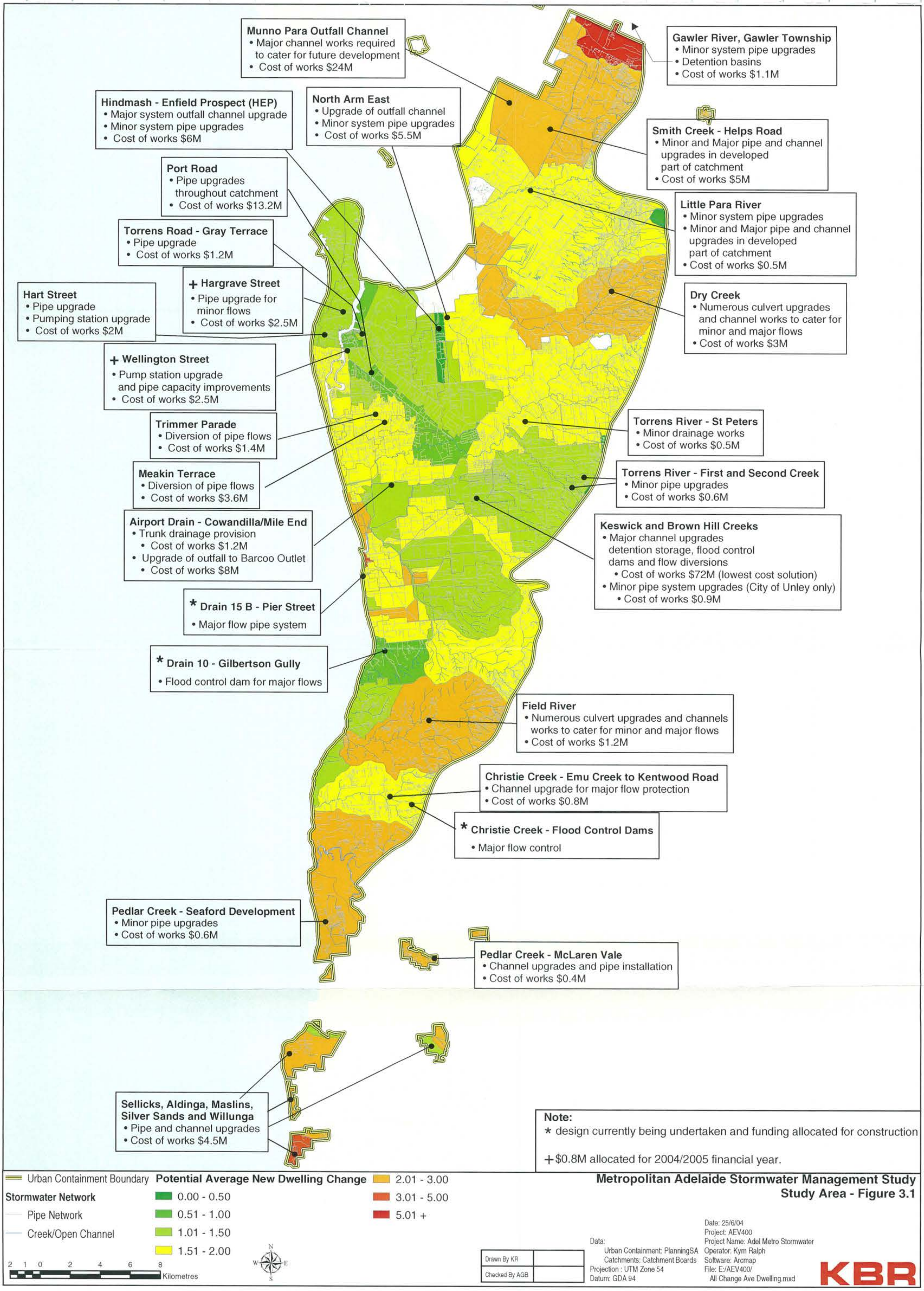
The common components of most of these models are:

- need for a capital injection of funding
- have a secured and predictable revenue source
- operational cost savings can be realised
- risks can be managed.

The first of the dot points above applies to stormwater drainage infrastructure in Metropolitan Adelaide. The remainder, however, need to be considered in more detail. Although governance and funding arrangements are outside the scope of this study (other than apportionment of council costs as per Part C), the mechanism as to how stormwater infrastructure projects can be facilitated, specifically the concept of 'output' based contracts, has been included.

The revenue source for stormwater infrastructure relies in part to access to the water resource, which is considered only of small value (presently), highly unreliable and high risk. Current inquiries into water pricing issues and the value of water resource may ultimately change this current inequity.

The model potentially could be based on a 'performance' based contract, whereby the whole of the assets (or responsibility thereof) are transferred to a private entity, they are managed and upgraded to a pre-determined and specified standard. The potential water 'resource' becomes the property of the private entity and capital works are funded by the entity. As a revenue source, in addition to the 'potential' of the value of



Metropolitan Adelaide Stormwater Management Study
Study Area - Figure 3.1

the water resource, income is primarily a 'fee' paid by the State Government and councils to the entity. Penalties would apply to the non-performance of the stormwater infrastructure.

Subsets of the above model include the SA Water/United Water arrangement for operating and maintaining the water supply assets of metropolitan Adelaide. Under this arrangement, public ownership of the infrastructure is maintained.

The potential benefits of this model include:

- the opportunity to bring innovation and greater commercial aspects to solving some of the significant stormwater problems in metropolitan Adelaide;
- works can be done sooner rather than later due to an injection of capital funding;
- stormwater harvesting, reduction in volumetric outfalls to the sea and opportunities for use and non potable supply will be addressed in a commercial environment.

The potential of output based approaches rely on the ability to clearly and unambiguously define and specify those outputs. The outputs are required to be tangible and measurable.

Current perceived risks associated with this model include:

- lack of market appetite from the private sector (as has recently been raised by the current State Government);
- not a common procurement method;
- potential legal and contractual complexities potentially add significantly to the cost of administration and contract management;
- inability to control extraordinary unknowns (e.g. extreme events, reducing annual rainfall, rising sea levels, etc.), hydrology is probabilistic, not an exact science.

The aim of such a model is to achieve the most cost effective commercial outcome at the same time as being able to transfer risk. In reality, however, risk transfer can result in significant cost premium.

There exists some perceptions (whether real or not) that stormwater works, particularly flood mitigation, is 'over engineered' primarily due to there being an absence of incentive to implement the most cost effective, yet technically acceptable scheme. This issue, however, relates back to previous observations of this report that at present there is insufficient rigorous cost/benefit analysis being undertaken in assessing options for stormwater infrastructure projects.

It is considered that agreeing transfer of risk/liability issues, negotiating successful contractual arrangements and the potential difficulty in the ongoing management and regulation of such an arrangement will be significant barriers to successful implementation.

3.5 REGULATORY AND POLICY FRAMEWORK

Currently, there is no consistent approach across each of the metropolitan Development Plans with respect to the manner in which stormwater management is addressed. While 84% of the council's within the study area have been consolidated in recent years to take into consideration the 'Stormwater in Urban Areas PAR (Ministerial)', several councils still need to incorporate this into their Development Plans. Some Development Plans make specific reference to stormwater management objectives and principles of development control, and others incorporate them under broader headings of 'public utilities' or 'water management'.

The Development Plans that have elected to combine stormwater objectives and principles of development control in the council wide section, makes for a more clear, concise and user friendly document for readers.

There are several specific recommendations that would enable stormwater to be addressed more simply in the Development Plans:

1. The words 'stormwater management' should be used in the council wide section of the Development Plan.
2. City wide objectives and principles of development control regarding stormwater management should be grouped together and discussed 'one after the other' in the council wide section of the plan.
3. With the development of comprehensive material in the Metropolitan Adelaide Planning Strategy 2004 which concerns stormwater management it is necessary to further review the content of the Stormwater in Urban Areas PAR to ensure that its direction is consistent with the new Strategy. Following this review all council plans should be consolidated to include the revised intentions of the Stormwater in Urban Areas PAR (Ministerial) (see Figure 6.1).
4. Greater policy consistency achieved in the way all Council Development Plans addressed stormwater management.

Criticisms of the current arrangements are that the process still requires agreement between the councils involved, particularly with respect to the cost sharing principles (refer Study Report – Part C). Without this, there currently appears to be no legislative powers which can effectively force councils to cooperate and contribute to stormwater related problems across a catchment.

A legislative mechanism and agreed policy for setting the 'rules' for this scenario, particularly in relation to cost sharing principles, would largely provide the basis for agreement to overcome the current political difficulties in implementing large problematic stormwater infrastructure projects.

3.6 FURTHER INVESTIGATIONS

Continued research into design tools

Experience in working with a number of councils within the study area has shown that there is a wide range of design requirements. Not only in the design standards chosen for drainage infrastructure (as mentioned earlier), but the specific detail of drainage 'component' design is different. This is quite often due to the personal experiences of the council staff involved, as well as historical precedence of that council. This includes such components as pit types, pit capacities, flow width requirements, etc. Whilst this issue may not be a major contributor to poor stormwater management, it is important to raise these inconsistencies.

A paper by Pezzaniti et al (2000) concluded that installation of undersized drainage components, in particular side entry pits and other inlets has been identified as a possible source of flooding problems and that more accurate information from continued research and development be undertaken to minimise litigation. Work by organisations such as the Urban Water Resource Centre at the University of South Australia must continue and funding maintained.

It is mentioned previously that there are various approaches, design methodologies and standards across metropolitan Adelaide. Whilst it is recognised that these discrepancies do not have significant impact on the level of service provided by the drainage infrastructure (assuming it is designed correctly), it would make design and analysis of stormwater systems considerably more efficient if a uniform approach to drainage design practice was adopted. This has been explored and implemented in Queensland with the production of the Queensland Urban Drainage Manual (QUDM) which was prepared for the Water Resources Commission, the Local Government Engineers Association of Queensland and the Brisbane City Council. The purpose of this document is to provide technical details to formalise the design process, and to provide details of appropriate design methods and procedures.

It is recommended that the production of such a manual be explored for Adelaide practice.

Better understanding and ability to calibrate hydrologic and hydraulic models can be improved through additional gauging of pipe and stream flows and better distribution of pluviograph networks.

Quantification of on-site flow management

The qualitative effect of on-site detention (OSD) and retention (OSR) is emerging as a practical option for flow control, however, as discussed previously, its overall effectiveness is very much catchment dependent.

The research undertaken to date by groups such as the Urban Water Research Centre at University of South Australia appears sound, and suggests numerous benefits (and problems) may exist if applied to real scenarios. These issues need further exploration on actual catchments at a research based level and/or extensions to USMPs as part of a consultancy.

Infrastructure condition data base

No details are provided within USMPs or stormwater infrastructure reports on age, deterioration or expected remaining life of existing infrastructure. It is apparent that limited up-to-date asset register databases are maintained for the stormwater infrastructure network in metropolitan Adelaide.

On the basis of the potential significant cost, it is a strong recommendation that local government address this situation by establishing comprehensive asset register databases for stormwater infrastructure, field verification and regular maintenance to keep it up-to-date.

Detailed flood hazard and floodplain assessment

Where appropriate, all further drainage studies, including the latest USMPs, should include more detailed topographic mapping to better identify low spots and overland flow paths. Contours generated at intervals of say 0.2 m would likely be appropriate to provide a better assessment for most of the flat and low lying areas in metropolitan Adelaide.

By utilising detailed topographic mapping, detailed hydrologic and hydraulic analysis can be undertaken to determine major flow path directions, flood hazards and flood levels throughout catchments which can then be related to existing and proposed floor levels. The type of mapping would be of a similar nature recently undertaken for Brown Hill and Keswick Creek catchments in creating digital terrain models as part of the floodplain mapping study and presented within the USMP.

Effect of full development and urban consolidation

Previous drainage studies would have taken into account of the full extent of development that was proposed at the time of the study. Assumed parameters may therefore be out of date in terms of current zoning plans and the potential for urban infill and consolidation. The effect of this is that the magnitude of works and hence costs prepared to date may be underestimated in some cases.

Without undertaking a detailed review of the basis of hydrologic assumptions within each report in detail, it is not possible to determine the extent of projects which may fall into this category. Whilst this may impact on the accuracy of budget costing, it is usually standard practice at the detailed design phase of the project, to review the hydrological parameters, and so this issue would be dealt with at that stage.

4 Conclusions and recommendations

4.1 CONCLUSIONS

Current state of drainage systems

Through the consultation phase of this study, it was found that the performance of the existing stormwater networks varies significantly from council to council and catchment to catchment depending on a number of factors. Councils that have recently merged (e.g. Cities of Onkaparinga and Port Adelaide Enfield) have a range of system capacities due to the differing standards of the former individual councils. Those that are situated near the coast where the land is flat and low lying are generally worse off than those located nearer the Mt Lofty Ranges.

Northern and southern councils (e.g. Cities of Playford, Salisbury and Onkaparinga) are large and generally have significant open space available for detention and water quality improvement facilities on a large scale. Older, inner metropolitan council areas are generally consolidated, flatter and have less (or no) opportunities for incorporation of open space for flood mitigation and stormwater improvement works.

Existing problems are the result of a lack of underground infrastructure, insufficient capacity of existing 'minor' and 'major' systems, urban consolidation and topography. Even those areas with sufficient underground pipe infrastructure are sometimes vulnerable due to a lack of sufficient inlet capacity to the pipe system (e.g. Cities of Marion and Burnside). Current problems can vary from nuisance street flows to more significant property inundation occurring a few times a year (e.g. Hart Street – Port Adelaide Enfield).

Floodplain and hazard mapping of catchments such as Brown Hill and Keswick Creeks indicate that areas of the inner southern and western suburbs of Adelaide are flood prone, even in smaller events, and that major floods will cause widespread inundation and damage to property, and even potentially loss of life.

Areas close to or in the Mt Lofty Ranges can also suffer from flooding problems. Whilst these areas are steeper, they also rely on natural creek systems, adequate road design, planning and sufficient side entry pit capacity to control flooding conditions. In the eastern suburbs, much of the natural creek systems (e.g. First to Fifth Creeks) run through private property. Maintenance of creek sections and controlling development along these creeks with private property is difficult. Roads with one way cross fall, cul de sacs and development adjacent to or within close proximity of creeks and watercourses are often problematic. There are also issues relating to responsibilities and maintenance of such watercourses to prevent flooding.

Some councils at the downstream end of catchments (i.e. Cities of Holdfast Bay and Marion) have expressed concern with development occurring upstream in other council areas. It is realised that to some extent, the controls imposed by their own council are only as good as the controls imposed upstream. This is linked with legislation and to some degree political and planning issues such as minimum allotment sizes, allowable site coverage, water quality etc.

Design standard

The standard of design varies from council to council and location to location. The general standard of underground systems in the metropolitan area is between a 1 and 5 year ARI standard. Some areas have a higher minor system design standard including areas of the Torrens Road system (8 year ARI), Adelaide CBD (20 year ARI) and parts of the City of Onkaparinga (10 year ARI).

However, these standards are often historical standards in the sense that they are derived from design rainfall average recurrence intervals that have varied through time and on hydrological models that have changed through time as better information has become available.

To re-analyse the drainage systems in Adelaide in order to establish their current standards is well beyond the scope of this study.

What is of importance is that the range of design standards being adopted for new or upgraded systems are generally logical and in accordance with recommended practice.

The majority of councils generally have a target (ideal) system capacity of at least 5 year ARI for the minor drainage network and 100 year ARI standard for the major drainage network (overflow paths). Again, these standards are in accordance with recommended practice.

In some of the very flat areas, councils such as the City of Port Adelaide Enfield recognise that a lower standard (e.g. 2 year ARI system) is more realistic in order to achieve a balance between the costs and benefits. A flatter catchment will require larger drainage infrastructure, meaning higher infrastructure costs (often significant service relocation costs), for maybe only a small benefit to the community (e.g. in a trapped low spot, significant works may prevent flooding of only one or two residences at a very high cost). Flatter catchments also allow for more stormwater to be safely 'stored' (i.e. in roadways) for short periods before being drained away by the lower standard (minor) stormwater system.

Community awareness

There appears to be a lack of public awareness within the general community on stormwater related issues, with more importance being directed to other, more visible areas. This is probably due to the fact that stormwater systems are primarily located underground and not seen. A feature of Adelaide's Mediterranean climate is that there are often lengthy periods without rainfall and it may be years between significant storm events. The community becomes complacent in terms of flooding hazard and therefore forget that it can rain heavily and do not contemplate that drainage infrastructure at times will not cope.

Flood forums have been undertaken over the years (e.g. Brown Hill and Keswick Creek public forums and community consultation) involving councils, business owners and emergency services personnel, and the common scenario continues in that it is extremely difficult to get public involvement due to a perceived lack of risk and hence interest in flood risk.

The community and 'decision makers' often have little understanding of the difference between 'minor' and 'major' drainage systems and their role in conveying flows. Large watercourses such as engineered systems like the River Sturt open channel are designed to convey major flows (20 to 200 year ARI) and are critical in major flood control. These systems are of a higher standard than the normal suburban drainage systems.

Flood management strategies

Historically, flood mitigation strategies have been developed through the preparation of stormwater infrastructure studies, flood mitigation studies, catchment management plans, infrastructure planning studies and more recently the preparation of Urban Stormwater Master Plans. The preparation of such strategies has primarily involved local government, Catchment Water Management Boards, Transport SA (through the CMSS) and local drainage authorities.

USMPs are increasingly becoming a key mechanism for stormwater management and are identified in the Planning SA document 'Guidelines for Urban Stormwater Management'. The preparation of an USMP is undertaken on a catchment basis and to date have been produced for a number of catchments in metropolitan Adelaide.

A number of councils are waiting for the completion of USMPs which will be used to better define the way forward and provide clearer direction on stormwater management. Only initial USMPs have been produced to date which will lead to final USMPs in the near future.

The CMSS has been an important source of funding for the preparation of flood mitigation strategies and solutions for larger projects. The CMSS applies to catchments with area greater than 40 ha however in recent times the effective amount of funding has decreased significantly.

Minor flood mitigation works also depend on available funding. A number of councils have a defined budget for drainage upgrades and are actively upgrading their network. Others have less funding allocated or have other priorities higher than stormwater infrastructure works.

Flood mitigation strategies vary between each of the councils and from catchment to catchment. In areas which are most flood prone (i.e. inundation of property occurring a number of times each year), individuals in conjunction with council have implemented temporary mechanisms for protecting their property (e.g. sand bags).

Other development based strategies are also used ranging from detention basins for large scale developments to on-site detention tanks (Cities of Marion and Tea Tree Gully) and rainwater tanks on an individual allotment scale. The majority of councils encourage on-site stormwater disposal where technically feasible.

