Setting our future urban water directions

Support Paper 2

Drainage and flood management – managing rain for the next century

SOUTH AUSTRALIA

Government of South Australia
Department for Environment and Water

Introduction

To set South Australia on the path to integrated urban water management we are developing urban water directions to guide all stakeholders to deliver the integrated management of water, sewerage and stormwater services to contribute to the full suite of water security, public health, environmental and urban amenity outcomes that the community seeks.

The paper, *Setting our future urban water directions: Delivering integrated urban water management for the benefit of South Australia*, is the principal paper that contains key background information and summary of key issues relating to the provision of water supply; drainage, flood mitigation and other stormwater management objectives, and opportunities for water to contribute to healthy, green and cool cities and towns.

This paper (*Drainage and flood management – Managing our rain for the next century*) is one of three additional support papers:

- *Support Paper 1: Water supply for the future – All options on the table*
- *Support Paper 2: Drainage and flood management – Managing our rain for the next century* (this paper)
- *Support Paper 3: Water for life – Water to support healthy and enjoyable urban living*

Support Paper 2: Drainage and flood management – Managing our rain for the next century invites your feedback about what future stormwater management arrangements we will need to ensure our urban communities are as flood resilient as possible, for maximising the benefits of stormwater, and for protecting receiving environments from the damage that urban runoff flows can cause.

South Australia's approach to managing rain and runoff

Historically in South Australia, as around the world, rain and runoff in urban areas has been managed to limit the inconvenience of water ponding on roads and property, and to minimise the likelihood of land and buildings being frequently flooded (including from flooded creeks or rivers).

As towns and cities expanded, there was a need to manage increasing amounts of runoff from hard surfaces such as roads and houses, and protect new development from flooding. Networks of stormwater pipes and drains were constructed to carry water to receiving creeks, rivers, and the ocean, and many sections of natural watercourses were straightened, diverted into large pipes, or reshaped and lined with concrete (see *Case Example – the Keswick Creek*).

What do we mean by 'rain' and 'runoff'?

For the purpose of this paper, rain means the rain that falls on land, including on any building surfaces such as roofs and other built areas. It also includes rain that is then captured and retained within the property where it fell, for example by rainwater tanks and soil infiltration.

Runoff is rain once it has escaped the property where it originally fell, which in urban areas are often serviced by stormwater drainage networks.

Our towns and cities now feature extensive drainage and flood mitigation infrastructure including pits, pipes, drains and constructed channels, levee banks and detention basins. Kerbed roads, and in some places open spaces, are also designed to safely carry the runoff from 'major' rain events.

Since the mid-1950s our 'minor-major' approach to urban drainage (see Figure 1) has prevented Adelaide and other cities and towns from experiencing frequent major floods; it is also the reason why urban assets such as roads are able to operate effectively for the vast majority of times that it rains.

However, the cost to provide and maintain the infrastructure that provides us with this degree of convenience and flood protection is considerable; between 2014-15 and 2018-19 metropolitan councils collectively spent an average of more than $100 million per year and regional councils collectively spent an average of almost $30 million per year on stormwater management. The replacement cost of flood mitigation and drainage infrastructure across metropolitan Adelaide is more than $4.2 billion ($2018), and across the entire state likely exceeds $5 billion.

Case Example – Keswick Creek

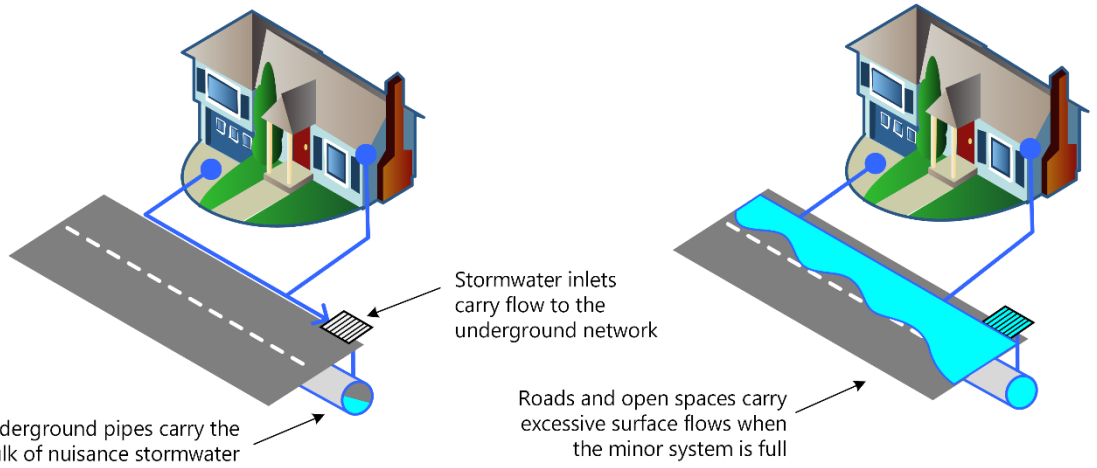
The article *'Inglorious Treatment of Keswick Creek'* which appeared in The Advertiser on 27 November 1948 provides insights into the nature of changes that occurred in relation to that creek system since European settlement of its catchment. The article paints a sad picture of a creek that had become extensively degraded and transformed from a formerly natural ephemeral creek into a highly engineered urban drain for conveying increased levels of runoff along with any contamination and refuse washed into it from connected areas.

Keswick Creek is one of many instances where drains have largely replaced natural creeks; it highlights the need to protect and when practically possible seek to reinstate some of the aspects of naturalised creek systems that are highly valued by our communities - where this can be achieved alongside the ongoing need for mitigating the risk of flooding.

https://trove.nla.gov.au/newspaper/article/43793106?searchTerm=%22keswick%20creek%22&searchLimits=dateFrom=1948-01-01|||dateTo=1948-12-31

Highly modified urban drains provide efficient conveyance but they usually exhibit few to no environmental values present in natural watercourses. Source: Brownhill and Keswick Creek Stormwater Project

Figure 1 - The minor and major drainage system – the conventional design approach to protect urban areas from flooding involves the planning and development of minor and major infrastructure



The **'minor system'** – typically underground pipe networks and other infrastructure to collect and convey urban runoff during most small rainfall events (these being the bulk of all rainfall events). If, however, runoff exceeds the minor system's capacity then surface flow occurs.