Outstanding flood mitigation projects

A number of significant constraints have been identified that will limit the ability to achieve long-term flood protection. One of the most significant constraints is the limited funding available to councils to improve the drainage capacities and extend underground infrastructure. Not only are the internal council funds limited, but external funding in the form of the State Government Catchment Management Subsidy Scheme has been reducing in recent years (refer Appendix D).

A summary outlining the value of the identified major drainage works required to provide flood protection to all areas is outlined in Table 4.1. Based on current funding levels, it is estimated that up to 30 years will be required to complete the outstanding projects (excluding development dependent ones). Note that this time frame excludes minor works projects (<40 ha in catchment area).

Table 4.1 Cost of identified major drainage works

Description	Cost ($ million)
Known projects applicable to CMSS (refer Appendix E)	59.6
Development dependent projects applicable to CMSS:	
• Sellicks/Aldinga	3
Large scale projects	
• Brown Hill and Keswick Creek	72
• Smith Creek outfall	24
Minor projects (<40 Ha) – non CMSS	Not included
Total	**$158.6 million**

Prioritisation of CMSS work is undertaken on an annual basis with very little quantitative analysis, except being a function of 'significance and urgency' and taking into account the amount of money available for that year.

Flood hazard

Flood hazard assessment is a measure of severity of a potential flood based on flood behaviour, topography, population at risk and emergency management. Current guidelines place flood hazard into four categories (low, medium, high or extreme). A commonly used technical parameter used to assist in flood hazard measurement is the relationship with flow velocities and depth. Such assessment is complex and relies on the use of detailed modelling procedures and accurate spatial topographic data. To date, only the Brown Hill and Keswick Creek and River Torrens catchment has undergone detailed flood hazard assessment.

Hazard mapping has indicated the Brown Hill and Keswick Creek catchment has predominantly wide spread low-medium flood hazard with small areas of high-extreme hazard (along watercourses and low lying areas). In particular, the Royal Show Grounds, parts of upper Brown Hill Creek, Keswick Creek between Greenhill Road and Royal Adelaide Showgrounds, parts of Cowandilla and the Adelaide Airport contain areas of high-extreme hazard.

Flood damage

Flood damage, is an assessment of the direct and indirect financial and non financial costs caused by flooding. Like flood hazard assessment, flood damage assessment is a complex and time consuming exercise and has not been quantified for most of the Adelaide catchments. An assessment of the average annual cost of damages has not been quantified, except for the Brown Hill and Keswick Creek catchment which is estimated at $10 million per year in 2003 dollars.

Stormwater flow management

Stormwater flow management can be controlled at three levels; catchment, drainage system and site.

The traditional approach which is embedded within Australian Rainfall and Runoff has been to look at stormwater management at a drainage system level using the 'minor' and 'major' system approach using measures such as pipe upgrades, detention basins etc. More recently, WSUD principles are being applied at a drainage system level, however WSUD solutions are largely suitable only for new developments where there is opportunity to incorporate open space into the planning and 'shaping' of the development.

At a site level (on-site management) measures include detention (OSD) and retention (OSR) and are increasingly required for new development. OSD includes tanks, above and below ground, and OSR includes rainwater tanks, infiltration and soakage into the soil. Most councils require the post development flows to be limited to a permissible value known as the pre-development flow (or equivalent).

Some approaches require detention of large storm events (e.g. 20 to 100 year ARI) to a smaller event (e.g. 5 year ARI) and others consider only the smaller events. Some councils apply a 'blanket' approach across the entire council, and others apply it to specific areas using some technical basis on drainage infrastructure capacities. Others adopt a permissible discharge with no sound engineering basis.

Both City of Mitcham and City of Tea Tree Gully have developed a complying approach to OSD where modular tank sizes are pre-calculated for residential developments. The remainder of councils use a demonstrated approach where a proposal and calculations are submitted to council for approval on a case by case basis. Similar approaches have been adopted interstate by the UPRCT, City of Newcastle and Manly Council.

The notion that on-site retention and detention and other WSUD principles (e.g. wetlands) will solve major system problems is false. Such devices are suited for minor systems, and would be overwhelmed during major events. The majority of metropolitan Adelaide is flat and will provide little opportunity to collect on-site surface flows from large events, and roofs are not designed to collect large storm events.

The large events are, and will continue to be, a significant problem (unless dealt with at a catchment or sub catchment level) and the resulting runoff will be increased unless the amount of infill development is controlled.

With respect to rainwater and detention tanks, the key findings of recent research are as follows:

- rainwater tanks need to be large enough (>5 kL) to provide sufficient storage for flood mitigation purposes;
- rainwater tanks require sufficient daily demand (detention tanks do not);
- performance (i.e. catchment flow reduction) is catchment specific:
  - larger catchments appear better suited to rainwater tanks;
  - smaller catchments appear better suited to detention tanks;
- the location within the catchment is important on flow reduction;
- rainwater tanks can improve downstream water quality by reducing runoff volume, meaning water quality improvements downstream can be more easily managed;

- detention tanks do not reduce volume but extend the duration of low flow periods which may cause downstream environmental issues (e.g. erosion of a watercourse) or compound downstream flooding problems.

Environmental management

Stormwater runoff from urban catchments is typically high in contaminants such as heavy metals, hydrocarbons, organic matter and faecal coliforms. The majority of these pollutants are generated either from industry or from roadways.

Up to 90% of the pollutant load in stormwater is captured in the small, frequent (up to 3 month ARI) rainfall events, and it has been these smaller events that have been targeted in the design of stormwater pollution control devices (gross pollutant traps, sedimentation basins).

Stormwater harvesting and use schemes also target the capture of smaller frequent events, in the order of 3 month ARI, as this represents in the order of 70% of the annual rainfall yield from a catchment able to be captured. Such schemes are considered 'off site' as they capture street runoff as well as site runoff. Due to the nature of Adelaide's rainfall, with often high intensity, short duration events and occasional 'flash flooding' opportunities to capture higher quantities of runoff are limited, and the size and cost of infrastructure and facilities (open space and diversion infrastructure) is costly for larger ARI events.

It has been shown that neighbourhood, sub-catchment and catchment wide detention basins incorporating a sedimentation component and/or gross pollutant traps significantly reduce the pollutant loads of stormwater.

It is important to recognise that on-site detention does little to reduce pollutant loads from the catchment as it is primarily roof water, whereas pollutant loads are generally sourced from roadways.

Given that only a small portion of pollutants are derived from allotments, on-site retention will do little to reduce the pollutant load. The reduction in stormwater volume will result in an increase in concentration as less water enters the stormwater system resulting in more efficient treatment at a catchment or sub catchment level.

Reduction in stormwater discharge can be achieved and has been successful for small scales through injection into the shallow aquifer. Under the recent Environment Protection Policy (Water Quality) and EPA Code of Practice for ASR systems, disposal to the aquifer of any stormwater requires licence conditions to be met, with a quite onerous sampling and testing regimes for water quality. It has been recently commented by the EPA that such systems 'are likely to be more difficult to obtain EPA approval' under the new guidelines and policy. On this basis, it is unlikely under the current requirement that such disposal methods are considered feasible for small development (i.e. residential).

Regulatory and policy framework

The Statutory Planning system for South Australia and in particular Metropolitan Adelaide stems from the Development Act 1993. Section 22 of the Act requires a Planning Strategy to be developed and maintained and this document is the core instrument defining what can be a part of the Development Plan. Whilst local government has a large part of the formulation of the Development Plan in sections that are particular to its jurisdiction it is the case that a subject as important and prevailing as stormwater management should be devolved from the strategic level.

The Statutory Planning System and its instruments is currently in a significant period of change and whilst there have been recent attempts at the development of guidelines (eg PAR's, Specifications and Bulletins) for stormwater there are more far reaching changes currently in train. In particular:

- The Better Development Plan Programme and the development of a module that relates to stormwater.
- Changes to planning processes through the Development (Sustainable Development) Amendment Bill 2004 with the proposal that Councils prepare Strategic Directions and Infrastructure Reports and the relationship these reports will have to the State Infrastructure Plan.
- The revision of the Metropolitan Adelaide Planning Strategy and the significant emphasis on Ecologically Sustainable Development and the management of Metropolitan Adelaide particularly in relation to urban containment and integrated land and water use.

It is the coordination of these changes particularly in relation to this report that will be crucial to the development of an efficient and effective stormwater management system for Metropolitan Adelaide.

A review of the BCA and associated Australian Standards (AS/NZS 3500.3.2 and AS/NZS 3500.5 – Domestic installations, Section 5 – Stormwater drainage) was undertaken. The drainage solutions of the BCA and elements of the Australian Standards have a well founded basis and are technically sound.

The only main weakness was that it did not provide any direction on the design of on-site stormwater detention and retention systems. It provides no discussion on the flood proofing of new buildings or the retrofitting of existing buildings to reduce flood damage.

Urban development

Recent urban consolidation development trends are likely to exacerbate the existing problems and flood hazards if not properly managed.

The potential for urban consolidation has been assessed by Planning SA. The highest potential for consolidation is found within the Cities of West Torrens, Charles Sturt and Campbelltown. More specifically, these areas relate to the Meakin Terrace, Trimmer Parade and Third to Fifth Creek catchments. These catchments contain large allotments with high potential for further subdivision.

Both Meakin Terrace and Trimmer Parade catchments are flat and currently have poor drainage infrastructure and outfalls. On the other hand Third to Fifth Creek catchments have reasonable grade and convenient outfalls to the River Torrens which has a high standard of flood protection. Similarly in areas such as the City of Tea Tree Gully, there is a well defined natural drainage network (small creeks), steeper terrain and less chance for infill because it is a newer urban environment.

Some councils are better placed than others to handle the impact of development, particularly infill development. Councils on the northern and southern fringes of Adelaide such as the Cities of Onkaparinga, Playford and Salisbury have reasonable areas of open space and can manage and incorporate detention facilities with proper planning incorporating WSUD solutions. It is more likely these councils will experience broad acre (i.e.'greenfield') type residential development which can be planned for in advance and create less impact on all infrastructure including drainage.

Large urban renewal projects involving urban consolidation have primarily been based around areas dominated by Housing Trust dwellings (i.e. Mitchell Park) or are currently progressing and/or proposed (i.e. Westwood, Kilburn, Gilles Plains, Seaton, Royal Park, Salisbury North). The Westwood project (formerly know as 'The Parks') commenced in 1999 and is Australia's largest residential renewal project with the proposed creation of 2,500 private allotments. For this project, flows are estimated to increase by up to 50% due to an increase in impervious area. A smaller development at Seaton and Royal Park is expected to result in peak flows to increase by up to 20%. No comprehensive assessment has been undertaken to investigate the impacts of potential development on a metropolitan wide basis.

New developments are requiring house runoff (from roofs and paved surfaces) to connect to the formal Council drainage system (street or underground drainage system). This additional connectivity means there is a higher potential for increased runoff during small events (< 20 year ARI). The additional connectivity has little effect during larger events (>20 year ARI) as roof drainage under the BCA is limited to a 20 year ARI standard. The overall additional impervious area (regardless of connectivity) contributes more significantly to the increase in runoff during the larger events.

Output based specification

An output based procurement model has been considered as a mechanism for achieving the completion of outstanding stormwater works. Such a model can be applied to specific individual projects on a catchment wide basis or on a metropolitan wide basis. Key issues associated with such a model, and its relative merits and feasibility, are summarised below:

- the potential of output based approaches rely on the ability to clearly and unambiguously define and specify those outputs—outputs are required to be tangible and measurable;
- provides the opportunity to incorporate potentially innovative and cost effective solutions to stormwater problems, whilst meeting minimum requirements;
- enables key aspects of flood mitigation, water quality improvement and stormwater use opportunities to be examined together and fall under the one contractual responsibility;
- provides for the opportunity to explore a number of funding and contractual arrangements.

Key risks of such an approach applied to stormwater infrastructure include:

- hydrology and flooding is probabilistic, not an exact science;
- potential legal and contractual complexities potentially add significant cost to administration and management of output based contracts;
- potential cost savings and other benefits (i.e. whole of water cycle approach) are likely to only be realised if the approach is applied over a whole catchment or on a metropolitan wide basis, not limited to project by project.

It is considered that the uncertain and inexact nature of stormwater management and flood mitigation, together with the high level of liability and litigious potential of flooding poses more risks than likely beneficial outcomes of applying an output based contract model. In addition (as recently stated by the State Government), current appetite from the private sector with respect to public private partnership (PPP) approaches and investment in public infrastructure in Adelaide is poor.

Information gaps

There are a number of important issues that are unquantified and their effects on stormwater management are unknown:

- age and deterioration of stormwater infrastructure:
  - failure of underground infrastructure is sudden and the costs are not generally included in council budgets
  - the age and condition of stormwater infrastructure is not fully considered in council asset registers;

- extent of small projects works (catchments <40 ha):
  - the cumulative effect of all small projects works is likely to be significant, but has not been assessed or included in any long-term budgets;
- accurate flood hazard assessment of problematic catchments:
  - a lack of detailed flood hazard assessment means there are no accurate details on the impact of storm events, except for anecdotal evidence and broad hydrologic and hydraulic assessment;
- accurate flood damage assessment:
  - flood damage assessment across Adelaide has never been compiled therefore the financial consequences of flooding are unknown;
- effect of climate change (e.g. sea level rise, changes to rainfall intensity):
  - predication of future climate suggest more intense rainfall, higher temperatures and increased sea levels
  - the hydraulic effect on stormwater system capacity caused by these changes have not been assessed;
- effect of poor outfall capacity and conditions on upstream capacity:
  - the effect of poor maintenance at outfalls has not been assessed on stormwater system capacity;
- long-term problem areas:
  - no quantitative assessment can be undertaken for drainage problems beyond a 20–30 year planning horizon.

4.2 RECOMMENDATIONS

Flood hazard management

The minor system standard is set by reference to accepted practice and community standards, coupled with appropriate engineering judgement. There is no reason to change this current philosophy.

The greater opportunity to apply a more subjective qualitative approach is to major drainage systems based on a risk management approach instead of a blanket ARI standard, particularly for larger projects. To undertake such analysis requires better definition of tangible costs and a better understanding of the risk management process.

Additional flood hazard mapping must be undertaken on more catchments for such analysis to be performed.

WSUD should be embraced, with recognition that there are limitations to its practicality, primarily with available open space. The vision of WSUD solutions needs to be assessed as part of the preparation of the USMP at a catchment level in collaboration with conventional AR&R approaches.

For larger projects, particularly those in existing developed areas with no or inadequate drainage systems, apart from on-site methods, the lack of open space will inhibit WSUD solutions. Strategic property acquisition should be investigated when preparing the USMP.

Stormwater flow reduction

Where possible (i.e. where space is available) the use of detention basins at a catchment or sub-catchment level should still be a desirable form of peak flow reduction for both the minor and major drainage system.

The blanket approach across a catchment or council area to OSD and OSR is premature (and may be detrimental) as preliminary work has shown their effectiveness is very catchment specific. It is recommended that councils undertake an immediate review of current requirements for on-site stormwater management.

It is recommended that further analysis be undertaken to assess the following:

- determine which method (OSD or OSR) is more beneficial for catchment flow reduction on a catchment by catchment basis;
- determine in which part of the catchment the devices are most beneficial;
- what size tanks (OSD or OSR) are more beneficial;
- for rainwater tanks, determine what demand is required to be coupled with storage to provide the most effective flow reduction;
- assess outfall conditions and determine the impact of either reduced runoff volume (OSR) or extended low flow periods (OSD).

The analysis should be incorporated into the preparation of the USMP on a catchment by catchment basis.

At locations where large rainwater tanks with high demand are found to be beneficial, rebates should be incorporated as part of the 2006 mandate.

Minimum allotment sizes and private open space requirements needs to be considered, as this will have a significant impact on the practicality of on-site solutions, particularly infiltration/soakage solutions and above ground tanks.

Assessment of outstanding projects

The current methods for assessing CMSS funding allocations to outstanding projects are by necessity somewhat subjective. Given the large amount of outstanding work (estimated at approximately $160 million) it is recommended that more objective analysis methods be explored for the allocation of future funding.

One approach often cited is that cost-benefit analysis be used. This approach is alluded to in the CMSS review of 2002:

> The intermittent and unpredictable nature of flood events (in Adelaide) makes it difficult to assess the significance and urgency of proceeding with the (identified and unidentified) projects. It would only be possible to make such an assessment by undertaking an extensive measure of the risks and costs associated with flooding events that could occur as a consequence of projects not proceeding sooner.'

Cost-benefit analysis is not new but has been confined in the past to larger scale flood mitigation projects on the major drainage systems such as the River Torrens and Little Para River. This is due largely to the difficulty and cost in measuring the benefits from such projects (both directly in identifying flood prone areas and then determining the benefit in terms of the amount of damage to be avoided by the project) and indirectly in assessing intangible and social benefits in economic terms. While advances in technology (hydraulic models and mapping systems) have made the identification of flood prone areas somewhat easier the determination of resultant damages and other intangible factors remains problematic. If not carried out with care the assessing of the benefits from a project can easily turn into a subjective exercise in itself.

In view of this while cost-benefit analysis has its place in determining the optimal standard for catchment wide projects (e.g. Brown Hill and Keswick Creeks) the extension of this requirement to projects that are more concerned with the provision of an adequate minor drainage system or to partially completed catchment wide projects is considered to be unrealistic.

It is therefore recommended that those overall catchment projects that are not yet started, that require the expenditure of significant sums of money and involve the upgrading of the major drainage system should be required to undertake detailed economic analysis to determine both the optimal standard and the cost-benefit of the project as an aid to assessing the comparative merits of such projects.

However as much of the outstanding work involves work on the minor drainage system and/or work to complete currently partially completed overall projects it is considered that the comparative merits of such individual projects could be adequately assessed by requiring the applicant to provide more objective information on the broad extent and frequency of flooding in those areas where the work is to take place.

Also as concluded in the 2002 CMSS review, a period of 10 years should be adopted as a guide for addressing the outstanding projects and as a basis for renegotiating the current funding arrangements.

Projects considered to be of highest priority are:

- Brown Hill and Keswick Creek Catchments—major system channel upgrades, detention storage, flood control dams and flow diversions into adjacent catchments, minor system pipe upgrades ($72 million lowest cost option estimated to date);
- Port Road Catchment—major and minor pipe system and open channel infrastructure upgrade ($13.2 million);
- Airport Drain, Cowandilla – Mile End Outfall—major system trunk drainage and outfall channel works ($8 million in outstanding works—note works planned for commencement with $2 million allocated funding);
- Trimmer Parade/Meakin Terrace Catchments—minor system diversion pipe works ($5 million).

The remainder (medium or low priority) need further detailed cost-benefit assessment to determine their exact priority.

Regulatory and policy tools

The module under the Better Development Plan process in relation to stormwater must be reviewed in accordance with the recommendations of the Metropolitan Adelaide Stormwater Management Study.

The intention to require local government to prepare strategic directions and infrastructure reports must be strongly supported and that these reports be closely related to the State Infrastructure Plan.

The State Infrastructure Plan should be referred to in the Development (Sustainable Development) Amendment Bill 2004 and particularly the link between the Plan and the infrastructure reports of local government.

The provisions within the Metropolitan Adelaide Planning Strategy that relate to the management of water be should be considered as a priority in the amendment of the Development Plan within the Metropolitan Area of Adelaide. Any amendment will also take account of the development of the Stormwater Module as a part of the Better Development Plan process. It is likely that this will require a particular programme and a Ministerial Planning Amendment Report in order to emphasise the imperative of this task.

It is recommended that the review of the Development Plan and other policies and guidelines that will follow from a comprehensive incorporation of the 2004 Metropolitan Planning Strategy must involve all Councils within the Metropolitan

Area and include consideration of drainage systems and catchment wide outcomes as well as specific local or site level concerns.

Other measures such as flood proofing and retrofitting of existing buildings can be achieved with relatively minimal cost. Better flood proofing of new buildings in flood prone areas should be introduced and incorporated into the national Building Code, in a similar way to wind and earthquakes are.

Statutory planning

It is recommended that the module being prepared under the Better Development Plan process in relation to stormwater be reviewed in accordance with the recommendations of the Metropolitan Adelaide Stormwater Management Study.

In addition, the provisions within the Metropolitan Adelaide Planning Strategy that relate to the management of water be considered as a priority in the amendment of the Development Plan within the Metropolitan Area of Adelaide. Any amendment will also take account of the development of the Stormwater Module as a part of the Better Development Plan process. It is likely that this will require a particular programme and a Ministerial Planning Amendment Report in order to emphasise the imperative of this task.

It is recommended that Urban Stormwater Master Plans be completed with the necessary detail at the local level to gain an accurate picture of the current network system, potential impacts of development, use opportunities, water quality/amenity issues and flood hazard/flood plain mapping. Their importance is currently not recognised and should be.

Further recommendations of stormwater use opportunities will be discussed in Part B of this study.

Cost sharing

Cost sharing arrangements between developers and councils have been successfully demonstrated on large projects (i.e. Westwood). Such arrangements should be pursued where possible, particularly in areas where the existing stormwater drainage infrastructure is considered to be of poor standard.

This arrangement can only work if the money is put towards the stormwater drainage works. The danger of financial contributions are that they may be put towards other (less critical or perceived urgent) areas. The amount of contribution is also difficult to determine as it is catchment dependent. Further work is required to examine how this process can be put to best use, particularly where (and if) on-site management does not prove to provide benefit.

Private landowner responsibility

The issue of ownership and liability issues associated with on-site stormwater management must be addressed. The legal issues associated with on site flow reduction and disposal is quite different to those associated with stormwater use, however their operation can be linked (i.e. large rainwater tanks).

It is recommended that legal advice be sought on who is responsible for maintenance and operation of on-site measures for stormwater flow reduction (and disposal) and how this couples with the dual role of capturing on-site stormwater as a resource (i.e. for use).

This is a very important concept because if the devices are not adequately maintained, their effectiveness is significantly compromised.

Further investigations

In addition to the investigations and further work outlined above, the following work is required to fully quantify and understand the overall picture of Adelaide's stormwater management requirements:

- continued research into design methods and tools – maintain funding and support to research organisations into enhancing stormwater management techniques;
- condition of infrastructure – preparation of an infrastructure condition data base containing the age of stormwater infrastructure;
- extent of small projects (<40 ha in catchment area) – the cumulative effect and impact from a financial aspect of every small drainage project has not been quantified;
- effect of climate change – effects of long-term sea level rise and changes to rainfall intensity of design procedures has not been considered;
- impact poor outfall conditions have on drainage capacity – effect of sand build up and poor outlet maintenance has not been quantified;
- quantify the effect of full development and urban consolidation – most stormwater studies have assumed the full extent of development that was proposed at that time. Changes in Development Plans have occurred and costs prepared may be incorrect;
- long-term problem areas – the current planning horizon is limited to a 20–30 year period. Beyond this period no assessment has been made.

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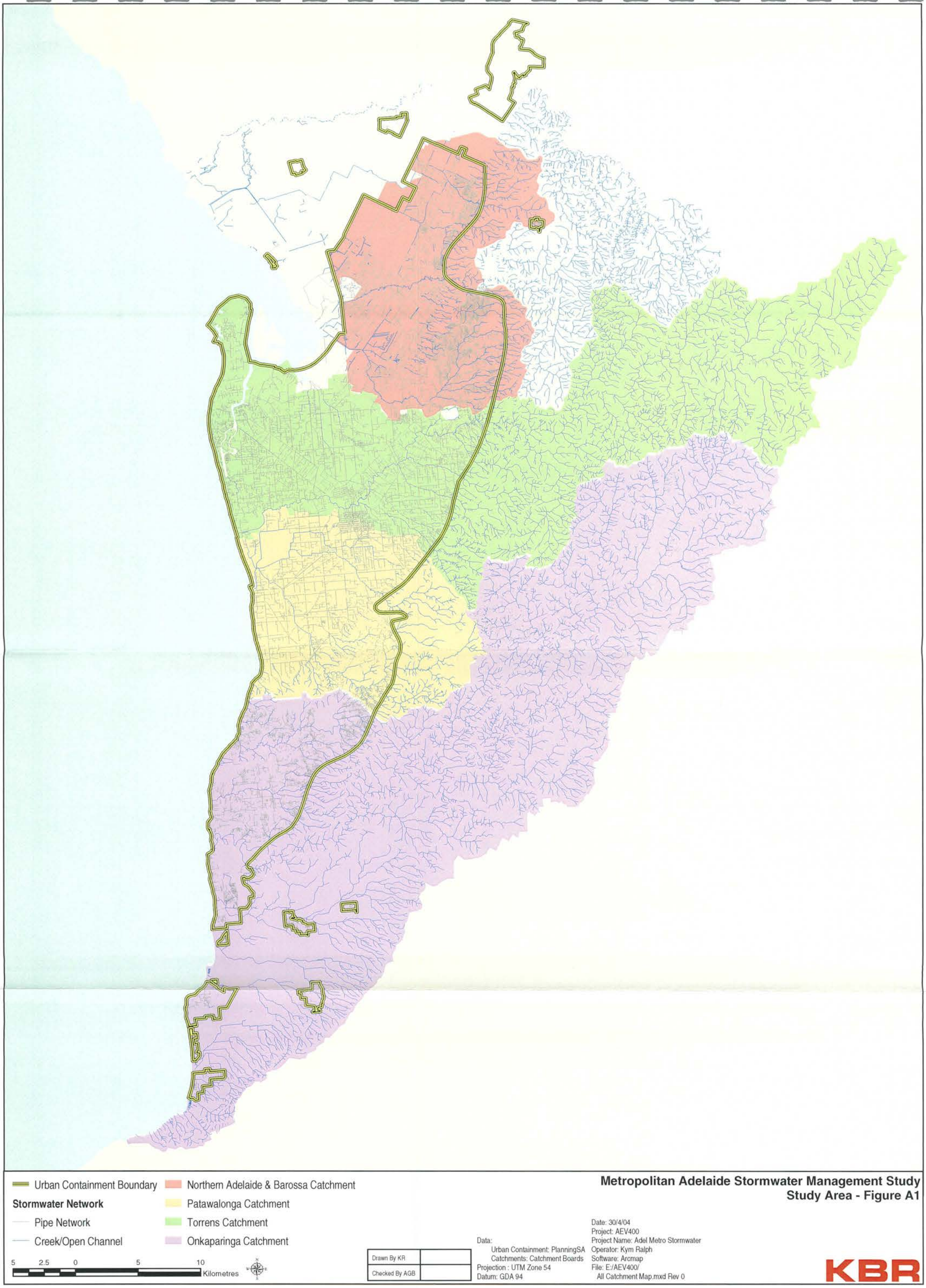
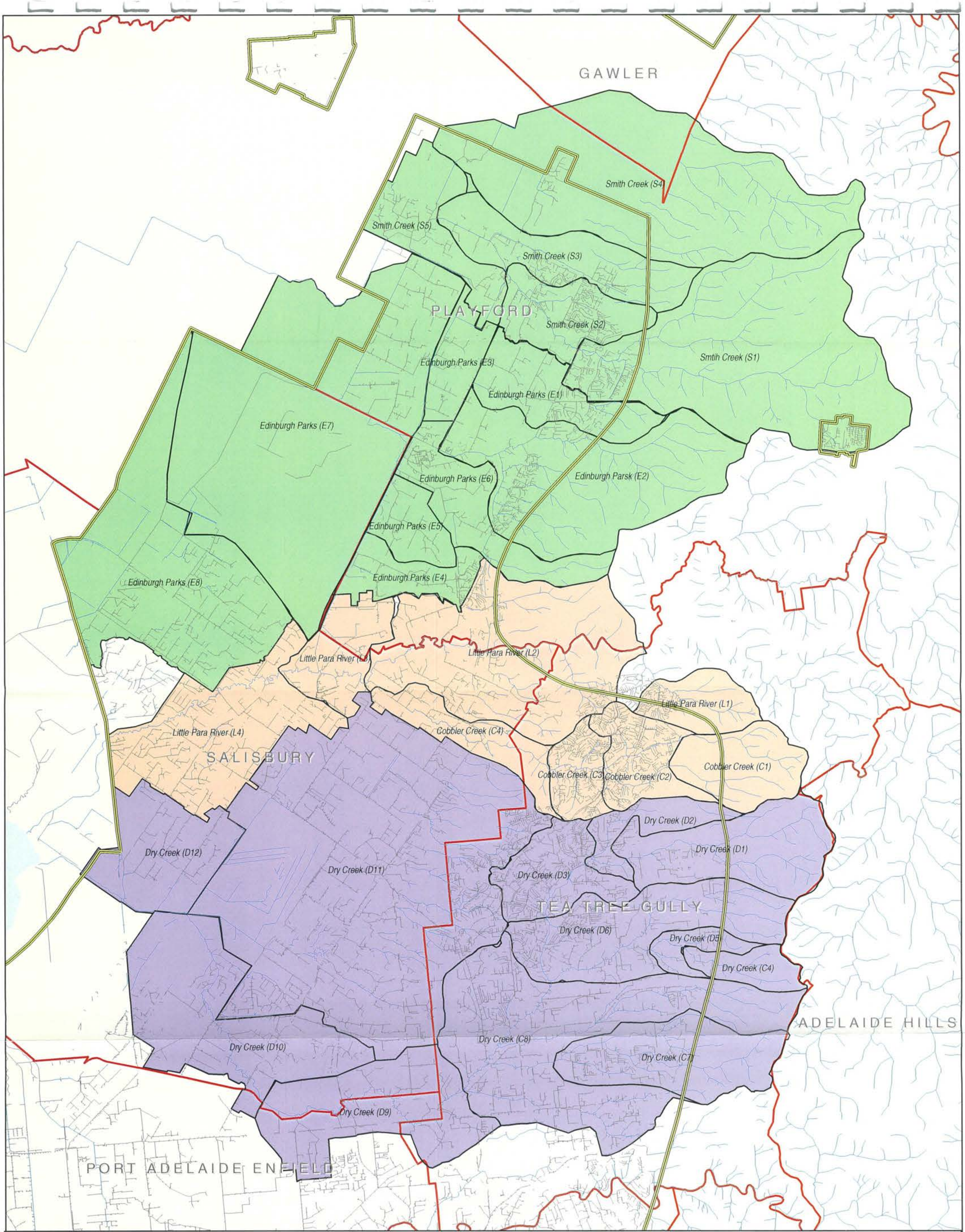
Appendix A

CATCHMENT BOUNDARIES AND STORMWATER NETWORKS


Urban Containment Boundary
Stormwater Network
Pipe Network
Creek/Open Channel
Northern Adelaide & Barossa Catchment
Patawalonga Catchment
Torrens Catchment
Onkaparinga Catchment
5 2.5 0 5 10
Kilometres
Drawn By KR
Checked By AGB
Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94
Date: 30/4/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
All Catchment Map.mxd Rev 0
Metropolitan Adelaide Stormwater Management Study
Study Area - Figure A1
KBR



Urban Containment Boundary

Stormwater Network

Pipe Network

Creek/Open Channel

Local Government Areas

Northern Adelaide Barossa Catchments

Dry Creek

Helps Road / Smith Creek

Little Para River

Northern Adelaide Barossa Sub-Catchments

5 2.5 0 Kilometres

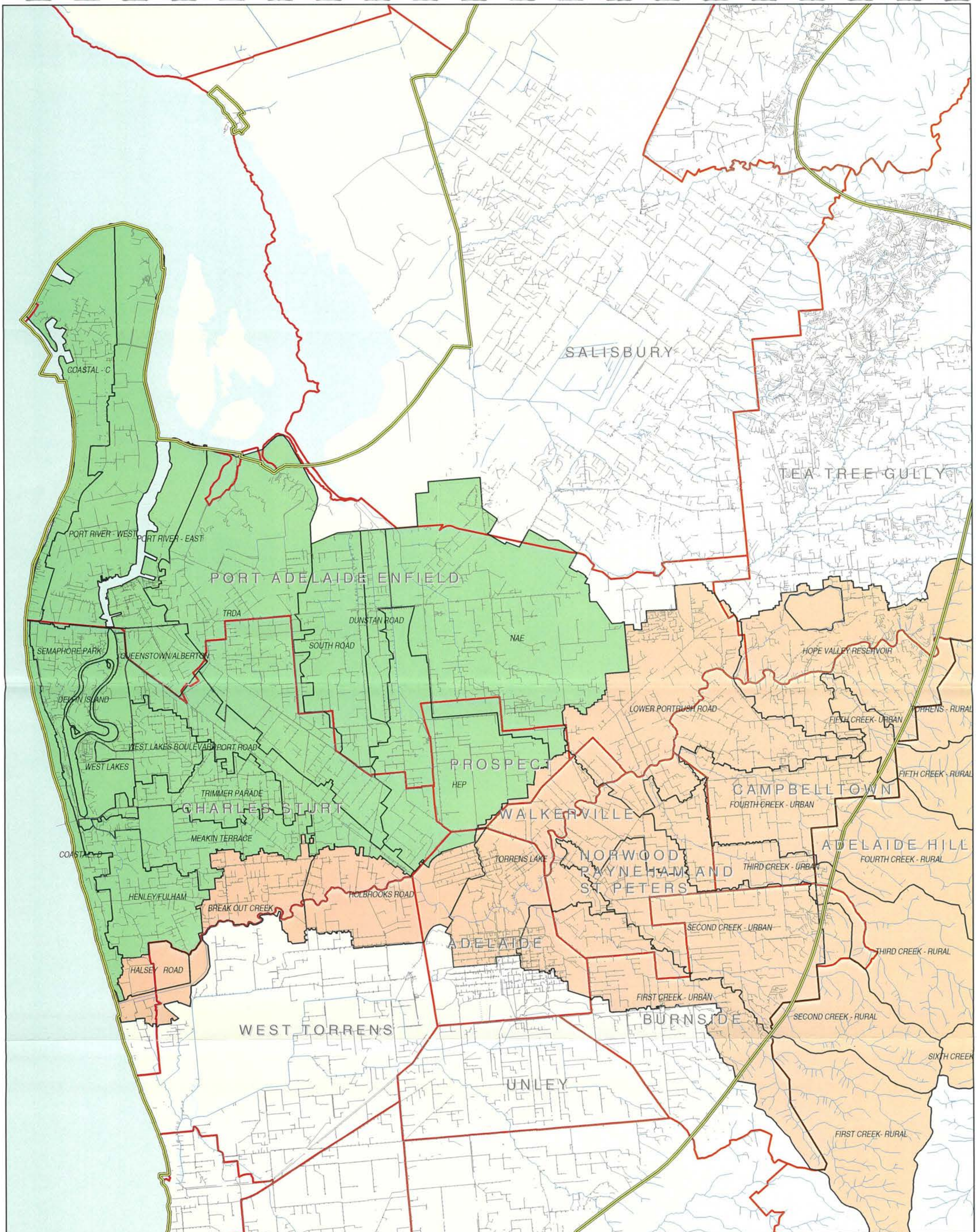
Drawn By KR	
Checked By AGB	

Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94

Metropolitan Adelaide Stormwater Management Study
Northern Adelaide & Barossa Catchment - Figure A2

Date: 30/4/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
NAB Catchment Map.mxd Rev 0