The **'major system'** – comprising the underground piped system when it is at full capacity, together with the road network for carrying the excess surface runoff in a reasonably safe manner. The aim of this is to ensure that roads remain trafficable during major events.

Current and emerging challenges

There are a number of significant current and emerging challenges and opportunities that collectively warrant a constructive review of our existing arrangements for managing rain and runoff.

Findon Road in Adelaide after heavy summer rain - Jan. 2021. Without an adequate minor drainage capacity, many urban areas would suffer more frequent flooding.

Flooding will remain an ever-present threat in many urban areas. The cost to upgrade flood protection and drainage infrastructure in existing extensively built-up and flood-prone areas can be considerable, and in some densely populated areas there may already be too much other infrastructure (such as water pipes, gas pipes and phone lines) to fit larger stormwater drains. It is therefore opportune to consider how we can best keep the costs of stormwater management as low as possible while providing our communities with the appropriate level of flood resilience, in a socially responsible manner.

Additional risks are also emerging (Figure 2). Unless they are adequately managed, our urban communities will become increasingly vulnerable to flooding, and state government, councils, and communities will face higher flood damage costs over the coming decades.

The infill development case study presented on the following page provides an example of some of the challenges.

Figure 2. Emerging risks

Ageing infrastructure	• Most drainage infrastructure was built decades ago • Some will require replacement soon
Climate change	• Projections include increased storm severity and continued sea level rise • When other natural disasters (also from climate change) occur at the same time or closely with urban flooding it can place additional pressure on human and financial resources to respond
Urban development	• The 30 Year Plan for Greater Adelaide encourages infill development to prevent urban sprawl into prime agricultural land • Infill development places greater demands on stormwater infrastructure with more runoff occurring from increased hard surfaces
Changing urban lifestyles	• In many areas, gardens are being reduced in size and replaced with hard surfaces (paving, sheds, carports) – more hard surfaces means more stormwater runoff
Demographic changes	• More people living in towns and cities means potentially more people exposed to flood risk
Under appreciation of urban flood risk	• Urban communities may be unaware that they live and work in flood prone areas • Many of those who have never experienced a flood may believe they face no flood risk and are ill prepared to protect themselves and their property from flood
Emerging maintenance issues	• Drainage infrastructure requires maintenance to work efficiently • Increased focus on urban greening and water sensitive infrastructure may increase the cost of maintenance – e.g. regular clean out of raingardens to allow them to function

Urban Development - Infill Development Challenges Case Study Example

- Minor infill development is the single largest provider of new housing in the Greater Adelaide area, with a net increase of about 2,500 residential dwellings per year between 2012 and 2018 – this is about 40% of the metropolitan housing supply growth.
- Minor infill development increases housing density and can create allotments with up to 80-90% hard surfaces - this is about twice the area of hard surfaces that most existing minor stormwater drainage networks were designed for when they were built.
- There is evidence that increasing the area of hard surfaces increases peak stormwater flows, and the frequency and volume of runoff. For example, the Frederick Street catchment, a 50 hectare urban catchment near Glenelg, has experienced a 17% increase in total impervious area between 1993 and 2013, with a resulting increase in stormwater peak
- Designed in the late 1960s, the Frederick Street drainage system is likely to have achieved its 'designed for' minor drainage performance (being an annual exceedance probability of 20% (or '1 in 5' chance) in the early 1980s. Research suggests that due to subsequent development and impervious paving, it has since reduced to providing in the order of a 50% (or '1 in 2' chance) annual exceedance probability - meaning that there is reduced capacity for managing minor runoff events, and surface flows and associated inconvenience and damages occur more often.
- The Stormwater Management Plan prepared for the Marion-Holdfast catchment area, which includes the Fredrick Street catchment, indicated that the flood damage caused by a 5% (or '1 in 20' chance) annual exceedance probability storm event would increase from $1.2 million (in 2013) to $4.9 million (by 2040), with the number of houses flooded above floor level increasing from 9 to 52 houses.

These figures show the changes in impervious areas in the Frederick Street catchment, near Glenelg, between 1969 (left) and by 2013 (right). Over that time the catchment's total imperviousness increased by more than 60%, which resulted in runoff peak flows and runoff volumes increasing by about 40% (Source: Kemp, Pezzaniti and Myers. University of South Australia)

Climate challenges – case study example

More intense rain will occur due to climate change although it is still uncertain how much more intense rainfall will be.

Sea level rise is another and more obvious climate related challenge that is likely to affect many low-lying coastal areas, including urban settlements where stormwater discharges take place. Higher sea levels can make it much more challenging to discharge stormwater runoff at rates needed to avoid flooding.

The *Stormwater Management Plan – Coastal Catchments between Glenelg and Marino* (2014) shows how sea level rise combined with urban stormwater flows from upstream catchments could increase flood risk associated with the Patawalonga Lake system.

Under dry weather conditions, the Patawalonga Lake is designed to operate as a tidal flushed lake, with water entering its southern end through the Glenelg Gates on a rising tide, and draining via the Barcoo Outlet at the lake's northern end on a falling tide. Low flows of stormwater that arrive at the northern end of the lake from Brown Hill Creek, Sturt River and Patawalonga Creek are diverted directly to sea through the Barcoo Outlet.

However, when stormwater flows exceed the capacity of the Barcoo Outlet – either because the runoff rate is higher than the outlet to convey, or if the tide level in Gulf St Vincent is so high as to reduce the outlet's capacity – then the stormwater is allowed to flow into the lake. Under this flood operating mode, the lake stores stormwater until the lake level exceeds the tide level by enough to allow water to be released from the lake to the sea through the Glenelg Gates.