KBR



Urban Containment Boundary

Stormwater Network

Pipe Network

Creek/Open Channel

Torrens Catchments

Extended Torrens / Port Adelaide

Torrens River

Torrens Sub-Catchments

Local Government Areas

1 0.5 0 1 2 3 4 Kilometres

N W E S

Drawn By KR	
Checked By AGB	

Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94

Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
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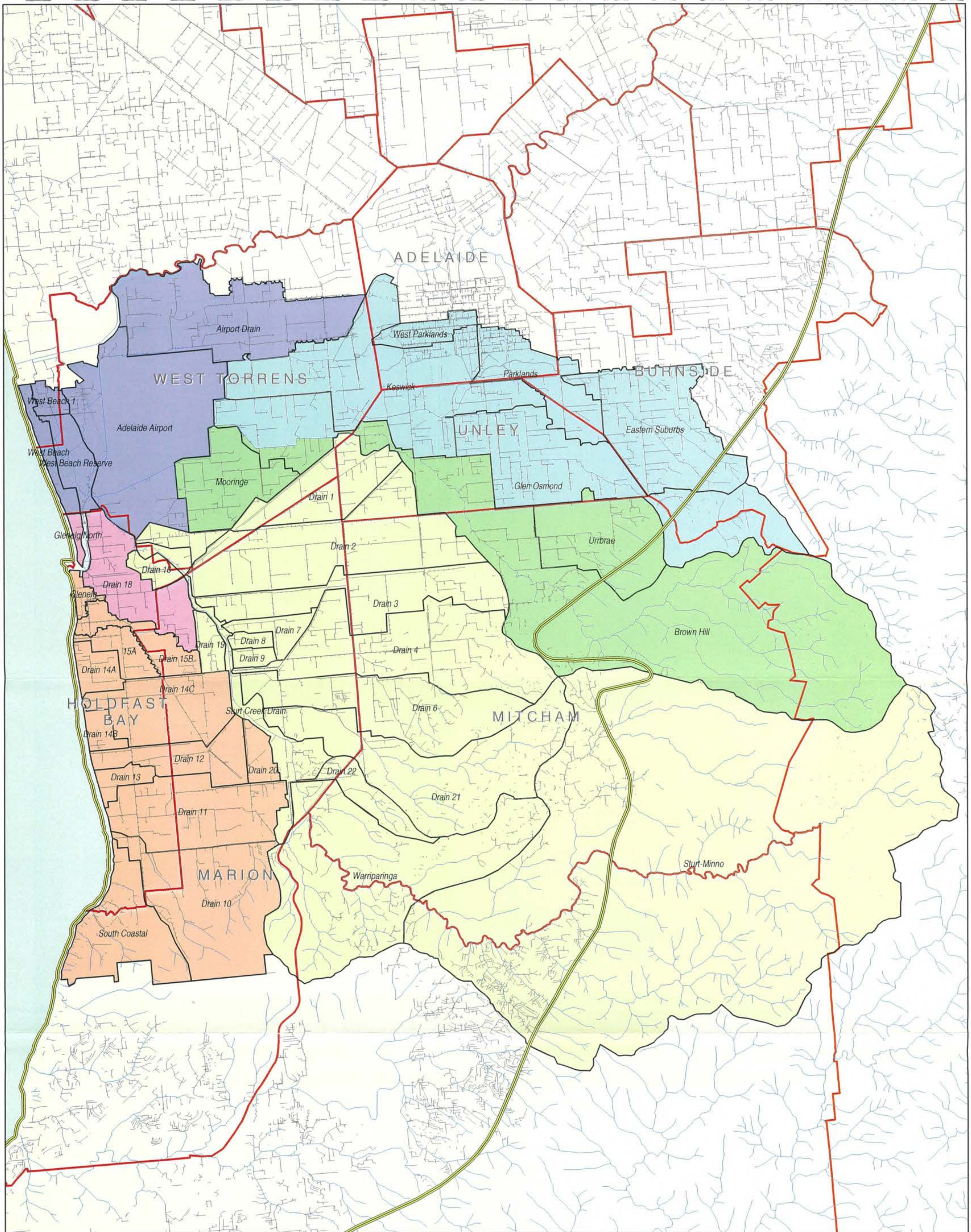
TCWMB Catchment Map.mxd Rev 0

Metropolitan Adelaide Stormwater Management Study
Torrens Catchment - Figure A3

KBR



Urban Containment Boundary

Stormwater Network

- Pipe Network
- Creek/Open Channel
- Local Government Areas

Patawalonga Sub-Catchments

Patawalonga Catchments

- Airport Drain Catchment
- Brown Hill Creek
- Coastal Catchments
- Keswick Creek
- Local Patawalonga Catchment
- Sturt River

0 0.5 1 2 3 4 Kilometres

N E S W

Metropolitan Adelaide Stormwater Management Study
Patalalonga Catchment - Figure A4

Drawn By KR	
Checked By AGB	

Data:
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Catchments: Catchment Boards
Projection : UTM Zone 54
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Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
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KBR

Metropolitan Adelaide Stormwater Management Study
Onkaparinga Catchment - Figure A5

Drawn By KR	
Checked By AGB	

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Catchments: Catchment Boards
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Datum: GDA 94

Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
OCWMB Catchment Map.mxd Rev 0

KBR

Appendix B

COUNCIL CONSULTATION SUMMARY NOTES

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)?
- for major (1 in 20 to 1 in 100 year) events?

What design period are your system capacities?

- minor system (pipes)
- major system (overflow paths)

What is your target (ideal) system capacity?

- minor system (pipes)
- major system (overflow paths)

What are the current flooding hazard areas?

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

What works are planned in the short term (5 yr outlook)?

What works are planned in the longer term?

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Does Council maintain any detention basins or flood retention dams?

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Playford – 27 February 2004

Adrian Swaitnik – City of Playford
Mark Temme – City of Playford
Nathan Silby – Kellogg Brown & Root
Terry Bell – Kellogg Brown & Root
Bill Lipp – Transport SA

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - 4 to 5
  - The maintenance of the network is good with programme to clean out pits $60 to $80k budget for maintenance and $150k for open drains. Extensive cleaning has prevented any significant incidence of flooding from the minor network.
  - Some minor surface runoff problems exist in kerb and water table through ground movement.
- for major (1 in 20 and above) events
  - 3

Older areas are subject to some flooding but there has been no major event in recent times.

All newer areas are to a higher standard.

More needs to be known about the condition of the SAHT areas after almost 50 years of operation.

What design period are your system capacities?

- local system (piped system)
  - It is thought to be about 1:5 but the systems have not be analysed of late.
- major system (creek system)
  - Smiths Creek is currently rated at 1:50 year protection but is to be upgraded to provide 1:100.
  - Stebonheath is 1:100 but some local work is being done in Andrews Farm to raise standard.
  - Smith Creek is 1:50 with the installation of a proposed detention system upstream ($800,000 dam east of Blair Park Drive) this will be 1:100.

- Adams Creek 1:50 is currently being funded to the 1:100 standard with input from Sustainable Regions funding.
- Main area of concern are near the railway line on Stebonheath Rd.
- Protection to the Elizabeth Regional centre is unknown.

- Playford has established comprehensive drainage plans for the Council area. As part of Council's asset management plan they intend to complete a network analysis to determine the current system capacities. Once this has been completed they will then be able to determine the current level of service and the extent of the upgrades required.

What is your target (ideal) system capacity?

Target design is 1:100 for the major system and 1:5 for the minor system.

The proposed Main Drain from South of Davoren Road and Stebonheath will be built at 1:100.

What are the current flooding hazard areas?

Minor flooding in the Vale and South is currently being addressed.

Railway Drain in Elizabeth South and fronting the Adelaide Gawler main line will require work and this will need to be more aesthetic in keeping with contemporary treatments.

Area around Elizabeth Centre will need further work this will link into the Adams Road project and the Helps Road system in Salisbury.

Runoff from Munno Para District Centre through Commonwealth land. This will need to be put in place and discussion to take place with AdRail in regard to upgrading culvert.

Potential areas of concern in regard to land use change:

Area flows into Kudla will be an issue and recent changes to UGB by increasing areas subject to land division in vicinity of Gawler will have some impact but probably affect Heaslip Road and Angle Vale more than other parts of Playford.

Heaslip Road delay will mean drainage in this area will be delayed (Outside UGB)

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

No work has been undertaken on a comprehensive hydraulic plan and there is a need for an Urban Stormwater Master Plan. Once this master plan is developed it may identify other areas of concern that are currently not recognised.

Area west from Stebonheath Road in Munno Para West will need to be redesigned. Larger allotments that are being divided and possible exit of water to drain south of the Golf Course (Fradd FCP)

General Motors Holden

Possible impact of urban infill although present system could cater for this not much is known of the older Housing Trust built system.

Impact of new development in Playford North east and west of Main North Road. (did the Tonkin Report take this into account) Eastern area will have space for on-site detention.

Blakeview development.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

- Land availability is not a major constraint and drainage can be allowed in major land divisions.
- Budgets are limited with major capital outlays to undertake necessary works.

What works are planned in the short term (5 yr outlook)?

Network analysis.

Smith Creek $800k project with $700k in budget.

Adams Creek ($2.5M) $400k budgeted and rest from Sustainable Futures funding.

Kettering Road (Elizabeth South Railway Drain) $150k for two years and in budget but this could increase to $500K.

The ten identified sites in the 1998 study are still being investigated.

What works are planned in the longer term?

No long term plans have been developed as it is expected that these will be determined as part of the network analysis.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

In the process of developing one through the network analysis and stormwater Master Plan process.

Does Council maintain any detention basins or flood retention dams?

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Norwood Payneham St Peters – 4 March 2004

Malcolm Chadwick – Manager Technical Services, City of Norwood Payneham St Peters
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Terry Bell – Principal Planner, KBR
Bill Lipp – Manager Stormwater Services, Transport SA

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event) – 4
- for major (1 in 20 to 1 in 100 year) events – varies

What design period are your system capacities?

- minor system (pipe system) – 2 to 5 year ARI
- major system (overland flowpaths/creeks) – generally approx. 20 year ARI

What is your target (ideal) system capacity?

- minor system –5 year ARI
- major system – 20 to 100 year ARI

What are the current flooding hazard areas?

Primarily creek systems through private properties.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Infill development is considered an emerging problem and some planning controls are being recommended/implemented. Examples include floor levels in Kensington and Norwood to be 300 mm above the 50 year ARI flood level and in these areas development cannot occur within the 20 year ARI floodplain.

Significant sections of the creek systems pass through private property, typically overgrown with primarily exotic tree species.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

Access to significant sections of the creek systems through private property.

What works are planned in the short term (5 yr outlook)?

Council are working through a 10-year stormwater works programme based on an identified priority list. This has been occurring for approximately 4 years and most of the significant flooding/inadequate stormwater infrastructure has been addressed.

What works are planned in the longer term?

Continue with works programme as noted above.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Refer attached.

Does Council maintain any detention basins or flood retention dams?

No.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

None identified to date.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of West Torrens – 12 March 2004

Angelo Catanari – Manager Technical Services
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Amanda Price – Senior Planner, KBR

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event) – 2
- for major (1 in 20 to 1 in 100 year) events – 3

What design period are your system capacities?

- minor system (pipe system) – 1 to 5 year ARI
- major system (overland flowpaths) – varies significantly, however generally less than 100 year.

What is your target (ideal) system capacity?

- minor system – 5 year ARI
- major system – 100 year ARI

What are the current flooding hazard areas?

Lockleys, Mile End, Thebarton, West Beach, Torrensville.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Infill development both within Council area and upstream is significantly impacting on infrastructure capacity.

Council places detention/retention requirements on developments involving land greater than 1,000 m^2, and imposes a maximum discharge rate from the site of 20 L/s in the 1 in 20 year event.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

Cost and land availability.

Agreement with upstream councils on method of addressing flooding issues and cost sharing principles.

What works are planned in the short term (5 yr outlook)?

Works being undertaken based on stormwater capacity investigation.

Mile End – Cowandilla Outfall Drain.

What works are planned in the longer term?

Flood mitigation, channel capacity works within Keswick and Brownhill Creek systems.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Not formal. USMP to be developed.

Does Council maintain any detention basins or flood retention dams?

Yes, generally smaller, neighbourhood scale.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Investigations being undertaken at Thebarton and Glenelg. High groundwater table levels in western suburbs makes construction of open storages and detention basins difficult.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Charles Sturt – 3 March 2004

Peter Lockett – City of Charles Sturt
Adrian Sykes – City of Charles Sturt
Stan Robb – City of Charles Sturt
Bill Lipp – Transport SA
James Pannell – Kellogg Brown & Root
Scott Haynes – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 2
- for major (1 in 20 and above) events
  - rank 1

What design period are your system capacities?

- minor system
  - from < 1 yr ARI (Port Road system) up to 8 yr ARI (Torrens Road system)
- major system
  - varies, unable to say exactly but would not meet 100 yr standard in many locations except for newer areas (e.g. West Lakes).

What is your target (ideal) system capacity?

- minor system
  - 5 yr ARI
- major system
  - 100 yr ARI

Realistically some areas will not achieve this standard. Trapped low spots behind dunes are likely to only achieve 50 yr ARI standard. Majority of the underground system likely to achieve only 2 yr ARI standard based on cost constraints.

What are the current flooding hazard areas?

All areas are flat and low lying and will suffer significant flooding during major events. Numerous areas have inadequate minor system capacity resulting in road ponding and inundation of private property in isolated areas. USMPs undertaken for Port Road, Trimmer Terrace, Meakin Terrace, Torrens Road. Almost completed USMP for HEP catchment (encompassing areas of Charles Sturt, Port Adelaide Enfield and Prospect).

Port Road catchment – trunk drain down Port Road restricts drainage from lateral systems. Frequent surface flooding occurs every year at various locations. Numerous commercial properties exist along Port Road and are often affected.

Trimmer & Meakin Terrace catchment – surface ponding occurs at numerous locations. More significant ponding occurs at Crittenden Road/Findon Road and Pioneer Street/Lucerne Grove. Floodplain mapping currently being done to assess flow paths and depths in major events.

Torrens Road catchment – generally quite good, some minor ponding on roadways

Henley/Fulham catchment – surface ponding at numerous locations.

Coastal trapped low spots – limited overflow paths in major events. Some areas have pump stations with no back up.

Other risks related to chemical spills and seepage from factories.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Future flood hazards are likely to be caused by infill/urban consolidation on the smaller allotment scale. There are only a few opportunities for larger developments on currently undeveloped land except proposed residential developments possible at Cheltenham Racecourse, any of the golf courses, Underdale Campus (north). Infill development will exacerbate the existing problems and flood hazards if not properly dealt with.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works – works subject to funding both from internal sources and external (State Government Stormwater Subsidy Scheme).

Replacement of drainage systems due to ageing infrastructure will impact on what can be spent on new drainage and upgrades.

Technical issues such as long term sea level and groundwater rises are a future constraint.

Availability of land for detention basins is very limited. Some land is vacant but is possibly contaminated.

Politics/legislation – development controls (water quality, allotment sizes).

Insurance costs – public liability.

What works are planned in the short term (5 yr outlook)?

Details to come out of completed USMPs. Significant amount of money is to go towards road reseal programme over next few years.

What works are planned in the longer term?

Proceed with works programme as outlined in USMPs. Council keen to seek State Government funding to upgrade major trunk drainage/channel works similar to Transport SA funding of major roads.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Residential infill developments require the developer to manage stormwater discharge on –site. Post development flows detained to pre development flows (1 in 5 yr ARI only). No requirement for detention in 100 yr ARI. For coastal areas on sandy soils this can be discharged into the soil system.

For larger scale developments flow management achieved using detention basins (or similar) to restrict post development flows to pre development levels for both minor and major events.

Council do not ask for rainwater/detention tanks (expensive to maintain, restrict usable space on allotments, ownership transfers, does not lead to affordable housing, requires expensive backflow prevention device if plumbed to SA Water main).

Some shop owners along flood prone areas use sand bags for flood protection.

Does Council maintain any detention basins or flood retention dams?

Yes, Parfitt Square, Gleneagles reserve, possible sites in Grange Golf Course/Royal Adelaide Golf Course.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Council keen to further develop re-use schemes. Currently have small ASR scheme at Parfitt Square. Possible locations at Grange Lakes, Port Road, Grange Golf Course, Cheltenham Racecourse.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Campbelltown – 8 March 2004

Peter Merkel – Technical Officer, City of Campbelltown
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Scott Haynes – Senior Planner, KBR

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event) – 4
- for major (1 in 20 to 1 in 100 year) events – 3

What design period are your system capacities?

- minor system (pipe system) – generally 5 year ARI
- major system (overland flowpaths):
  - Third and Fourth Creeks 30 year ARI
  - other areas up to 100 year ARI

What is your target (ideal) system capacity?

- minor system – 5 year up to 10 year ARI (Arthur Street)
- major system – 100 year ARI

What are the current flooding hazard areas?

Some minor problem areas. Potentially Third to Fifth Creeks in large events.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Infill development is significant in Council area, however, generally good grades and stormwater drainage is not a significant problem.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

Cost and potentially land availability along creeks in private property.

What works are planned in the short term (5 yr outlook)?

Rostrevor Drain, Morialta Road to Fourth Creek.

What works are planned in the longer term?

Dawn Avenue.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Works based on previous floodplain mapping and flood studies.

Does Council maintain any detention basins or flood retention dams?

Not on a community scale.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Yes, at Torrens Valley Sportsfield.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Burnside – 25 February 2004

Stephen West – Environmental Engineer, City of Burnside
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Amanda Price – Senior Planner, KBR

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - 2 to 3
  - Side entry pits inadequate in many situations. Kerb and Watertable carries overflows further downstream.
- for major (1 in 20 to 1 in 100 year) events
  - 2
  - Tree choked creeks on private properties are a concern. Possibility of debris dams forming, resulting in upstream flooding.

What design period are your system capacities?

- minor system (pipe system) – 1 to 10 year ARI
- major system (overland flowpaths) – up to 100 year ARI

What is your target (ideal) system capacity?

- minor system – 2 to 5 year ARI
- major system – 100 year ARI

What are the current flooding hazard areas?

Beulah Park, Glenside, Dulwich, Rose Park, Toorak Gardens.

Low kerb heights in many of the older areas (i.e. Tusmore) remains to be a nuisance problem as flows easily overtop the kerbs.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Creeks passing through private property, typically overgrown with primarily exotic tree species.

Infill development is considered an emerging problem and some planning controls are being recommended. Floor levels to be set above 100 year ARI flood level and development is 'controlled' in designated 'water course zones'.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

Confidently understanding the magnitude and location of flooding problems and opportunities for mitigation.

What works are planned in the short term (5 yr outlook)?

Complete infrastructure studies for whole council area. Stage 1 has been completed (1st Creek system). Stage 2 (South of 1st Creek) is currently being undertaken. Stage 3 (remainder of Council area) to follow Stage 2.

Complete 1st to 5th Creek Floodplain Mapping Study.

Complete Burnside Urban Stormwater Master Plan.

Proceed with urgent recommendations of the infrastructure capacity study, plus small scale projects identified by Council staff.

Undertake any urgent actions resulting from the 1st to 5th Creek Floodplain Mapping Study.

What works are planned in the longer term?

Continue with priorities as noted above.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

No specific strategy.

Burnside Development Plan has requirements for on-site detention/retention (worded 'should' not 'must').

Opportunities to incorporate flood mitigation outcomes into Council works are undertaken where possible (i.e. Linden Gardens).

Does Council maintain any detention basins or flood retention dams?

Council maintains flood retention/detention basins at Glenside Campus, Kensington Gardens Reserve (2), Penfold Park, Gandy's Gully, Allendale Avenue and Heywood Drive.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Yes, opportunities are considered and adopted where physically and financially viable (e.g. Linden Gardens).

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with Adelaide City Council – 4 March 2004

Shane Jennings – Asset Engineer, Adelaide City Council (ACC)
Stephen Mudge – Policy and Planning, ACC
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Terry Bell – Principal Planner, KBR

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event) – 5
  - system originally designed for 20-year ARI
- for major (1 in 20 to 1 in 100 year) events – 4
  - roads generally okay
  - in parklands (especially south), inundation is generally uncontrolled, however generally nuisance rather than property threatening.

What design period are your system capacities?

- minor system (pipe system) – 20 year ARI
- major system (overland flowpaths) – 100 year ARI (although creek breakouts occur in parklands during lesser events.

What is your target (ideal) system capacity?

- minor system – 5 year ARI
- major system – 100 year ARI

What are the current flooding hazard areas?

South Parklands, where larger events can spill into South Terrace.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Parklands due to flows from upstream councils increasing with greater infill development.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

Agreement between councils on method of addressing flooding issues and cost sharing principles.

Access to parklands for flood mitigation devices (detention basins/wetlands, etc), due to 'alienation' of parklands (preventing some areas to be useable).

What works are planned in the short term (5 yr outlook)?

Formalising flood mitigation works in South Parklands.

Preparation of an USMP for ACC.

Informal detention in East and South Parklands.

What works are planned in the longer term?

Continue with works programme as noted above.

Potential Wetland/flood mitigation basin for Victoria Park Racecourse in East Parklands.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Not formal.

Does Council maintain any detention basins or flood retention dams?

Yes, generally in Parklands.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

ASR is being investigated in a number of sites. Aquifer suitability appears to be marginal. Economically not feasible as ACC receives free access to water supplies.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with Adelaide Hills Council – 25 February 2004

Matthew Dawkins – Manager Assets, Adelaide Hills Council
Anthony Bowman – Study Manager, Kellogg Brown & Root

Areas within Urban Growth Boundary only (Teringie, Woodforde)

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event) – 5
- for major (1 in 20 to 1 in 100 year) events – 5

What design period are your system capacities?

- minor system (pipe system) – generally 2 to 5 year (anecdotal)
- major system (overland flowpaths) – unknown

What is your target (ideal) system capacity?

- minor system – 5 year
- major system – 100 year

What are the current flooding hazard areas?

Relatively new areas, stormwater systems installed with subdivisions in last 10 to 20 years. No problems known of.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

New areas, unlikely to be a problem.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

Not identified.

What works are planned in the short term (5 yr outlook)?

None other that associated with new subdivisions.

What works are planned in the longer term?

As above.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Not for these areas. Minimising scour in creeks and watercourses is primary objective.

Does Council maintain any detention basins or flood retention dams?

Not in those areas within the study boundary.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

The area covered by the study generally has not looked at or sought water re-use strategies. Elsewhere in the Council area however, Council encourages developers to consider re-use opportunities, especially where large roof areas are available and there is likely to be high water use activities where the runoff quality is suitable for the intended purpose (i.e. toilet flushing).

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with Town of Walkerville – 2 March 2004

Mark Draper – Manager Works and Infrastructure, Town of Walkerville
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Terry Bell – Senior Planner, KBR

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event) – 4
- for major (1 in 20 to 1 in 100 year) events – 3

What design period are your system capacities?

- minor system (pipe system) – generally 2 to 10 year
- major system (overland flowpaths) – varies up to 100 year

What is your target (ideal) system capacity?

- minor system – 5 to 10 year
- major system – 100 year in critical areas

What are the current flooding hazard areas?

Walkerville generally only has minor nuisance problem areas, generally localised and often caused by blockages.

Most of the systems were installed through the 1960s.

Some problems with runoff occur adjacent North East Road.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

There are no broad scale areas of development/redevelopment sites within the Council area. Infill development is occurring through Vale Park, however generally good grades throughout the Council area result in few problems. Planning studies show that infill development will generally increase all surface flows by approximately 30%.

What are the significant constraints to achieving long term flood protection? (Cost, land availability, etc)

General lack of land availability prevents detention basins from being incorporated into s/w systems (except Robe Terrace). Cost is a factor for larger works as catchments are too small for CMSS contribution.

What works are planned in the short term (5 yr outlook)?

Council have a 5-year works plan, with current expenditure in the order of $300 k/a, being approximately 1/3 of their capital works budget.

What works are planned in the longer term?

Nothing significant.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

A Council wide strategy will be developed, based on stormwater infrastructure study being completed at present.

Does Council maintain any detention basins or flood retention dams?

Only one adjacent Robe Terrace, constructed as part of the Robe Terrace upgrade.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Generally no, insufficient land available for capture works. Possibility on a small, local scale.

Metropolitan Adelaide Stormwater Management Study Part A – Audit of existing information

Meeting with City of Salisbury – 27 February 2004

Harry Pitrans – Manager Infrastructure Planning, City of Salisbury
Anthony Bowman – Study Manager, Kellogg Brown & Root (KBR)
Scott Haynes – Senior Planner, KBR
Bill Lipp – Manager Stormwater Services, Transport SA

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - 4 for the major systems
  - 3 for the minor (pipe) systems
- for major (1 in 20 to 1 in 100 year) events
  - as above

What design period are your system capacities?

- minor system
  - 2 to 5 year
- major system
  - 10 to 100 year

What is your target (ideal) system capacity?

- minor system
  - 5 year
- major system
  - 100 year

What are the current flooding hazard areas?

General flooding on plains, primarily on lateral drains. Works generally targeted around complaints and Council officer knowledge of problem areas.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Burton (Springbank Waters), Parafield Gardens (industry/residential), Salisbury East Campus, likely to residential - will require on-site detention.

Burton West industrial area, Parafield Gardens commercial area, Edinburgh Parks - will require on-site detention to manage flood mitigation.

Infill land development on an individual allotment basis has not been significant to date and there are no requirements currently in the development plan provisions for on-site detention. Stormwater management is undertaken on a local neighbourhood and catchment basis, such that Council has ownership and is responsible for maintenance.

Open space provision in new developments must be useable, however, can incorporate stormwater detention for inundation in events

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Both cost and land availability are the major constraints.

What works are planned in the short term (5 yr outlook)?

Angle Vale Crescent Stage 2
Little Para overflow channel weir
Burton West Stage 2
Rowe Park Detention Basin, Ingle Farm

What works are planned in the longer term?

Burton West
Direk

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Flood mitigation strategies for the main systems (Dry Creek, Little Para, Helps Road) has been undertaken.

No USMP has been undertaken to date for the pipe networks. Strategies being produced currently focus on stormwater as part of water resource strategy, looking at re-use opportunities. An USMP is likely to be undertaken some time in the future.

Does Council maintain any detention basins or flood retention dams?

Yes, 23 detention basins and flood retention dams.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Yes, numerous, including Parafield, Edinburgh Parks, Kaurna Park, Paddocks, Pooraka, etc (refer Northern Adelaide Water Resources Plan).

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Prospect – 1 March 2004

Paul Gelston – City of Prospect
Sarah Murphy – Kellogg Brown & Root
Amanda Price – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - 3-4 for the local network system
  - Prospect does not define roads as 'major' and 'minor' as all 'major' roads are under TSA control. All roads are therefore minor.
- for major (1 in 20 and above) events
  - 2-3 for the local network system.

What design period are your system capacities?

- minor system (piped system)
  - approximately 5 year, this will be confirmed in new stormwater management plan being prepared by Tonkin Consulting. Tonkin do all stormwater design work.
- major system (creek system)
  - Prospect has no creek systems, all stormwater drainage is underground infrastructure.

What is your target (ideal) system capacity?

- minor system
  -
- major system
  -

Awaiting completion of stormwater master plan for recommendations of what are ideal system capacities.

What are the current flooding hazard areas?

No major problem areas. Several pipe upgrades have been carried out in the last 10-15 years in response to Tonkin's original Stormwater Master Plan for the Hindmarsh Enfield Prospect (HEP) catchment.

Minor problem areas:

- Collingrove Ave/Galway Ave intersection–minor flooding problems as pipe not sized adequately.
- Brooke St/Hepburn St intersection–minor flooding problems.
- Belford Road–1200 dia pipe was installed to assist in draining Churchill road in big events, but still some problems. Pipe may need to be extended.
- Beatrice St–old box drain under northern footpath (1930's) in poor condition, floods during heavy rain. Temporary relief drain has been installed.

All future works will be driven by the Stormwater Master Plan (as all works have been in the past).

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Not sure at this stage. No major areas in the catchment that will be redeveloped (eg no Housing Trust Areas), any development will be small scale infill development. Again, awaiting Stormwater Master Plan for identification of any areas expected to experience flooding problems.

Only subdivision on the horizon is development associated with planned Wetland on Churchill Road/ Regency Road intersection (Railway corridor).

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost, land availability and topography of land (flat catchment). Main problem within the City of Prospect is land availability. There is not a lot of un-used open space, although some playing fields/large reserves could be looked at for flood retention.

What works are planned in the short term (5 yr outlook)?

- Waiting on completion of Stormwater Master Plan for recommendations.
- $100K in next year's budget to be contributed to Grand Junction Road bridge upgrade.
- Study commissioned this year looking at the 'health' of the stormwater system (CCTV etc), structural assessment of underground pipe systems.

What works are planned in the longer term?

- Waiting on Stormwater Master Plan for recommendations.
- Implementation of findings of structural assessment of pipe system.
- Continue to provide funds to downstream catchments (City of Port Adelaide Enfield).

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Don't really have a flood mitigation strategy other than what is outlined in Stormwater Master plan.

Council try to promote on site retention on a lot by lot basis for infill development using Conditions of Approval, but there are no cost penalties for non-compliance.

Does Council maintain any detention basins or flood retention dams?

No, generally insufficient land available for stormwater detention/retention.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Prospect Wetland on corner of Churchill Road and Regency Road is still being considered. Council trying to gain approvals for purchase of land. Council see this as more of an amenity Wetland, although the preferred concept (refer KBR Concept Design) included an ASR scheme. Council do no have use for water in that area, unless an industry (such as Spotless) are interested in purchasing recycled water.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Port Adelaide Enfield – 24 February 2004

Wally Iasello – City of Port Adelaide
Les Dearman – City of Port Adelaide
James Pannell – Kellogg Brown & Root
Amanda Price – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

Varies considerably depending on location within the Council area. Council split into three areas.

Eastern (generally east of Main North Road)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 4
- for major (1 in 20 to 1 in 100 year) events
  - rank 3

Western (east of Port River but west of Main North Road)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 3
- for major (1 in 20 to 1 in 100 year) events
  - rank 2

Port Adelaide/Le Fevre Peninsula

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 2
- for major (1 in 20 to 1 in 100 year) events
  - rank 2

What design period are your system capacities?

Standard varies considerably throughout the Council area. 'Enfield' area is generally better standard than 'Port Adelaide' region.

Newer developments and land divisions such as Northgate and Regent Gardens have 5 yr ARI standard for minor and 100 yr ARI standard for major drainage networks.

The remaining existing networks have a full range of design standards. Some pit/pipe systems have only 1 yr ARI standard (i.e. Hart Street) others have up to a 20 yr ARI standard (i.e. trunk drainage system in HEP). The majority of drains are in the 2-5 yr ARI range.

Major flow protection also varies considerably. Some areas in trapped low spots have only 5 yr ARI protection, some areas have 100 yr ARI protection (i.e. newer developments and steeper areas to the east).

What is your target (ideal) system capacity?

- minor system
  - 5 yr ARI
- major system
  - 100 yr ARI

Above are 'ideal' standards. In reality due to the topography of the land and current development, these standards are not feasible at a number of locations. A 2 yr ARI standard for minor drainage and 20-50 yr ARI standard is probably more realistic for the western part of the Council.

What are the current flooding hazard areas?

North Arm East catchment – Clearview, Enfield, Kilburn
Hart Street pump station catchment – Ethelton, Glanville

Hargraves Terrace/Lulu Terrace catchment – Peterhead, Birkenhead

Gray Terrace catchment – Rosewater, Gilman

Wellington Street pump station catchment – Alberton, Queenstown, Rosewater

Hack Street - Port Adelaide

Outer Harbour, Osborne

Issues are inadequate pit and pipe capacity (minor systems) and low spots creating overland flow issues (major events).

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Increase in sea level is a major issue for Port Adelaide/Le Fevre Peninsula area.

Infill developments in Gepps Cross and Enfield. Larger scale development of Hampstead Centre, Strathmont Centre and Hillcrest Hospital will require detention.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works (area is flat - big pipes and little scope to avoid service clashes). Major flow protection is biggest issue.

Comes down to a cost/benefit analysis (i.e. do you spend millions of dollars to solve a problem to only two or three residences).

Long term sea level rise will impact on flood protection.

What works are planned in the short term (5 yr outlook)?

An important part of the strategy is to finalise and complete stormwater studies and USMPs for the Council.

Council have a short term programme to undertake pit/pipe and pump station upgrades.

What works are planned in the longer term?

Continue with works programme as funds become available.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Stormwater management for larger scale developments are relatively easy to manage by undertaking stormwater master plans in agreement with the developers up front.

The redevelopment of smaller private parcels of land into even smaller allotments is more problematic as there is no master planning. Councils current requirement is to provide a rainwater tank (single module) connected to the garden/soakage pit and/or street. For coastal areas on sandy soils discharge via soakage is encouraged. Council want more work to be done on detention tank sizing/development prior to implementing as per recommendation by Planning SA.

Issue of financial contributions from developers should be looked at in more detail.

Does Council maintain any detention basins or flood retention dams?

Numerous detention basins for control of minor and major flows, two retention basins and wetlands (Barker Inlet/Magazine Creek).

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Council keen to further develop re-use schemes. Currently have small reuse schemes at Northgate and Oakden. Need to further investigate larger scale schemes, such as State Sports Park/Pines Hockey stadium by diverting stormwater from Grand Junction Road.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Onkaparinga – 1 March 2004

Renee Base – City of Onkaparinga
James Pannell – Kellogg Brown & Root
Scott Haynes – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

Willunga/Happy Valley

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 2.5
- for major (1 in 20 to 1 in 100 year) events
  - rank 1

Noarlunga

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 4
- for major (1 in 20 to 1 in 100 year) events
  - rank 4

What design period are your system capacities?

Willunga/Happy Valley

- minor system (piped system)
  - up to 5 yr ARI
- major system (creek system)
  - varies from say 20 yr up to 100 yr ARI.

Noarlunga

- minor system (piped system)
  - 10 yr ARI
- major system (creek system)
  - varies from say 20 yr up to 100 yr ARI.

What is your target (ideal) system capacity?

- minor system
  - 10 yr ARI
- major system
  - 100 yr ARI

Note: minor system target of 10 yr higher than TSA standard of 5 yr (has been a problem for major roadway upgrades)

What are the current flooding hazard areas?

- Old Noarlunga, Port Noarlunga - flooding in major events due to backwater from Onkaparinga River up local pipe drainage.
- Christies Creek – upstream of Main South Road and Kentwood Road (d/s of Main South Road).
- Field River – numerous locations requiring pipe/culvert upgrades due to inadequate capacity.
- Sellicks/Silver Sands/Aldinga – minor event nuisance flooding due to lack of drainage infrastructure.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Infill/urban consolidation is not seen as a major issue for stormwater drainage capacity infrastructure. Biggest problems are with larger scale land developments but with master stormwater planning these issues are minimised. Major developments include Huntfield Heights and Seaford Rise. Smaller developments are occurring at Aldinga and Sellicks. Possible future redevelopment of Port Stanvac refinery.

Being a coastal Council, issues associated with long term sea level rise are a concern.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works – works subject to funding. Technical issues such as long term sea level rises are a future constraint.

What works are planned in the short term (5 yr outlook)?

Tonkin Consulting currently completing draft Stormwater Management Scoping Study for the whole Council. This will identify issues and areas to concentrate future catchment analysis and development of Urban Stormwater Master Plans. Council are currently spending $800 K per year for drainage upgrades, wetland management and watercourse erosion control projects.

What works are planned in the longer term?

Continue with works programme based on the outcomes of catchment analysis as recommended in the Scoping Study as funds become available.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Current requirement for redevelopment of large allotments into smaller allotments is to provide a rainwater tank (single module) connected to the garden/soakage pit or plumbed into the house (grey water). Council is very keen to further develop on-site detention and retention for larger developments.

Larger developments require detention (basins usually) to restrict post development flows to predevelopment flows. Master stormwater plans undertaken where possible (i.e Seaford Rise incorporating detention basins for minor and major flow control).

Council have approved smaller developments at Aldinga/Sellicks Beach with detention basins, however Council still yet to upgrade existing drainage infrastructure to 10 year ARI standard.

Does Council maintain any detention basins or flood retention dams?

Numerous detention basins for managing minor/major flows.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Council keen to further develop re-use schemes, particularly 'at source' on the allotment scale level. Council have only one small ASR scheme at Aldinga (Acacia Tce) used to irrigate surrounding vegetation. Council is currently investigating the potential for ASR at McLaren Flat wetland in partnership with the Onkaparinga Catchment Water Management Board. Other sites may be considered in due course subject to further feasibility analysis.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Mitcham – 23 February 2004

Andrew Ciric – City of Mitcham
Con Theodoroulakas – City of Mitcham
James Pannell – Kellogg Brown & Root
Scott Haynes– Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 4
- for major (1 in 20 to 1 in 100 year) events
  - rank 3

Areas along Brownhill Creek and Sturt River/Minno Creek are flood prone, particularly in major events.

What design period are your system capacities?

- minor system (piped system)
  - generally 5 yr ARI
- major system (creek system)
  - varies from say 20 yr up to 100 yr.

What is your target (ideal) system capacity?

- minor system
  - 5 yr ARI
- major system
  - 100 yr ARI

What are the current flooding hazard areas?

- excessive flow widths/nuisance flooding in roadways – area bounded by Cross Road/South Road, Daws Road, Goodwood Road, Angas Road, railway line
- cul-de-sacs with potential for overflows – steeper areas generally
- low spots/sags – numerous, scattered throughout area – overflow issue
- minor water courses in private property– defining a 'watercourse'

- Brownhill Creek – major event flooding of properties in Torrens Park/Kingswood
- Sturt River/Minno Creek – major event flooding along the watercourse

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

At this stage no major developments proposed other than Craigburn Farm second stage. Minor land developments up to 20 allotments and infill/urban consolidation will impact on capacity of drainage systems.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works – works subject to funding. Need to undertake cost/benefit analysis (particularly for larger drainage issues) to determine if an upgrade is worthwhile.

Political issues and increasing public awareness as stormwater/drainage is very low on peoples priority.

What works are planned in the short term (5 yr outlook)?

Continue more detailed drainage investigations in South Western Suburbs Drainage Scheme, Brownhill Creek and Sturt River/Minno Creek catchments to assess capacities in more detail and mitigation options. Investigate in detail the potential for flooding at downhill facing cul-de-sacs, low road side allotments and smaller watercourse flooding.

Council are considering increasing the drainage budget to undertake drainage works/upgrades (i.e $500-600K for funding such works over next few years). Works programme is not yet finalised.

What works are planned in the longer term?

Continue with works programme as funds become available.