The Stormwater Management Plan indicates that an extreme tide could happen, in conjunction with minor rainfall that is sufficient to fill the Patawalonga Lake. The Plan suggests that a 0.5 metre sea level rise (a level consistent with projected climate change impacts on sea levels over about the next 50 years) may considerably increase the frequency of extreme water levels in the lake. It indicates, for example, that a level of 2.1 metres that is currently a 1% ('1 in 100' chance) annual exceedance probability could happen in future with a 20% ('1 in 5' chance) to 50% ('1 in 2' chance) probability, and a level of 2.3 metres which is currently a 0.2% ('1 in 500' chance) annual exceedance probability could happen in future with a 10% ('1 in 10' chance) probability.

Providing for the services needed

Urban watercourses

Watercourses in the urban environment include natural features and those constructed as part of a drainage system. They often serve a number of functions that may include:

- Providing drainage and flood management
- Providing opportunities for recreational and social activities on the waterway or adjacent land
- Providing opportunities for cultural connections to the land and health benefits that come from enjoying outdoor areas
- Supporting healthy aquatic and riparian habitat corridors.

The diversity of functions associated with urban watercourses presents a challenge when trying to deal with the enormous complexity of issues that can arise, and the need to have regard to many stakeholders with a broad range of interests and perspectives.

Urban watercourse management in South Australia has long been a difficult and contentious issue, particularly in metropolitan Adelaide where parts of watercourses that perform as regional stormwater drains fall substantially within privately-owned land. Private ownership of urban watercourses places some risk against their owners, who may be required to maintain the watercourse, and may also occasion substantial difficulties in access by public authorities for maintenance, as well as problems of assigning or defining the roles and responsibilities of these authorities.

While this paper focuses on the drainage and flood management aspects of urban watercourses, **Paper 3: Water for life** considers the environmental aspects of managing urban watercourses.

While the presence of urban watercourses on private land is not unique to Adelaide or South Australia, earlier legislative action in some other states established clearer roles and responsibilities that has significantly mitigated the extent of watercourse ownership issues compared to South Australia's situation. For example, in Melbourne's Port Phillip and Westernport region, Melbourne Water (and its predecessors) have managed designated rivers, creeks and regional drains since the 1920s, and are empowered by legislation that permits them to levy waterways and drainage charges on properties. A potential option for South Australia could be to consider the inclusion of drainage within the scope of the *Water Industry Act 2012 (SA)* which would provide for licenced water industry entities to access private land for investigation or to carry out work in accordance with the requirements of the Act (section 44 and 45 of the *Water Industry Act 2012)*.

The opportunity to clarify the roles and responsibilities for watercourse management in South Australia could be undertaken in connection with the matters considered in relation to the issues raised later in this paper. In particular, this would be useful in relation to whether the management responsibilities for local and regional stormwater systems might be split by placing the responsibility for managing urban watercourses that provide regional drainage services under a single service provider for both drainage and waterway management.

Flooding

Floods are a natural phenomenon that results when water covers land that is normally dry. While floods can have positive ecological benefits, significant negative impacts can arise if floods occur in areas where significant human occupancy or movement occurs.

Flooding is the most costly natural disaster in South Australia. Between 1967 and 2013, the economic cost of flooding in South Australia annually averaged about $48 million, which is about the same annual cost as all other natural hazards combined over the same period. In addition to financial cost, flooding often causes significant inconvenience, discomfort and distress and mental health impact.

It is not practical to prevent all floods occurring in areas of our towns and cities that were often unknowingly built on flood prone land. For this reason, it is important that communities living within a floodplain have access to information that allows them to minimise the consequences of floods they may experience. Many urban areas face residual risk of rare and extreme floods that exceed the major drainage standards provided for in their area. In 2019 the Insurance Council of Australia indicated some areas of Adelaide that may, if they had better access to information, rank among its list of the top 20 national locations with the highest degree of flood exposure.

Flash floods (see *Types of flooding*) are the most common form of flooding in urban areas and the most problematic because they are difficult to predict in time to warn the threatened community.

Flood mapping information

Nationally and within this state there is acknowledgement that information about flood risk should be readily available. Some of the sources that highlight the importance of providing access to the best available flood mapping include the:

- *National Strategy for Disaster Resilience* (COAG, 2011)
- *National Disaster Risk Reduction Framework* (2019)
- *Stormwater Management Agreement* (2013).

As South Australia's Hazard Leader for Flood, the Department for Environment and Water (DEW) coordinates activities that help South Australia prepare for, manage and respond to flood disasters. This includes collating flood maps from across metropolitan and rural areas of South Australia. Publicly accessible flood maps for some of the states' urban and non-urban areas are available from *https://www.waterconnect.sa.gov.au/Hazard-Management/Flood-Awareness/SitePages/Home.aspx*

Types of flooding

Floods arise from one or a combination of the mechanisms described below. This paper primarily concerns riverine flooding from small or medium catchments and flash flooding, which are the most common sources of flood risk facing our state.

Riverine flooding (or fluvial flooding) is caused by prolonged or severe rain in the upper reaches of the catchment of a watercourse. Floodwaters travel through the river or creek and break out where the volume of water is too great for the size of the channel. Riverine flooding can occur very quickly after rain in small catchments (within hours), but in large catchments such as the Murray-Darling Basin floods can take many weeks to travel down a river.

Flash Flooding (or pluvial flooding) is caused by high intensity storm events. Flash floods occur very quickly after rainfall (less than 6 hours and often considerably faster) and can generate fast-moving water. In urban areas, flash flooding is characterised by overland flows and ponding of water. As there is little opportunity to warn and prepare people, flash flooding can be very destructive.

Coastal Flooding is caused by high tides and storm surge, and may be exacerbated by wind-wave generation. This type of flooding is fairly uncommon in South Australia, but may occur at the same time—or soon after—riverine or flash flooding from the same storm weather system. Future sea level rise as a result of climate change may increase the frequency and severity of coastal flooding.

Groundwater Flooding is not known to happen frequently in urban areas of South Australia. It occurs in urban situations when sub-surface water emerges from the ground at the surface or into built structures such as basements.

Infrastructure Failure Flooding can be caused by failure of infrastructure including levees, dams and pipes.