Council is currently preparing a Strategic Plan which will include consideration to upgrade drainage systems, reduce erosion problems at drainage outlets, and improve water quality and watercourse mitigation and restoration measures. A Stormwater Infrastructure Study has been completed and is being reviewed for consideration in preparing an Urban Stormwater Master Plan.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Current requirement for redevelopment of large allotments into smaller allotments is to provide a 2000 L rainwater tank (single module) connected to the garden/soakage pit. A $400 rebate applies if your rainwater is plumbed into the house (grey water). Council want more work to be done on detention tank sizing/development prior to implementing as per recommendation by Planning SA. Council are very keen to further develop on-site detention/retention and water sensitive design solutions.

Larger developments (Blackwood Park) require detention basins to restrict post development flows to predevelopment flows.

The Stormwater Infrastructure Study identifies mitigation options which will be progressed as part of the Strategic Plan outcomes.

Does Council maintain any detention basins or flood retention dams?

Numerous detention basins at Blackwood Park for control of minor and major flows, Urrbrae wetland/detention basin, Frank Smith Reserve flood control dam and Claremont dam, Sturt River flood control dam.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Council are keen to further develop re-use schemes, particularly 'at source' on the allotment scale level.

There is currently an ASR project at Urrbrae Wetland.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Marion – 20 February 2004

Peter Fowler – City of Marion
David Melhiush– City of Marion
James Pannell – Kellogg Brown & Root
Scott Haynes – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 4
- for major (1 in 20 to 1 in 100 year) events
  - rank 3

What design period are your system capacities?

- minor system (piped system)
  - 2-50 year ARI (as per SWSDS review)
- major system (creek system)
  - varies considerably
  - some areas have 100 year ARI protection
  - some low spots in older areas have piped outlets through properties (appx 5 year ARI protection) with no overland flow path

What is your target (ideal) system capacity?

- minor system
  - 5 yr ARI
- major system
  - 100 yr ARI

What are the current flooding hazard areas?

- insufficient inlets and subsidiary pipes causing wide/nuisance flows (flatter areas);
- street flows going down driveways, particularly in one way cross fall roads at Hallet Cove, Seacombe Heights, Marino etc (steeper areas);
- isolated low spots causing significant ponding and private property inundation in major events;

- steep escarpment gullies – issues with filling, obstructions and maintenance. Lacks definition as to who is responsible (Council, catchment boards, private owner etc).

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

There is very little open space remaining for future residential development. Sheidow Park is almost complete.

The existing hazards will remain in the future until subsidiary drains built and inlets upgraded.

Main future flooding issues will be a result of infill development/urban consolidation at an individual allotment scale.

The largest areas for potential redevelopment (infill) across a number of allotments at a single time, are concentrated areas of South Australian Housing Trust ownership in Oaklands Park, Morphetville and Plympton Park.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works. Major flow protection is biggest issue.

What works are planned in the short term (5 yr outlook)?

Complete construction of unconstructed SWSDS lateral pipes and inlets. Add additional inlets to existing drains identified during review of SWSDS. Approx $700K to be spent each year on drainage upgrades.

What works are planned in the longer term?

Ensure completion of SWSDS works. Strategies for stormwater reuse to be explored and implemented.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

All new developments require consideration in both 5 and 100 year ARI design storms (i.e. shall not exceed the downstream capacity assuming full catchment development). Tables have been developed to limit stormwater runoff in 5 yr ARI to 0.25 ROC and 100 yr to 0.45 ROC for on-site (small) development.

Larger scale developments – require open space and encourage detention basins. Where detention basins not appropriate, oversized underground pipes with orifice outlets used (smaller developments i.e. 10-15 lots). In Sheidow Park there is no quantity restrictions put on the development because of the topography being too steep. Flood retention basins are constructed in gullies where possible to slow down water, more to minimise erosion rather that flow reduction.

Infill development- areas north of Seacombe Road have planning requirement to provide on-site detention if the roof area connecting to the street is greater than 30 % of allotment area. Different size tanks are specified for various allotment sizes.

Generally mixed public response regarding this requirement. Areas south of Seacombe Road have no requirement due to adequate pipe capacity.

Does Council maintain any detention basins or flood retention dams?

Numerous basins for control of minor and major flows (Mitchell Park and Sheidow Park) plus Warriparinga Wetland.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Council keen to look at re-use schemes. Not a great deal of available land/open space to implement wetland type systems, however potential for ASR scheme at Warriparinga Wetland could be investigated.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Holdfast Bay – 2 March 2004

Charles Sheffield – City of Holdfast Bay
James Pannell – Kellogg Brown & Root
Amanda Price – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - rank 2–3
- for major (1 in 20 to 1 in 100 year) events
  - Brighton rank 4
  - Glenelg rank 2

What design period are your system capacities?

- minor system (piped system)
  - up to 5 yr ARI (generally between 2 and 5 yr ARI)
- major system (creek system)
  - varies from say 20 yr up to 100 year

What is your target (ideal) system capacity?

- minor system
  - 5 year
- major system
  - 100 year

What are the current flooding hazard areas?

- Glenelg North – low lying area with drainage systems discharging into Patawalonga and Sturt River, influenced by tides.
- West of Brighton Road – coastal strip, immediately east of the dune system are low lying areas with limited outfall particularly in major events. There is also a lack of underground drainage (lateral systems) resulting in large surface flows along streets during minor events. The railway corridor also acts as a barrier and creates ponding during larger events.

- Gilbertson Gully – a number of residences have been constructed across Gilbertson Gully near Seacombe Road. Potential for inundation of these properties (and others north of Seacombe Road) in a major event.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

Future flood hazards are likely to be caused by infill/urban consolidation on the smaller allotment scale. There is very little opportunity for larger developments. Infill development will exacerbate the existing problems and flood hazards if not properly dealt with.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works – works subject to funding both from internal sources and external (State Government Stormwater Subsidy Scheme). Replacement of drainage systems due to ageing infrastructure will impact on what can be spent on new drainage and upgrades.

Technical issues such as long term sea level rises are a future constraint.

Availability of land for detention basins is very limited.

Sand movement (drain outfall blockages) is not predictable.

Politics – development controls upstream in Marion which are outside Holdfast Bay control.

Lack of awareness from the community on drainage issues meaning it is difficult to raise rates to fund projects. This is also partly due to the irregularity and low frequency of major flooding. However when it does happen the impacts are extreme from a social and financial aspect.

What works are planned in the short term (5 yr outlook)?

In 2001 Tonkin Consulting prepared a prioritised works programme for drainage upgrades and improvements. The value of works is estimated at $8.7 M and split into four categories. Council do not have a clear programme for stormwater upgrades as it is very dependent on funding. It is likely that only 3 or 4 projects will be completed in the next few years (including Gilbertson Gully flood control dam and Pier Street pipe upgrade).

What works are planned in the longer term?

Continue with works programme as outlined in 2001 Tonkin report.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Residential infill developments require the developer to manage stormwater discharge on –site. For coastal areas on sandy soils this can be discharged into the soil system, or otherwise required to install a 1000 L rainwater tank. Council are possibly looking at implementing financial contributions in lieu of rainwater tanks.

For larger scale developments there is no criteria or strategy for flow management in the development plan as there are very few opportunities for larger developments. Council would probably impose post flow control to pre development levels.

Does Council maintain any detention basins or flood retention dams?

None at present. Currently designing Gilbertson Gully flood control dam.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Council keen to further develop re-use schemes, particularly some of the coastal parks. Council currently use reclaimed water from Glenelg sewerage treatment plant along Glenelg North foreshore. Possible wetland sites at Gilbertson Gully, Bowker Street Reserve, Brighton Oval.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with Town of Gawler – 19 February 2004

Terry Spurling – Town of Gawler
James Pannell – Kellogg Brown & Root
Amanda Price – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- For minor (nuisance) events (say up to 1 in 5 year event)?
  - rank 2–3.
- For major (1 in 20 to 1 in 100 year) events?
  - rank 2.

What design period are your system capacities?

- Minor system (pipes)
  - 2–5 year ARI.
- Major system (overflow paths)
  - varies considerably—some areas have no major flow protection, some areas have 100 year ARI protection.

What is your target (ideal) system capacity?

- Minor system (pipes)?
  - 5 year ARI
- Major system (overflow paths)
  - 100 year ARI.

What are the current flooding hazard areas?

- Gawler River – major flooding issues due to major events (100 year ARI and greater). Lang Dames report identifies flood plain levels.
- Older areas of Gawler with very little street drainage infrastructure (both minor and major drainage issues). Some roads are narrow, steep cross fall and therefore have limited carrying capacity, often with driveways on low sides of roads. Upgrades of pit and pipe systems recommended in Kinhill report.

- Poorly planned developments where buildings are close to creeks, some older buildings are over watercourses.
- Flatter areas in upper catchment of Smith Creek (Munno Para Outfall) have no defined drainage channels. Channel works recommended in BC Tonkin (1998) report.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

- South-western area of the town centre where larger scale land developments are occurring. These areas have fairly large upstream catchments and are also developing, however no assessment of major flows has been undertaken to date.
- Some levee banks have been built along Gawler River since last major floods. The effect of these obstructions is unknown and likely to impact upstream.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Cost of works biggest issue. Council has other short-term priorities (Murray Street upgrade). Land availability is not a major issue as there is plenty of open space to work with.

What works are planned in the short term (5 year outlook)?

- Study of Gawler township undertaken in 1991 by Kinhill focussing on four strategic areas. Only some of the proposed work has been implemented.
- 1–2 year—Council is keen to develop better stormwater management and planning objectives to minimise flooding. Possibility to undertake an Urban Stormwater Master Plan and update previous Kinhill report. Gawler River flood plain mapping needs to be reviewed based on upstream flood control dams.
- 2–5 year—commence implementing some of the works as funds become available.

What works are planned in the longer term?

Unable to say exactly until clearer and updated stormwater management strategy is completed. All works proposed to date are likely to be required as a minimum.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

On larger scale developments, developers are required to provide usable open space and areas are encouraged to be set aside for detention basins.

Stormwater discharge is expected to complement the existing minor and major flow capacities of the downstream system.

For smaller infill/consolidation developments, required to limit post development Q100 discharge to the same as predevelopment Q5 discharge OR provide a financial contribution.

Does Council maintain any detention basins or flood retention dams?

Council has three or four existing detention basins. The capacity of the older basins are unknown, however one or two newer ones have been constructed for larger land divisions for minor flow reduction.

More detention basins are proposed for new land developments and possibly within the Gawler Racecourse.

A significant flood control dam is proposed south-west of the Gawler township.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

Potential wetland proposed within Gawler Racecourse for ASR purposes. Council is keen to implement a stormwater reuse scheme for watering/horticultural and community purposes. There is insufficient industry demand for such a scheme.

Metropolitan Adelaide Stormwater Management Study
Part A – Audit of existing information

Meeting with City of Unley – 8 March 2004

Chris Tually – City of Unley
Bill Lipp – Transport SA
Anthony Bowman – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - 4 for the local network system
- for major (1 in 20 and above) events
  - 4 for the local network system
  - 1 for the creek systems

What design period are your system capacities?

- local system (piped system)
  - approximately 10 year
- major system (creek system)
  - varies along length of creeks.

What is your target (ideal) system capacity?

- minor system
  - 10 year
- major system
  - 50 year

What are the current flooding hazard areas?

Brownhill Creek, Glen Osmond Creek, Parklands Creek. Significant portions of the creek systems are within private property.

Short duration, high intensity events cause problems in the Unley, Parkside and Wayville areas. Problems in the local system network are generally related to creek system surcharge.

Areas in Myrtle Bank and Fullarton, and in particular Glen Osmond Road, Fullarton Road and Kenilworth Road require additional piped systems. These systems cannot be installed until the South Parklands detention system is agreed and installed.

In the long term, and given recent development trends, what are likely to be the future flooding hazard areas?

At present, the creek systems are below satisfactory capacity whereas the local systems are functioning adequately. Infill development is impacting on system capacities, marginally on the local piped system, but is having a major impact on the creek systems. House improvement works (extensions, paving, etc) impacts on the system, but not as significant as infill development. 10 year ARI design period is based on 35% equivalent Impervious Area (EIA); this is being compromised by infill development. Current design is taking into account the increased impervious areas.

Ministerial PAR proposing a corridor 10 m each side of the creeks as non-complying development zone is also of concern.

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Agreement between Councils on flood mitigation standard of protection, cost sharing principles and priority of works.

What works are planned in the short term (5 yr outlook)?

Continuing to install local piped systems as per 1978 BC Tonkin Report (1998 revision – plans current to 2001).

Preparation of an Urban Stormwater Master Plan (USMP). Council has sought detail from, and wishes to work in concert with the Patawalonga Catchment Water Management Board. No response to date.

What works are planned in the longer term?

Major channel improvement works for the creeks.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

Council prefers to adopt a 'whole of catchment' approach, rather than being council boundary focussed.

Local piped systems are being installed based on priority works list with the exception of the Myrtle Bank and Fullarton areas as discussed previously.

Council has a flood response plan.

Does Council maintain any detention basins or flood retention dams?

No, insufficient land available on a large scale for stormwater detention/retention.

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

No, generally insufficient land available for capture works.

Metropolitan Adelaide Stormwater Management Study Part A – Audit of existing information

Meeting with City of Tea Tree Gully – 1 March 2004

David Murray – City of Tea Tree Gully
Paul Matthews – City of Tea Tree Gully
Nathan Silby – Kellogg Brown & Root
Scott Haynes – Kellogg Brown & Root

Generally, how does your stormwater network perform (rank 1 = very poor, 5 = no problems)

- for minor (nuisance) events (say up to 1 in 5 year event)
  - There has been minimal rain events within the City of Tea Tree Gully since the recent 'explosion' in the housing industry. The minor stormwater system is therefore given an average score of 3.
- for major (1 in 20 and above) events
  - A detailed investigation of the existing infrastructure is required to determine how the stormwater network would perform.

What design period are your system capacities?

- The minor pipe system has not been designed using one storm event. Design periods for the minor system would include 1 in 5, 1 in 10 and 1 in 20.
- The major system (overflow paths) has not been designed using one storm event. Design periods for the major system would include 1 in 20, 1 in 50 and 1 in 100.

What is your target (ideal) system capacity?

- The minor system (pipes), subject to the density of development, is generally 1 in 10. High density development i.e. Golden Grove 1 in 20.
- The major system (overflow paths) is generally 1 in 100 – If the adjacent land use is for Emergency Service Agencies (Police, Fire Brigade etc), Essential Services (Gas, Water, Electricity, Telephone etc) and Aged Care Facilities then the system design parameter is 1 in 200 – If the adjacent land use is for Hospitals and Civil Defence then the system design parameter is 1 in 500.

What are the current flooding hazard areas?

Potential flooding hazard areas area as follows: -

- Properties
  - Orange Grove Circuit

- Atlas Court
- Casurina Street
- Elizabeth Street
- Valley Road opposite the Shell service station
- Littler Drive
- Conifer Place
- Zephyr Court
- Reynolds Street
- 404 Grenfell Road
- Valley View Drive
- Ferrier Avenue

- Roads
  - Valley Road/Beckman
  - Milne & M^c^Ewin roads
  - Kelly road (access roads)
  - Grenfell & Haines roads
  - Seaview Road (unnamed road)
  - Heitman Court
  - Woona Court
  - Mulkarad ford
  - Peppermint Grove
  - Turtur Court
  - Elliston Road

Council have budgeted to undertake flood mapping throughout the Council it is hoped that this will identify potential flooding hazards.

In the long-term and given recent development trends, what are likely to be the future flooding hazard areas?

A flood study and flood plain mapping indicating flooding hazard areas was previously undertaken in 1980. An updated study of the flood hydrology followed by development of floodplain maps is proposed for the 2004/2005 and 2005/2006 subject to funding from:

- City of Tea Tree Gully.
- Salisbury Council.
- Commonwealth Funds (NDRMSP).

- State Funds (CMSS);
- Northern Adelaide and Barossa Catchment Water Management Board.

The future flooding hazard areas shall be identified from the above mentioned for the following events: -

- 20 year Average Recurrence Interval (ARI) flood;
- 50 year ARI flood;
- 100 year ARI flood;
- 500 year ARI flood;

Probable Maximum Flood (PMF)

What are the significant constraints to achieving long term flood protection? (cost, land availability, etc)

Funding and budgetary constraints: Numerous applications have been made to the Catchment Boards and the Department of Water Land & Biodiversity Conservation to assist with development of stormwater management and other strategies.

Land availability: Council is going through compulsory acquisition along Dry Creek. A recently completed property acquisition was Kelly road, Modbury.

Conflicting budgetary priorities: Long-term financial plans include significant investment in stormwater.

Time constraints:

What works are planned in the short term (5 yr outlook)?

As per Council's Strategic Plan and the Draft Water Management Strategy: –

ASR schemes: Banksia Park and Golden Grove areas

Creek rehabilitation including weirs, detention ponds and wetlands, and upgrading stormwater drainage: Modbury Heights and Wynn Vale Dam.

What works are planned in the longer term?

As per Council's Strategic Plan and the Draft Water Management Strategy (In addition, we require a full assessment of the minor and major stormwater systems to determine upgrading requirements).

There are eight other reaches of Dry Creek and several reaches of Cobbler Creek planned in the longer term. Wetlands are planned within the reach from Main North road to Main North East road. ASR schemes are planned for the southern side of the City of Tea Tree Gully.

Does Council have a flood mitigation strategy, either at the large scale or at individual allotment scale?

At individual allotment scale: - Onsite Detention tanks are a requirement of the Development Plan.

On the larger scale: - Council is undertaking flood mitigation works within Dry Creek and Developers are required to consider and incorporate flood mitigation works, detention basins/wetlands within subdivisions.

Does Council maintain any detention basins or flood retention dams?

Council maintains a number of detention basins within its reserves. The locations of these structures are as follows: -

- Atlantis Drive
- Middleton Court
- Valour Court
- Edinburgh Reserve
- Gifford Reserve
- M^{c}Kinley Court
- Kingfisher/Kestral Way
- Legacy Court
- Ardtornish
- Behind Glider Roll
- Wright Road/North East Road
- Rodgerst
- Awoonga/M^{c}Donnell
- Casurina/Illyarrie
- Torrens – Linear Park
- Reuben Richardson Road (Petworth Lakes)
- Braeburn
- Lake Eyre
- Out Door Class Room
- Grass Lands
- Wynn Vale Dam (Park Lake Drive)
- Golden Way (Greenwith Oval)
- Mahogany
- Civic Park
- M^{c}Cann
- M^{c}Leod
- Lake Ridge Court

- Lady Wood Reserve
- Illyarrie Oval
- Wicks Estate

Is there the opportunity and are stormwater re-use projects being considered within the Council area?

There are a number of opportunities for stormwater re-use projects within the Council area.

The City of Tea Tee Gully is currently managing two stormwater programmes that are focused on sustainability and water re-use. Drilling of extraction wells and the use of underground water for irrigation purposes has commenced as part of the first stage of a series of aquifer storage and recovery (ASR) schemes. Stormwater harvesting and treatment within wetlands has commenced and is aimed at improving water quality for recharging the underground fractured rock aquifers.

Extraction wells have been located at Tilley Reserve, Harpers Field, Solandra Reserve, Satsuma, Greenwith Oval and Tea Tree Gully Golf Club. All these sites are potential ASR sites.

Wetlands have been constructed in Milne and Golden Grove Roads, Grenfell and Golden Grove Roads, Dawson Reserve and Edinburgh Reserve.

Appendix C

SUMMARY OF CURRENTLY IDENTIFIED OUTSTANDING DRAINAGE AND FLOOD MITIGATION PROJECTS

Metropolitan Adelaide Stormwater Management Study—Summary of currently identified outstanding drainage and flood mitigation projects

Airport Drain, Cowandilla—Mile End Outfall

- major system outfall channel works are well defined, commencing 2004–2005
- generally flat areas with localised flooding, works considered high priority
- estimated cost of outstanding works $6 million (currently $2 million funding available).
- minor system pipe works in Cowandilla area are well defined with localised flooding. Works considered a medium priority with estimated cost of outstanding works $1.2 million.

Christie Creek Catchment

- major system channel upgrade and construction of flood control dams (3 proposed of which funding is allocated)
- scope well defined
- works considered medium priority
- estimated outstanding cost of channel works $0.8 million. Scope of required works is currently being reviewed by the Council.

Dry Creek Catchment

- major system road culvert upgrades and channel improvement works at a number of location in the catchment
- scope well defined and higher priority works completed
- works generally lower priority
- combined estimated cost of outstanding works $3 million.

Field River Catchment

- major system culvert upgrades and channel works at a number of locations
- scope of works reasonably well defined
- works considered low priority
- estimated cost for outstanding works $1.2 million.

Gawler River Catchment, Gawler Township

- minor system pipe upgrades and detention basins
- works considered medium priority as a rapid rate of development has occurred in recent years
- estimated outstanding cost of works $1.1 million.

Hargrave Street Catchment (Birkenhead)

- minor system pipe upgrade to prevent current localised flooding in a flat low lying area
- scope well defined
- works considered medium priority
- works planned to commence 2005
- allocated cost of outstanding works $1.7 million (currently $ 0.8 million available).

Hart Street Catchment (Ethelton)

- minor system pipe upgrade and pumping station upgrade to address localised flooding
- works well defined and considered medium priority
- works commenced in 2002—2003
- estimated outstanding cost $2 million.

Hindmarsh, Enfield, Prospect (HEP) catchment

- major system outfall channel upgrade and minor system pipe upgrades
- higher priority on outfall and lower priority on minor system
- scope well defined and understood
- estimated cost of outstanding works $6 million.

Keswick Creek and Brown Hill Creek Catchments

- major system channel upgrades, detention storage, flood control dams and flow diversions into adjacent catchments proposed
- flood hazards well documented
- widespread flooding in major events, localised flooding in minor events
- scope not well defined with four 'engineered' options recently investigated
- works considered high priority
- estimated cost of works range between $72 million and $88 million for 'engineered solution' although optimum standard or solution is yet to be identified and a lower overall cost is possible

- estimated costs for 'riverine' solution range up to $150 million (includes allowance for land acquisition)
- minor system pipe upgrades are well defined and works considered medium priority. Estimated cost of outstanding minor system works $0.9 million.

Little Para Catchment

- major system road culvert upgrades and channel improvement works
- scope well defined
- works generally lower priority
- estimated cost of outstanding works $0.5 million.

Meakin Terrace-Trimmer Parade Catchments

- minor system diversion pipe works required to address current low standard of the minor system
- high potential urban consolidation (infill development)
- scope of works well defined
- works considered high priority
- estimated cost of works $5 million.

North Arm East Catchment

- major system outfall channel upgrade and minor system pipe upgrades
- minor system works generally lower priority works
- outfall system should be of higher priority
- scope well defined and understood
- estimated cost of outstanding works $5.5 million.

Pedlar Creek Catchment

- minor system pipe upgrades and major system channel works
- works generally low priority
- estimated cost of works $1 million.

Port Road Catchment

- major and minor system pipe and open channel infrastructure upgrade
- required scope not well defined to date
- regular flooding of property
- works considered high priority
- estimated cost of works $13.2 million.

Sellicks, Aldinga, Maslins, Silver Sands and Willunga

- minor system pipe upgrades and major system channel works
- works generally low priority
- estimated cost of works $1.5 million.

Smith Creek—Helps Road Catchment

- both minor and major system pipe and channel upgrades at numerous locations throughout developed (upper) and developing sections of the catchment
- scope in developed areas well defined
- approximate cost $5 million (allowance only, costs not estimated to date)
- Munno Para Outfall Drain—major channel works required to cater for future development. Aproximate cost $24 million, however its need will be dependent on future development (i.e. currently not required).

Torrens River Catchment, St Peters

- minor system pipe upgrade
- works considered low priority
- estimated cost of works $0.5 million.

Torrens River Catchment, First and Second Creeks

- minor system pipe upgrades and major system channel works
- minor system works considered low priority, with higher priority to major system works
- estimated cost of works $0.6 million.

Torrens Road—Grey Terrace Catchment (Port Adelaide)

- minor system pipe upgrades
- scope of works required well defined
- works considered low to medium priority
- estimated cost of outstanding works $1.2 million to be staged over a number of years.

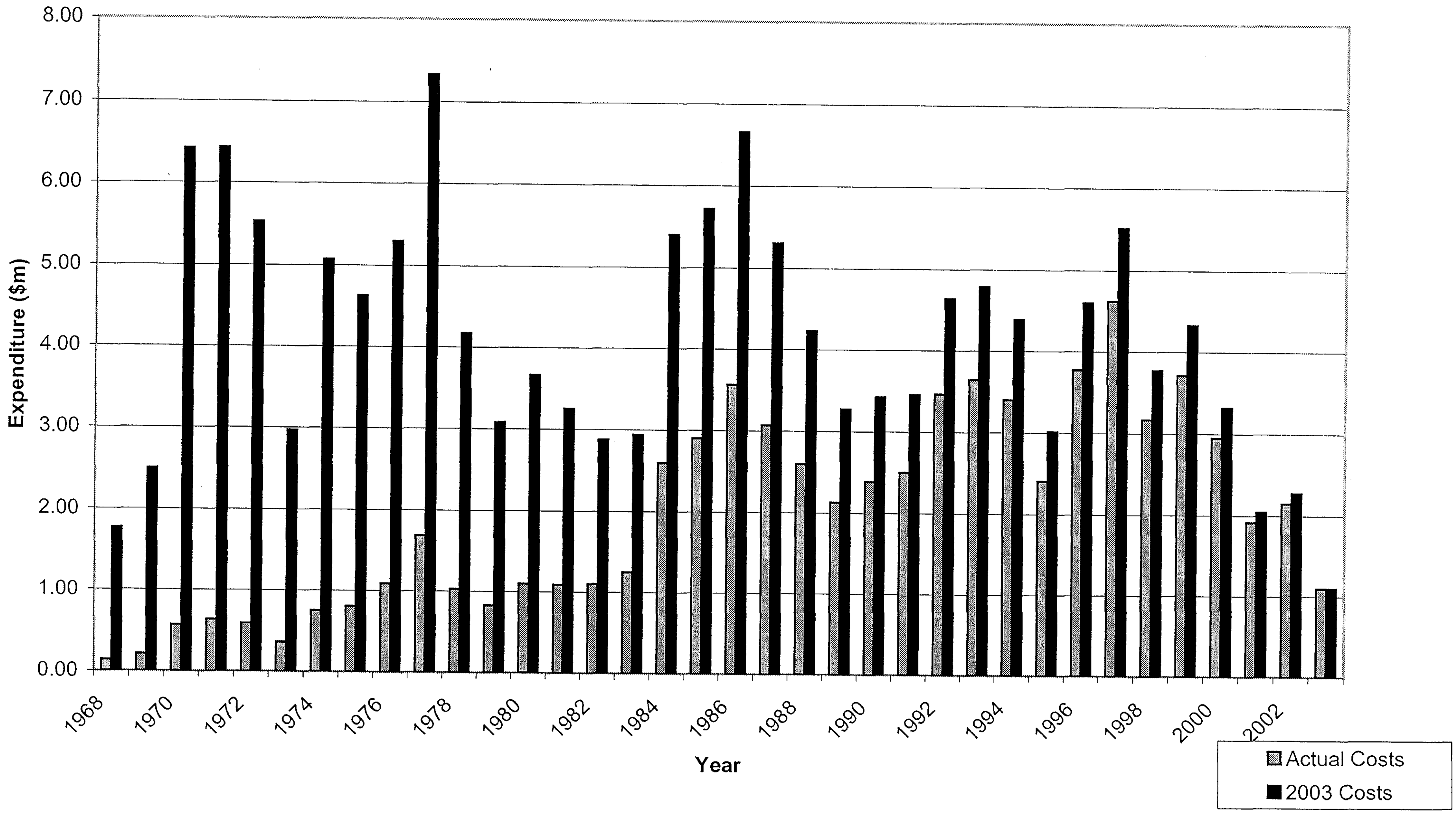
Wellington Street Catchment (Port Adelaide)

- minor system pipe upgrade to address localised flooding
- works well defined and considered medium priority
- estimated cost of outstanding works $1.7 million (currently $ 0.8 million available).

Appendix D

CATCHMENT MANAGEMENT SUBSIDY SCHEME HISTORICAL FUNDING

Appendix D - Catchment Management Subsidy Scheme Historical Funding



Appendix E

CATCHMENT MANAGEMENT SUBSIDY SCHEME IDENTIFIED PROJECT LIST AND OUTSTANDING COSTS

APPENDIX E - CATCHMENT MANAGEMENT SUBSIDY SCHEME IDENTIFIED PROJECT LIST AND OUTSTANDING COSTS

Catchment/Study Area	Council	Year/Source	Subsidy Costs ($K) Remaining (half total costs)	Comments
Airport Drain - Cowandilla/Mile End [2]	City of West Torrens	Tonkin (1986)	$3,600	Trunk drainage provision and upgrade of outfall channel to Barcoo Outlet
Christie Creek [4]	City of Onkaparinga	B.C. Tonkin (1995)	$400	Channel upgrades for major flow protection
Christie Creek - Three Flood Control Dams [1]	City of Onkaparinga	B.C. Tonkin (1995)	$0	Detailed design being undertaken
Drain 10 - Gilbertson Gully Flood Control Dam [1]	City of Holdfast Bay	Tonkin (2001)	$0	100 year ARI flow control. Detailed design being undertaken.
Drain 15 B - Pier Street, Glenelg [1]	City of Holdfast Bay	Tonkin (2001)	$0	Major flow (10-20 yr ARI) pipe system. Detailed design being undertaken.
Dry Creek	City of Tea Tree Gully, City of Salisbury	PPK (1997), B&R (2001)	$1,500	Numerous culvert upgrades and channel works on tributary creeks
Field River	City of Onkaparinga	B.C. Tonkin (1998)	$600	Exact subsidy costs not quantified. Estimate based on Bill Lipp (2001) spreadsheet
Gawler River - Gawler Township	Town of Gawler	Kinhill (1991)	$550	Detention basins and pipe upgrades
Hargrave Street [3]	City of Port Adelaide Enfield	Botting (1997)	$850	Pipe upgrades. Work to be staged over a number of years
Hart Street	City of Port Adelaide Enfield	Kinhill (1999)	$1,000	Carlisle St to Swan Tce pipe upgrade incomplete. Rising main & supply of pumps not done
Hindmarsh-Enfield-Prospect (HEP)	City of Port Adelaide Enfield	B.C. Tonkin (1985)	$3,000	Based on 50 % of outfall works incomplete. Subsidiary upgrades complete.
Keswick Creek - local underground drains	City of Unley	Tonkin (1978, 1998)	$450	Minor drain upgrades - Glen Osmond Road, Wattle Street, Goodwood Road, Parker Terrace
Little Para River	City of Salisbury	B&R (2001)	$250	Numerous culvert upgrades
Meakin Terrace - Crittenden Road diversion (part)	City of Charles Sturt	Tonkin (2001, 03)	$1,800	Crittenden Road diversion
North Arm East	City of Port Adelaide Enfield	B.C. Tonkin (1995)	$2,750	Outfall, Marmiom Drive, Milton Ave
Pedlar Creek - McLaren Vale	City of Onkaparinga	Kinhill (1987)	$200	Minor channel and pipe upgrades
Pedlar Creek - Seaford Residential Development	City of Onkaparinga	Kinhill (1991)	$300	Exact subsidy costs not quantified. Estimate based on Bill Lipp (2001) spreadsheet
Port Road	City of Charles Sturt, City of Port Adelaide Enfield	Arup (2000)	$6,600	Assumed 50 % of estimated works applicable for subsidy
Sellicks, Aldinga, Maslins, Silver Sands and Willunga	City of Onkaparinga	Kinhill (1986,87,88, 95)	$750	Numerous pipe, channel upgrades
Smith Creek/Helps Road - Developed area	City of Playford	B.C. Tonkin (1991, 1998)	$2,500	Exact subsidy costs not quantified. Estimate based on Bill Lipp (2001) spreadsheet
Torrens River - First & Second Creek	City of Norwood, Payneham & St Peters	B.C. Tonkin (1982)	$300	Minor drainage works
Torrens River - St Peters	City of Norwood, Payneham & St Peters	Tonkin (1999)	$250	Minor drainage works
Torrens Road - Gray Terrace	City of Port Adelaide Enfield	Maunsell (2002)	$600	Work to be staged over a number of years
Trimmer Parade - Crittenden Road diversion (part)	City of Charles Sturt	Tonkin (2001, 03)	$700	Diversion of flow out of Trimmer Parade catchment into Meakin Terrace
Wellington Street [3]	City of Port Adelaide Enfield		$850	Work to be staged over a number of years
		TOTAL SUBSIDY	$29,800	
		TOTAL PROJECT COST	$59,600	

[1] Design underway, full funding available for construction

[2] Approximately 30 % of funding available for design & construction of outfall channel to Barcoo Outlet

[3] $800 K funding available for for 2005

[4] Scope of work curmetly being reviewed

Costs indicated are those that have not yet been allocated/approved
For full details and assumptions of cost estimates refer to reports
Costs exclude land acquisition
Costs have been inflated to 2004 $ using Rawlinsons construction price index
All costs are based on those found in the relevant reports. No assessment of the assumptions used in the reports have been undertaken.
Costs exclude GST

Appendix F – Council Development Plan Analysis

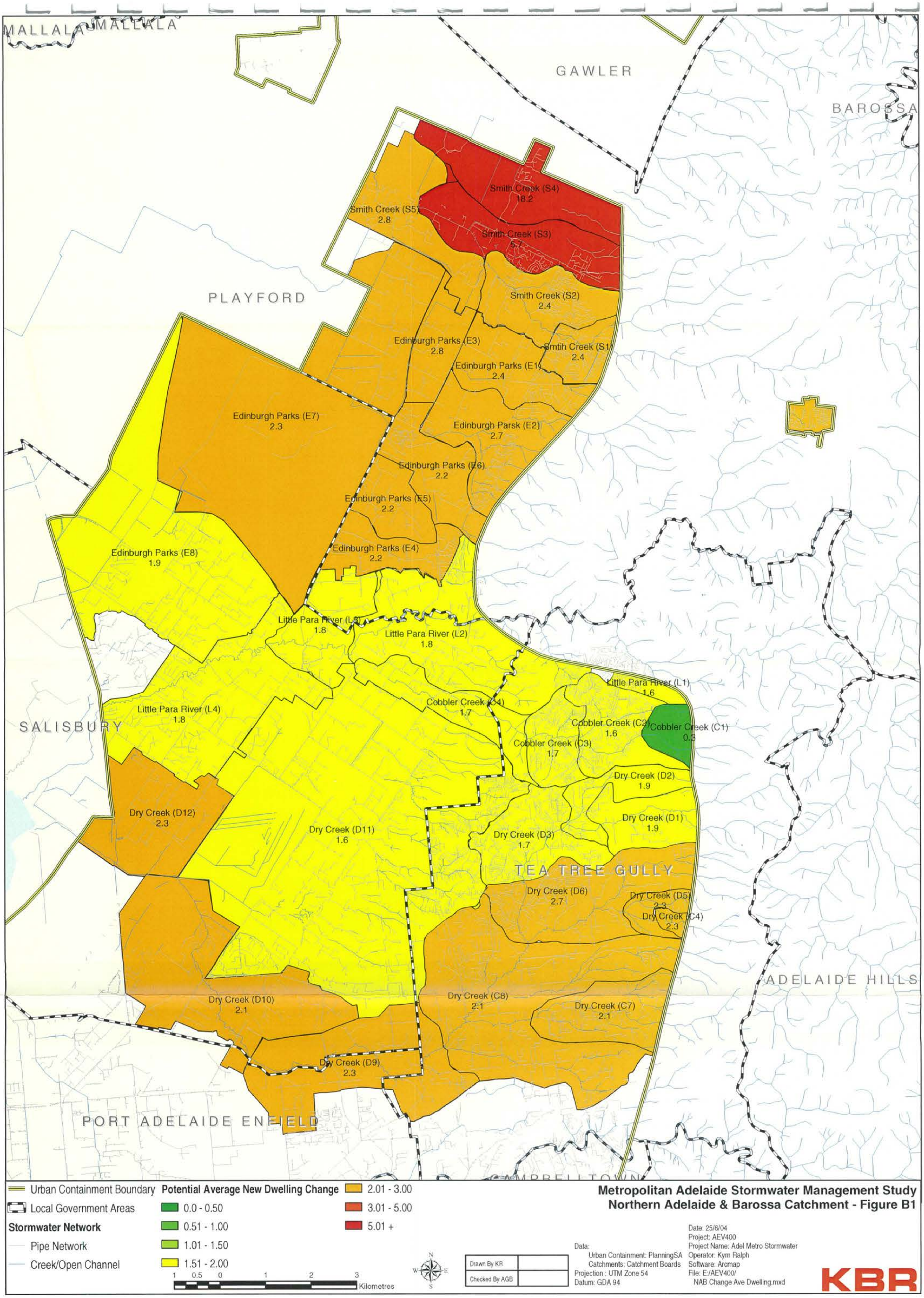
Council	Development Plan references	Recommendations
City of Salisbury	Stormwater management is addressed in an ad hoc manner throughout the Council's Development Plan. The plan details stormwater principles of development control in the city wide section. The plan does not include any specific city wide stormwater management objectives. The plan is now becoming somewhat outdated given it's reference to criteria set out in the Australian Model Code for Residential Development – Edition 2 – November 1990 and needs to be amended to include information from the recent Stormwater PAR/Bulletin.	Consolidate plan to take into consideration the Stormwater In Urban Areas PAR (Ministerial). Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Tea Tree Gully	The Development Plan was consolidated in January 2003 to take into consideration the Stormwater In Urban Areas PAR (Ministerial). The plan details specific stormwater objectives in the city wide section. Stormwater is covered in the principles of development control in the city wide section of the plan which details design techniques to illustrate a way of addressing the individual principles. In addition, the plan sets out a design criteria for stormwater management which need to be adhered to in terms of complying development.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
Town of Gawler	Stormwater management is addressed is an add hoc manner throughout the city wide section of the Development Plan. Principles of development control relating to stormwater are found under the general heading of Water.	Consolidate plan to take into consideration the Stormwater In Urban Areas PAR (Ministerial). Stormwater management should be listed as a separate section ie not under Water. Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Mitcham	The Development Plan was consolidated in June 2003 to take into consideration the Stormwater In Urban Areas PAR (Ministerial). The plan details stormwater objectives in the city wide section. The Plan's principles of development control are separated from the plan's objectives and those relating to Stormwater Management and flooding are addressed collectively. In addition, the plan includes a set of design criteria for stormwater management which needs to be adhered to in terms of complying development.	Stormwater management should be separated out from flooding and objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Holdfast Bay	The Development Plan was consolidated in December 2002 and now takes into consideration the Stormwater In Urban Areas PAR (Ministerial). The plan addresses Stormwater under the Environmental objectives of the plan and the principles of development control relevant to stormwater are grouped under Conservation.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Norwood, Payneham & St Peters	The Development Plan was consolidated in October 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). The plan details specific objectives for Stormwater Management and groups these with the relevant Stormwater Management principles of development council in the city wide section of the plan. Well set out and easy to locate.	