Drains can also 'fail' for other reasons. This photo shows a car that has been swept into a drain, severely reducing its ability to carry away floodwaters. Other obstacles often encountered in drains include woody plants and other vegetative debris, and urban rubbish. Drainage management including removal of obstacles is an ongoing challenge, which can be further exacerbated where the responsibilities and powers for clearing drains is not well defined.

While flood maps are widely viewed as critical information which the community should be able to access, they do have limitations which the community should be aware of. Among these limitations are:

- Flood maps may have been prepared using different approaches, data formats and modelled events.
- Methods used may have been superseded by newer 'best-practice' methods
- Flood maps may become less accurate or less relevant as time goes on because of catchment land use changes that have occurred since the map was prepared
- Flood events which may be less frequent than those identified in flood maps can still occur, and it is important that people who live or work within a floodplain understand that they will always face some degree of flood risk.

Although many flood maps have been voluntarily made available by local councils, some have legitimate concerns about sharing information widely. These concerns reflect the limitations described above and a fear of liability if information that is provided in good faith is subsequently demonstrated to be deficient in some way, or is misinterpreted or misapplied.

While use of the Flood Awareness Website and the flood maps therein is conditional upon terms and conditions which were developed in consultation with the Local Government Association and its insurer, additional measures that offer the owners of flood-related information protections may warrant consideration. Baker & McKenzie, in their report *Local Council Risk of Liability in the Face of Climate Change—Resolving Uncertainties* prepared for the Australian Local Government Association (July 2011) indicate in relation to liability issues for Australia's local councils "in each State and Territory (with the exception of the Northern Territory and South Australia, for which there is a general but weaker defence at common law) there is legislation which can limit the liability of Councils in civil litigation." Baker & McKenzie recommend that South Australia (and the Northern Territory) "implement statutory reform with respect to the civil liability of public authorities as the other jurisdictions have."

In other Australian jurisdictions, legislation offers various safeguards that appear to have been an important factor for open sharing of flood information. For example, in New South Wales, section 733 of the *Local Government Act 1993 (NSW)* exempts councils from incurring liability in respect of:

- any advice that a council furnishes in good faith relating to the likelihood of any land being flooded or the nature or extent of any such flooding, or
- anything done or omitted to be done in good faith by the council in so far as it relates to the likelihood of land being flooded or the nature or extent of any such flooding.

The New South Wales *Flood Prone Land Policy* also includes a statement concerning the protection of councils, government agencies, and their staff against claims for damages resulting from the issuing of advice or granting approvals on floodplains, providing such action was taken in accordance with the principles and guidelines contained in the *Floodplain Development Manual: the management of flood liable land*.

The State of Victoria also offers an example wherein liability – in this case in respect of the declaring a flood level – has been limited by an Act of Parliament. Section 211 of the *Water Act 1989 (Vic)* indemnifies an Authority of a water management district that declares a flood level relating to a specified area, or that declares a flood fringe area, from any loss or damage that is sustained directly or indirectly as a result of such a declaration.

Flood warning

Flood warning can be an effective non-structural flood mitigation strategy if it is timely and targeted. The goal of flood warning is to help flood management agencies and the members of flood-prone communities to understand the nature of developing floods so that they can take action to mitigate their effects.

A flood warning system is made up of a number of components which must be integrated if the system is to operate effectively (see Figure 3 - Elements of a *total flood warning system*). There are numerous key stakeholders in South Australia's flood warning and capability (Table 1). However, the responsibilities for flood warning networks and the roles of the Commonwealth, state and local governments have never been fully defined. One consequence is that there remain challenges in ensuring all components that make up the states' total flood warning system are adequately resourced.

The *Independent Review of the Extreme Weather Event South Australia 28 September – 5 October 2016* (known as the Burns Review) highlighted gaps in the monitoring network and the negative impact this has on the ability to warn the community to respond effectively to flooding. The review made recommendations to consider and provide resources for flood warning classification of stream gauges and other locations, and highlighted a symptom of a broader issue with flood warning infrastructure (Burns Review, recommendation 21). The Government response to this recommendation stated that *while significant investment in the infrastructure network is not currently possible, [the Department for Environment and Water] will continue current work to assess and prioritise flood risk across the State and undertake a review of existing water monitoring*

networks used for flood warning. This will inform where future resource allocation.... could be considered. A policy will need to be developed to clarify roles and responsibilities between State and local government.