City of Marion	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial).The plan details stormwater management objectives in the city wide section of the plan. The principles of development control relating to Stormwater management are listed in the city wide section, however they do not appear to be as detailed as other development plan's who has also incorporated the PAR changes.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference. Design techniques to address principles could be included to assist applicants.
City of Prospect	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). The Plan details Stormwater Management objectives in the city wide section of the plan. The principles of development control relating to Stormwater management are listed separately in the city wide section.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Burnside	The Development Plan was consolidated in December 2002 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). Stormwater Management is addressed in the City wide section of the Plan under the Utilities and Infrastructure section. Specific stormwater objectives and principles of development control, including design techniques, are grouped under this sub heading..	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Playford	There are no specific Stormwater Management objectives listed in the city wide section of the plan. However, Principles of Development Control are listed with associated performance criteria and design techniques are major and minor stormwater systems.	Consolidate plan to take into consideration the Stormwater In Urban Areas PAR (Ministerial). Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Campbelltown	The Development Plan was consolidated in December 2002 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). Stormwater Management is listed as a separate section under the broader Environmental section in the City wide section of the Plan. The objectives and principles of development control are grouped together are highlighted specific design techniques to address the criteria.	
City of Port Adelaide Enfield	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). Specific stormwater objectives are listed in the city wide section of the plan, with the principles of development control located in a separate section within the city wide section. Specific design techniques to address the design critera are included with the principles of development control.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
Adelaide City Council	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). No specific detailed stormwater management objectives are listed in the city wide section of the Plan. The principles of development control and related design techniques are separately addressed in the city wide section of the plan.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.

City of Charles Sturt	Stormwater Management principles of development control for major and minor systems are listed upfront in the 'general' introductory section of the plan. The plan details specific objectives for Stormwater Management and groups these with the relevant Stormwater Management principles of development council in the city wide section of the plan. Well set out and easy to locate.	
Adelaide Hills Council	The Development Plan was consolidated in December 2002 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). There are no specifically detailed stormwater management objectives in the city wide section of the plan. The principles of development control and related design techniques are separately addressed in the city wide section of the plan.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of West Torrens	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial).The objectives and principles of development control relating to Stormwater management are grouped together, with the design techniques for satisfying the criteria. This is under the collective broader heading of Public Utilities are is well set out and easy to locate.	
City of Unley	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). The Principles of Development control relating to stormwater management are listed upfront in the city wide section of the plan including the performance criteria and design techniques.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.
City of Onkaparinga	The Development Plan was consolidated in November 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). Objectives and principles of development control and grouped together in the city wide section of the plan under the heading of Water management. It may be more useful to separate out the stormwater management specific comments in the plan. This includes performance criteria and design techniques.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management and removed from the broader heading of water management for ease of reference.
City of Walkerville	The Development Plan was consolidated in January 2003 and takes into consideration the Stormwater In Urban Areas PAR (Ministerial). The objectives relating to Stormwater Mangaement are listed upfront in the city wide section of the plan. The principles of development control and design techniques and criteria are included separately in the city wide section of the plan.	Stormwater Management objectives and principles of development control should be grouped together under the heading of stormwater management for ease of reference.

Appendix G

CATCHMENT PLANS DEPICTING POTENTIAL DWELLING INCREASES

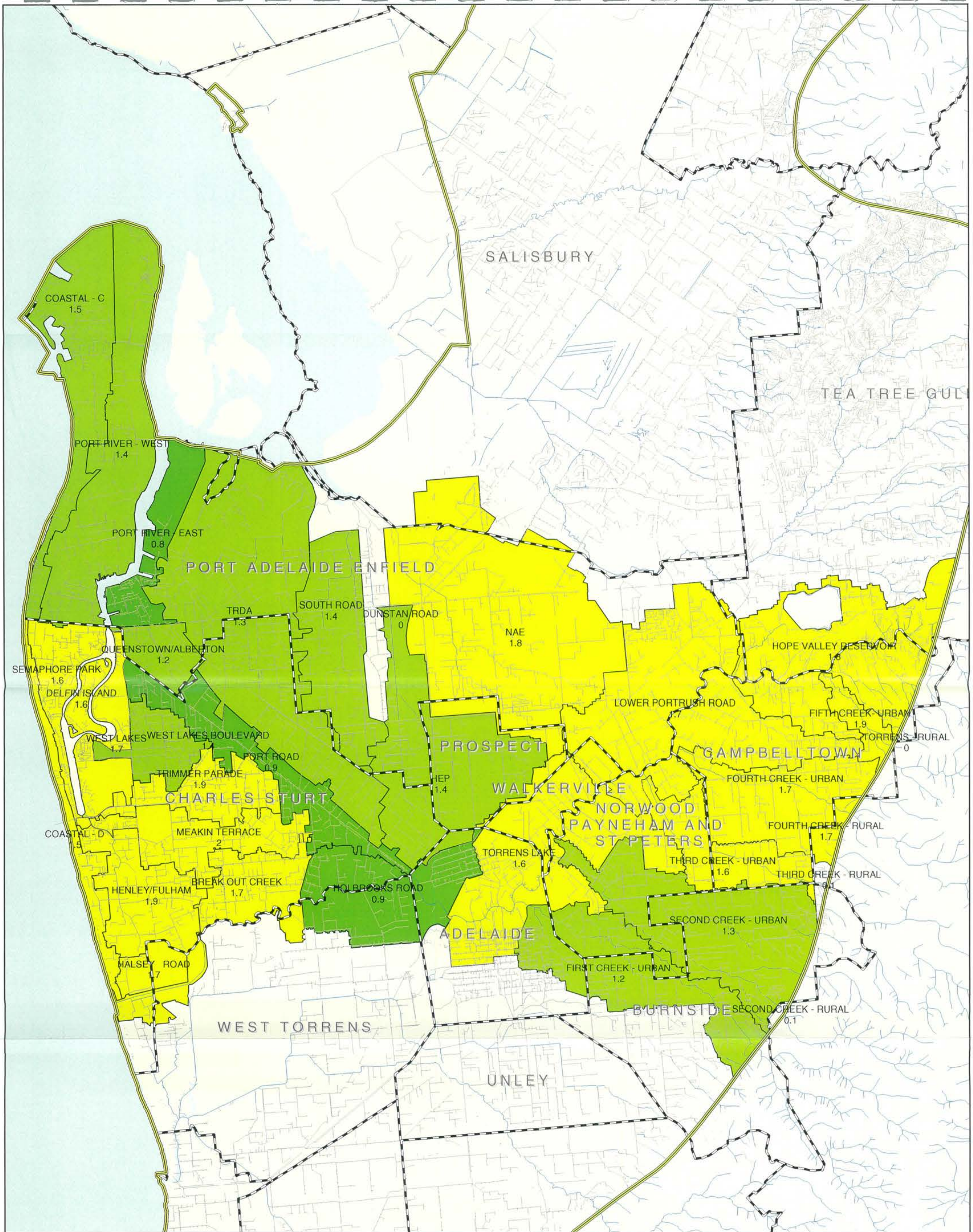


Metropolitan Adelaide Stormwater Management Study
Northern Adelaide & Barossa Catchment - Figure B1

Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94

Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
NAB Change Ave Dwelling.mxd

KBR



	Potential Average New Dwelling Change	
Urban Containment Boundary	0.0 - 0.50	2.01 - 3.00
Local Government Areas	0.51 - 1.00	3.01 - 5.00
Stormwater Network	1.01 - 1.50	5.01 +
Pipe Network	1.51 - 2.00	
Creek/Open Channel		

1 0.5 0 1 2 3 4 Kilometres

N S E W

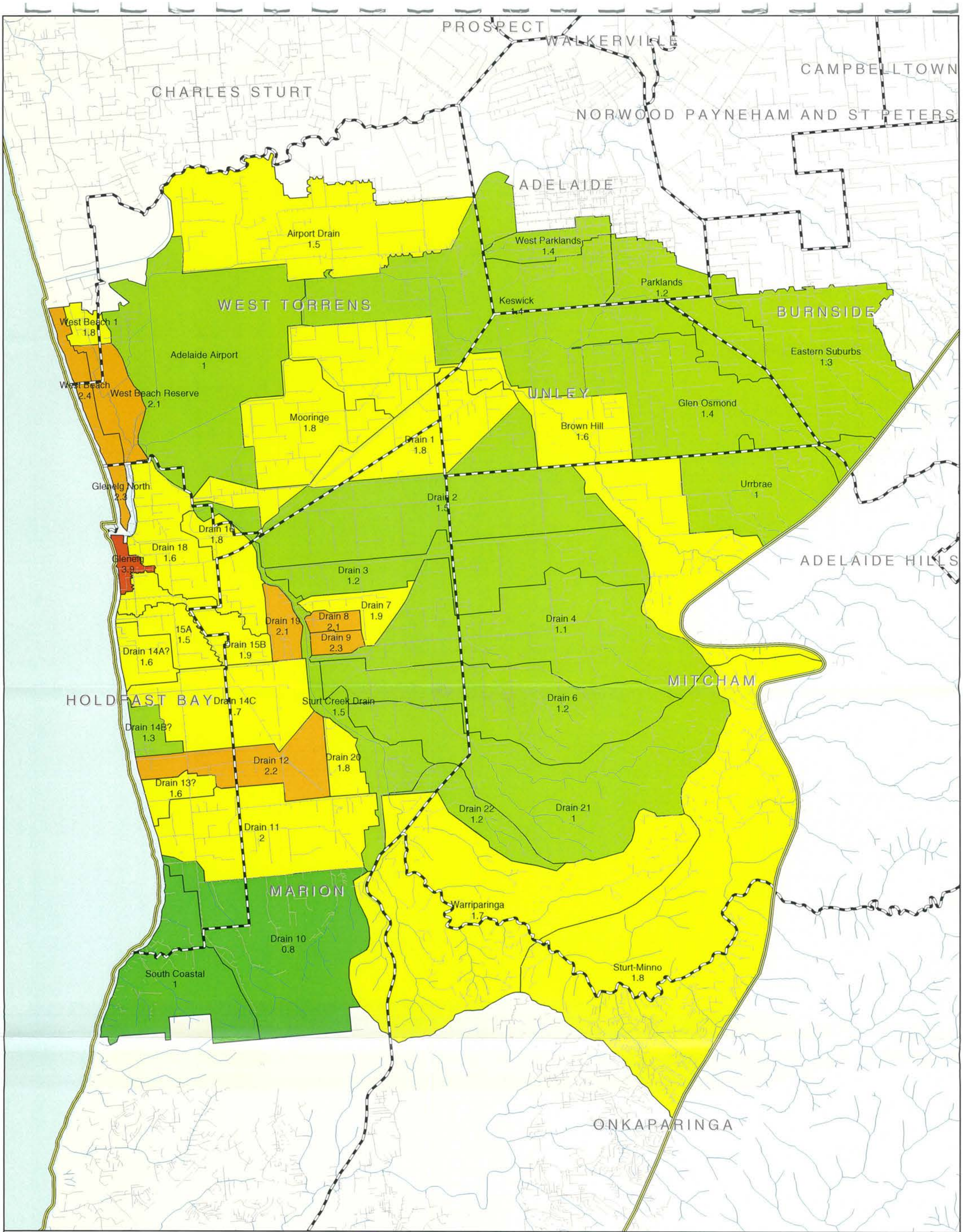
Drawn By KR
Checked By AGB

Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94

Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
TCWMB Change Avg Dwelling.mxd

Metropolitan Adelaide Stormwater Management Study
Torrens Catchment - Figure B2

KBR



Urban Containment Boundary
Local Government Areas
Stormwater Network
Pipe Network
Creek/Open Channel

Potential Average New Dwelling Change
- 0.0 - 0.50
- 0.51 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 3.00
- 3.01 - 5.00
- 5.01 +

1 0.5 0 1 2 Kilometres

N E S W

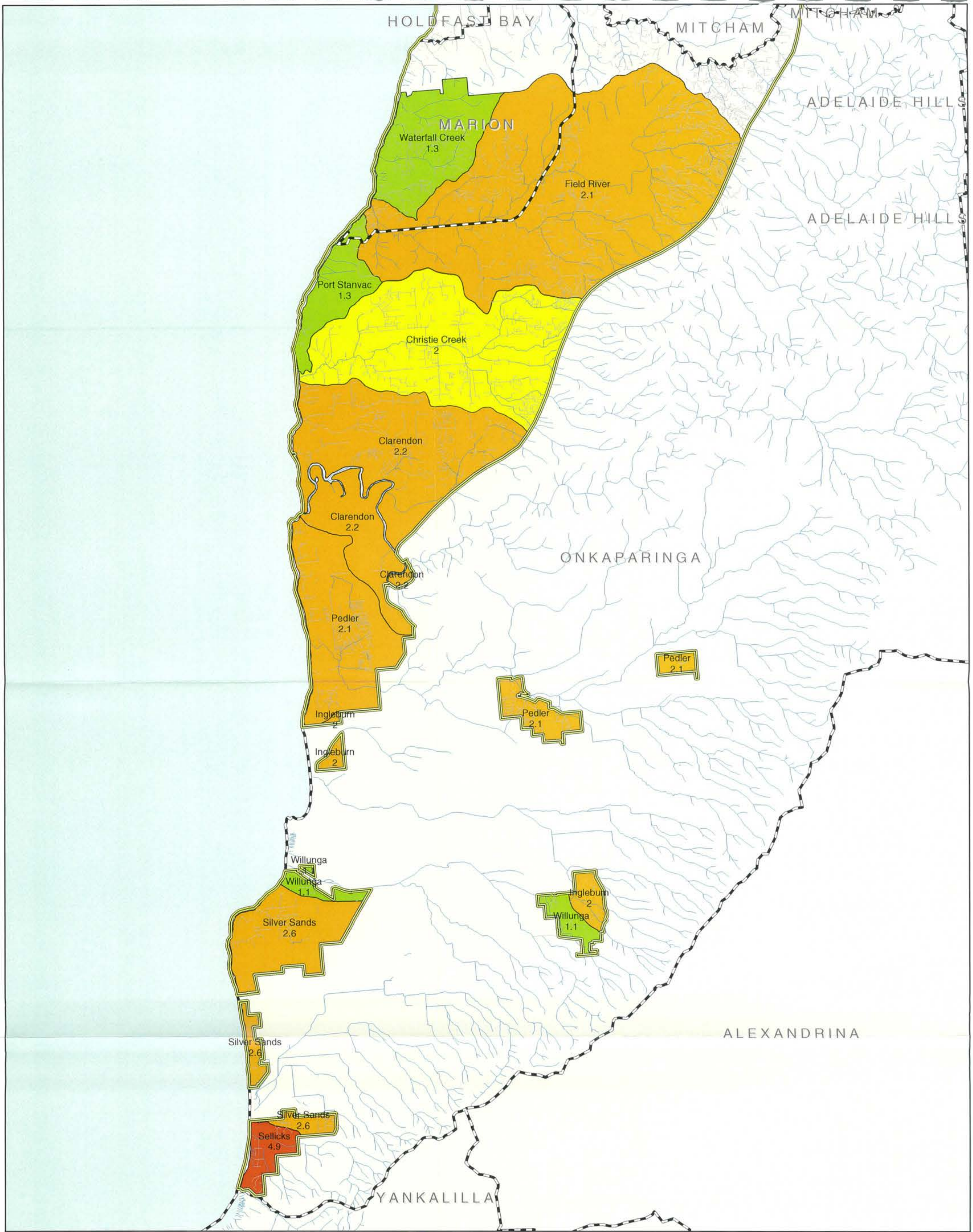
Metropolitan Adelaide Stormwater Management Study
Patawalonga Catchment - Figure B3

Drawn By KR	
Checked By AGB	

Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94

Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
PCWMB Change Acg Dwelling.mxd

KBR



Urban Containment Boundary

Local Government Areas

Stormwater Network

Pipe Network

Creek/Open Channel

Onkaparinga Catchment Change Avg Dwellings

0.0 - 0.50
0.51 - 1.00
1.01 - 1.50
1.51 - 2.00
2.01 - 3.00
3.01 - 5.00
5.01 +

1 0.5 0 1 2 3 4 5 Kilometres

N W E S

Metropolitan Adelaide Stormwater Management Study
Onkaparinga Catchment - Figure B4

Drawn By KR	
Checked By AGB	

Data:
Urban Containment: PlanningSA
Catchments: Catchment Boards
Projection : UTM Zone 54
Datum: GDA 94

Date: 25/6/04
Project: AEV400
Project Name: Adel Metro Stormwater
Operator: Kym Ralph
Software: Arcmap
File: E:/AEV400/
OCWMB Change Avg Dwelling.mxd

KBR