Figure 3. Elements of a total flood warning system

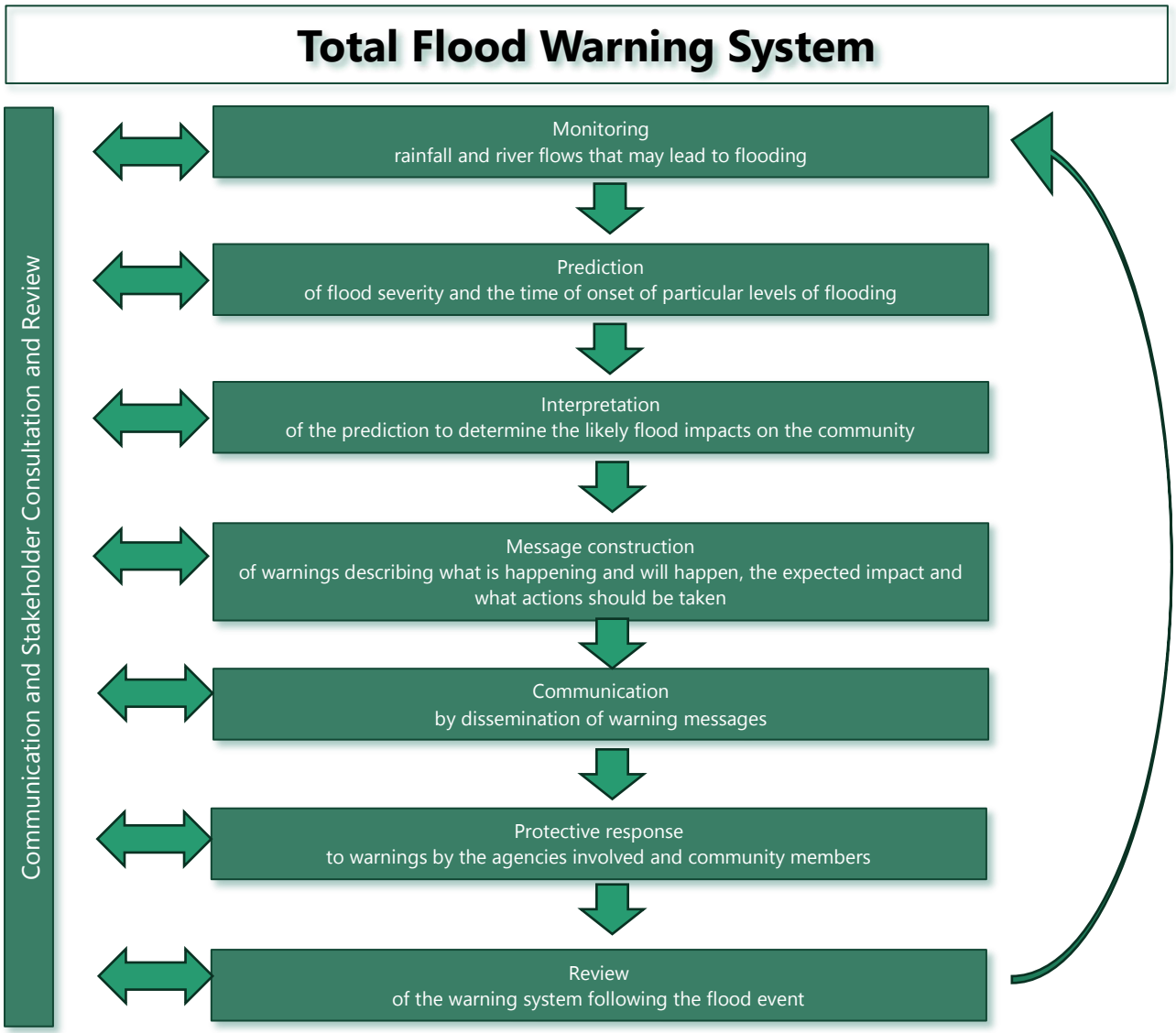


Table 1 – Key stakeholders in South Australia's flood warning capacity and capability

Organisation	Interest
South Australian State Emergency Service (SES)	• Principal emergency response agency for flood events • Provides flood warnings to ensure the public is warned and informed • Can greatly benefit from advanced warning to deploy response resources effectively
Bureau of Meteorology (BoM)	• National agency that provides prediction and flood warnings to partners and the public for riverine flooding, in catchments where a service has been established, and severe weather warnings • Provides a limited flood specific rain and river gauge network in South Australia • Provides some bespoke services to local government both for free and on a fee-for-service basis, including operation of the 'ALERT' rainfall gauge and provision of associated Alerts.
Department for Environment and Water (DEW)	• Operates the majority of the rain and river gauge network in South Australia. Although not dedicated flood warning gauges, they are used opportunistically in the absence of other surveillance to inform BoM prediction services and SES response • Owner of some of the control structures • Interprets BoM's flood prediction to determine the likely flood impacts on the community • Develops the strategic flood warning infrastructure plan for SA, provides technical advice on the development of new flood warning services, and supports flood intelligence
Landscapes Boards	• Operate some rain and river gauges in the South Australia network including most gauges in urban Adelaide areas • Landscape Board's gauges are not dedicated flood warning gauges but are used opportunistically to inform BoM prediction services and SES response
SA Water Corporation	• State-owned utility whose operations have potential to both positively and negatively impact on the magnitude and timing of flood events. These operations need to be accounted for in flood prediction • Owns some river gauges used by BoM for prediction services and to inform SES response
Local Government Authorities (Local Councils)	• Represent local communities who are the ultimate benefactors of a flood warning service • Through providing stormwater drainage (including structural flood mitigation) services, are consequently a principal source of flood risk information • Often contribute significant resources to flood response efforts and recovery operations • Fourteen councils currently have dedicated flood monitoring infrastructure (mostly in metropolitan Adelaide) as part of the ALERT service, which is operated on a cost recovery basis by the BoM for the councils and part funded by the SMA • Some councils own dedicated flood warning infrastructure • Assess new development applications, including applications for development in identified flood prone areas
Stormwater Management Authority (SMA)	• Provides guidelines for and funds stormwater management planning, which may include flood risk studies • Currently subsidises 50% of the cost of the ALERT service

While flash floods which impact urban areas are difficult to predict, additional experience and advances in technology such as reliable telemetry systems that rapidly transmit data from catchments; improved radar and satellite technology for remote detection of severe rainfall, and sophisticated hydrological and hydraulic modelling techniques have improved our ability to predict floods. Making best use of such technologies to enhance flood warning services might be an approach for improving flood resilience without necessarily involving the need for major (and high cost) flood mitigation infrastructure; however, its success would primarily rely on a high level of community awareness and the willingness and strong capacity of individuals who may be affected by a flood to respond in a timely and effective manner.

Coastal impacts

The Adelaide Coastal Waters Study identified that both stormwater and wastewater discharges were detrimentally impacting seagrasses off the coast of Adelaide. For stormwater discharges, the major pollutants of concern were identified as suspended solids and coloured dissolved organic matter. More recently, the Goyder Institute for Water Research has identified fine suspended solids which are picked up, carried by and discharged into Gulf St Vincent from the outlets of urban watercourses and stormwater drains during and after rainfall, as needing further management.

While major urban river discharges (e.g. outflow from the River Torrens, and some other major creeks along Adelaide's coast) are significant sources of sediment discharge, further information is required to understand the major sources of fine sediment and mechanisms by which they enter the stormwater system and the watercourses that discharge to the coastal environment, to be able to target interventions effectively.

In relation to Adelaide's stormwater discharges our existing evidence indicates that:

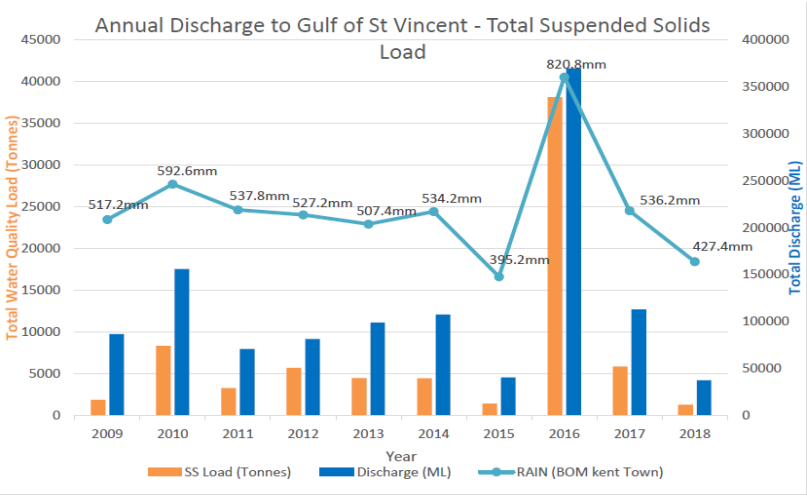
- once fine sediment conveyed by stormwater is discharged into Gulf St Vincent some of it settles and remains in the near-shore environment for considerable period, possibly decades. Regular resuspension of this sediment during turbulent conditions, such as coastal storms, reduces light conditions that are important to support healthy flourishing seagrass meadows.
- large amounts of sediment discharges from Adelaide's catchments into Gulf St Vincent during infrequent high runoff events. For example events in 2016, which was a year with very high rainfall and runoff discharge, resulted in more than half of the decade's total sediment load discharging to the Gulf (Figure 4). Much of the sediment load discharged during 2016 resulted from a few episodes of extremely heavy rainfall and runoff.
- coloured dissolved organic matter (CDOM), which is primarily leached from decaying organic matter and often makes runoff appear to be stained (sometimes appearing brown), can also impact urban runoff quality. The Adelaide Coastal Waters Study identifies CDOM reduction as also being important to help improve conditions for restoring seagrass condition in Adelaide's coastal waters.

These findings suggest there is further need for evidence-based research to be undertaken to inform policies that will deliver the most effective intervention strategies for restoring Adelaide's coastal waters to a more healthy state. It is appropriate that we plan for how we can develop the necessary evidence base, and how we are able to credibly demonstrate the effectiveness of our mitigation efforts.

For other areas of the State, the implications of stormwater discharges to coastal and other receiving water environments may also need further investigation.

For further discussion about water for nature see **Support Paper 3: Water for life**

Figure 4. Total suspended solids load discharged from Adelaide's stormwater drains between 2009 and 2019



The Adelaide Coastal Waters Study identified sediment derived primarily from urban runoff, along with nitrogen mainly derived from treated wastewater discharges and industry sources, as the primary cause for a decline in the health of Adelaide's nearshore seagrasses, the area of which reduced by around 50 square kilometres since the late 1940s. Over the last decade just over half of Adelaide's sediment discharges to Gulf St Vincent occurred as a result of a few exceptionally heavy rainfall events in 2016, with flows coming from both urban and upstream primarily non-urban areas.

Multi-objective stormwater management

Over the last few decades, stormwater management objectives in Australia and in many other countries have evolved to keep up with changing community attitudes. In place of heavily drainage-focused outcomes in vogue during the 19th and most of the 20th centuries, multi-objective stormwater management have become more popular, that aim to achieve:

- Mitigation of flood risk and building community resilience to flooding
- Mitigation of impacts of stormwater runoff on receiving waterways and ecosystems
- Realisation of opportunities to harvest runoff for beneficial uses.

For information on the extent that stormwater is captured and used for non-drinking supply see **Support Paper 1: Water for the future**

There are many approaches and techniques for multi-objective stormwater management already used in some South Australian towns and cities (Table 2).

The River Torrens (Karrawirra Parri) – A world class working example of multi objective stormwater management

Photo source: Green Adelaide

Since the 1970s the River Torrens has been re-visioned to deliver a high level of flood protection to urban areas close to the river and to also facilitate a wide range of multi-objective benefits for Adelaide and the wider South Australian community. This process integrated complementary activities such as upgrades to the Kangaroo Creek Dam to offer better downstream flood protection, and the protection of land close to the river system from inappropriate development. Additional measures have since been added, including native fish ladders to help fish movement in the lower Torrens, and riparian upgrades to support a richer biodiversity and improved amenity.

This is continuing with the Breakout Creek Stage 3 redevelopment project, at the lower end of the river, set to transform a remaining section of a fenced-off channel dug in the 1930s into an attractive, highly biodiverse area that will also open up more opportunities for community use and for enhancing water quality, while maintaining its flood conveyance to the sea.

A wide range of stakeholders agree that collaboration between organisations and appropriate policy settings are needed to address urban flood challenges, while also delivering other stormwater management benefits and achieving multiple outcomes. This can be seen with similar issues being raised through a range of reports and enquiries at a national, state and local level.

Table 2 – Examples of stormwater management from hazard, stormwater quality and resource perspectives

Scale	Issue	Examples
On-site (lot)	Flood Hazard	On-site retention and detention tanks (small lots), pervious surfaces[1]
	Stormwater quality	Well vegetated pervious surfaces[2]
	Stormwater resource use	Rainwater tanks, pervious surfaces[3]
Local (street or neighbourhood)	Flood Hazard	Detention basins
	Stormwater quality	Street sweeping, raingardens, gross pollutant traps
	Stormwater resource use	Street-kerb stormwater inlets[4], pervious paving in footpaths and car parking areas
Regional	Flood Hazard	Detention dams[5], detention basins, open space corridors[6]
	Stormwater quality	Constructed wetlands, sedimentation ponds, erosion management[7]
	Stormwater resource use	Large scale stormwater harvesting and use (e.g. through 'managed aquifer recharge')

[1] *Research for some metropolitan Adelaide catchments suggests up to about 40 mm of rain may be retained by pervious surfaces before they are likely to contribute significant amounts to surface runoff – making them an effective non-structural approach for reducing urban runoff rates and volumes during the majority of runoff events*

[2] *Pervious surfaces that contribute minimal runoff or dry or wet weather-derived contaminants (e.g. relatively flat and well vegetated pervious areas). Research suggests sediment losses in runoff events is likely to be much greater from bare surfaces than from well vegetated areas*

[3] *Increased infiltration and potential for uptake by plants (i.e. passive irrigation)*

[4] *Devices that direct street gutter flows to tanks or other structures in street mediums for slow release of the water by nearby street trees*

[5] *e.g. the River Sturt Flood Control Dam in metropolitan Adelaide*

[6] *Open space corridors providing a route for flood conveyance*

[7] *e.g. establishing dense vegetation or by other methods to minimise erosion from land adjacent to watercourses or from stream beds and banks*

Key to the successful and more consistent implementation of multi-objective stormwater management is clarifying the respective roles and responsibilities of those involved in stormwater management, where significant ambiguities currently exist. There also appears to be an appetite to consider market-based incentives designed to deliver the required stormwater management outcomes in an economically efficient manner, as opposed to or perhaps alongside traditional stormwater funding options provided from fiscally constrained local council rates, or state grants.

Examples of stormwater management at local and regional scale (clockwise from upper left): permeable paving, a street raingarden and a constructed stormwater wetland in the Adelaide Botanic Gardens.

Lot level opportunities

State Planning Policies (SPP) introduced through the *Planning, Development and Infrastructure Act 2016* promotes 'water sensitive urban design' to support objectives to:

- elevate the design quality of South Australia's built environment and public realm (SPP 2.3)
- provide climate ready development to be resilient to climate change impacts (SPP 5.4)
- ensure South Australia's water supply is able to support current and future needs (SPP14.5)
- build the resilience of communities, development and infrastructure from the adverse impacts of natural hazards (SPP15.4).

In addition, South Australia's new Planning and Design Code supports WSUD approaches at lot scale in new developments through various stormwater management related Performance Outcomes and deemed-to-satisfy provisions that should encourage minimum site perviousness and on-site rainwater tanks in residential settings to capture roof runoff for use, and to temporarily detain part of runoff.

In Melbourne and some other localities, stormwater management policies allow developers to reduce their obligations for implementing stormwater management controls on-site (such as stormwater runoff quality controls) by instead contributing to help fund off-site stormwater measures. Such schemes, which are voluntary, are known as stormwater in-lieu contribution schemes (or alternatively as voluntary stormwater offset schemes), and they offer potential benefits to both developers (through an offsite payment where it can achieve a lower cost outcome than achieving full compliance on-site), and local or regional stormwater managers provided the schemes are well designed and offer transparent accounting so that funds recovered are expended to deliver the off-site stormwater works identified by a detailed plan.

With the recent release of the Planning and Design Code, it may be possible for the government to investigate the potential applicability of voluntary stormwater offset arrangements.

Challenges remain for addressing poor stormwater runoff quality. These photos show (top) extensive sediment build-up in the Torrens Lake (source: Source: WikiCommons Photograph by YellowMonkey/Blnguyen), and (bottom) a plume of highly turbid runoff in Adelaide's coastal waters following heavy rainfall (Source: Adelaide Coastal Waters Study)

Local Level Opportunities

Over the last several decades there has been increased interest within Australia and overseas in the opportunities for using stormwater at a local scale to support multiple benefits such as:

- the passive watering of urban trees, for example through kerbside inlets and infiltration techniques
- improved water quality and amenity, for example through installing and maintaining street raingardens
- stormwater infiltration through pervious paving and footpaths
- using harvested stormwater for open space irrigation and for some commercial uses, to replace or supplement water that would otherwise be required from the drinking water network
- water quality improvement through opportunities to clean urban runoff before discharge or use for other purposes

Despite notable approaches, South Australia's experience has not been able to categorically demonstrate the cumulative effects such measures might have had for improving water quality. In relation to stormwater 'quantity' (runoff flow rates and volumes) some South Australian research has looked at the effectiveness of lot and local street scale measures for mitigating the potential for urban development to reduce the performance of the urban minor drainage network, however less well understood are the cumulative effect of such measures from an environmental management perspective.

Institutional arrangements

Legislation

South Australian legislation provides the overarching framework which governs how rain and runoff is managed to provide community flood resilience and other outcomes. Figure 5 provides a concise summary of the main existing legislative, regulatory and policy instruments that govern stormwater. Legislation that is unclear, ambiguous, outdated, or deficient of the appropriate drivers, incentives or necessary institutional powers, can hinder the ability to deliver and maintain cost-effective drainage, flood and other stormwater management services. A well-considered, clear and future-focused legislative framework can help to establish the institutional arrangements to drive best practice stormwater management responses. It is therefore appropriate to consider the current legislative framework and identify opportunities for legislative improvement as part of improved stormwater management in the future.

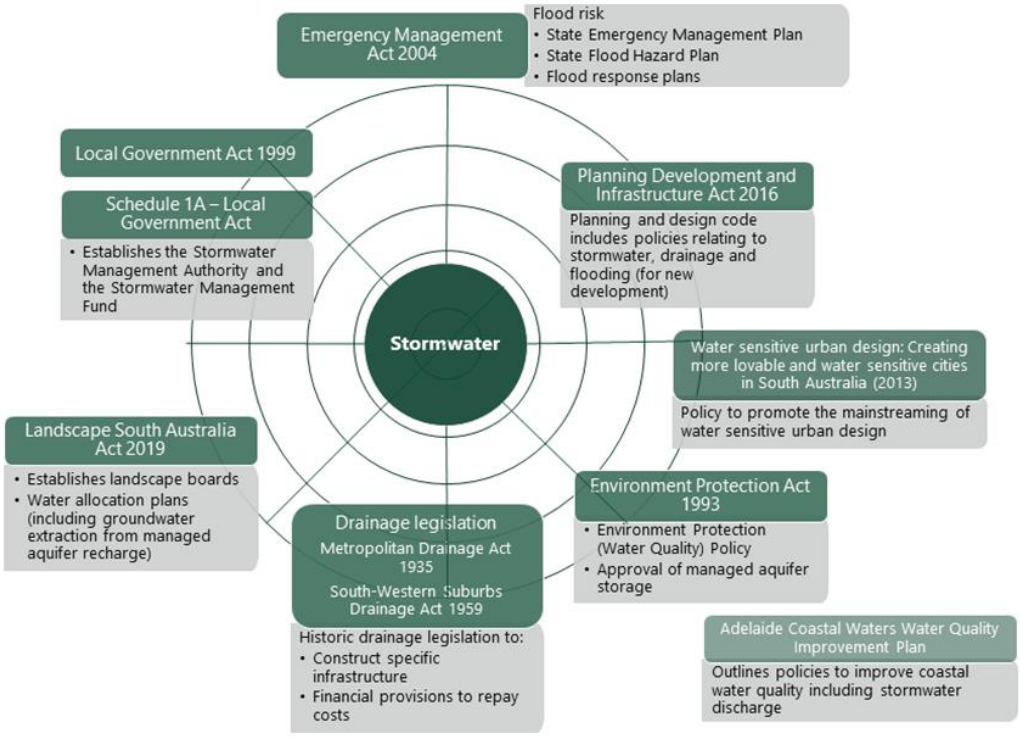
A notable feature of our current legislation is that there is no deliberately-designed legislation which delivers a multi-objective stormwater and urban watercourse management approach addressing all aspects of responsibilities for flood mitigation, preparedness, response and recovery; receiving water quality and environmental protection; and stormwater use.

One outcome of the increasingly layered legislative framework governing stormwater and urban watercourse management has been a proliferation in the number of organisations that have interests in various aspects of stormwater management. This includes: local and trunk flood and drainage infrastructure servicing, natural resources management, environmental protection, public health (associated with stormwater use), stormwater management planning, flood monitoring and flood warning service provisioning, flood response as part of emergency services provisioning, land use planning in relation to mitigating the impact of floods and to minimise the detrimental impacts of excessive stormwater runoff and stormwater quality, and flood recovery as part of national and state disaster response arrangements.

The *Local Government (Stormwater Management Amendment) Act 2016* (and predecessors), which introduced *Schedule 1A – Implementation of the Stormwater Management Agreement* into the Local Government Act, is unique in being the only legislative instrument deliberately designed to help facilitate urban flood prevention conjunctively with other multi-objective stormwater management outcomes at local and catchment scales. The Act primarily aims to facilitate the State and Local Government Stormwater Management Agreement (a non-legally binding agreement), stormwater management planning by local councils and support the implementation of approved stormwater management plans. The Stormwater Management Authority, established under Schedule 1A of the Act to facilitate these primary outcomes, is solely reliant on

the Stormwater Management Fund, which continues an annual State appropriation that has been provided to support drainage and other stormwater outcomes for over 50 years.

Figure 5 - Complexity of stormwater legislation



Other notable aspects of our legislative legacy pertaining to urban flooding and rain management include:

- **Numerous stakeholders**: South Australia's legislation provides the authorising environment to enable, invite, or sometimes compel, the involvement of many organisations. Those currently involved include: local councils, regional subsidiaries of several local councils, the Stormwater Management Authority, Landscape Boards, the Department for Environment and Water (including Green Adelaide), SA State Emergency Service, the Department for Infrastructure and Transport, State Emergency Management Committee, Australian Bureau of Meteorology, SA Water Corporation, and private watercourse and landowners. Planning and Land Use Services (in the Attorney-General's Department) and the State Planning Commission, also have interests in relation to the interconnection between land use planning with flooding and stormwater impacts.
- **Legislative clarity**: Some areas of current arrangements may not be sufficiently clear, in particular, there is a lack of clarity around responsibilities for stormwater management which is shared between state and local government. Issues of clarity around the respective responsibilities is long-running and appears to stem back to early European settlement. Typically, in the early days of settlement councils assumed the role of the primary delivery agent for urban drainage, possibly associated with their role in local road development (involving drainage) and the absence of a clear state legislative framework addressing drainage. Some exceptions arise where legislation has specifically established alternative arrangements for providing urban drainage services, e.g. South Australia's 'drainage Acts', which were established for the construction of particular stormwater management assets. Nevertheless there remains significant uncertainty regarding the precise responsibilities of councils, State Government and their agencies, and others. In relation to local councils' role, the South Australian Law Handbook lists 'stormwater drainage' among some other services that councils *may* provide, *"as they wish (provided they are not contravening other legislation)"*. In practice, imprecision regarding the 'shared' nature of responsibilities across local councils and the State Government has been a long-standing contentious issue between the tiers of government responsible for looking after the public interests of South Australian communities. The imprecise nature of responsibilities for stormwater management has been further complicated with the additions of non-drainage related agendas since the late 1980's, such as those relating to environmental protection and waterway health as part of natural resources and landscape management.
- **Funding**: Funding available through current legislative instruments relating to the management of rain and runoff is managed by different organisations for different objectives. This includes for example, the Stormwater Management Fund, Landscapes Levy, the Emergency Services Levy (relevant to emergency response/recovery, including

emergencies relating to floods and other disasters) and the Planning and Development Fund (to the extent it has also been used in connection with the delivery of multi-objective stormwater and waterway management outcomes.) Existing grant mechanisms do not necessarily provide an incentive to those who may directly contribute to the likelihood or potential consequences of urban flooding to proactively apply preventative measures; nor do they incentivise those who may themselves be minor contributors to the overall stormwater runoff problem (such as pollution) from taking steps to reduce their impact. The approach taken to mitigate stormwater issues is instead focused more towards prescriptive mechanisms such as through environmental regulation, water affecting activity permitting, and planning consent processes.

- **Shared responsibilities:** Although State Government and the Local Government Association both recognise stormwater as a shared responsibility, there is little explicit discernment of what that involves (although the State-Local Government Stormwater Management Agreement, which is not a legally binding agreement, outlines some expectations of each party). While a minimum long term State funding commitment exists, the amount available will not be able to ensure an adequate level of flood protection through traditional infrastructure and also achieve other outcomes should historic precedents in South Australia be followed, where past State Governments have contributed 50 per cent of the funding for flood protection infrastructure built pursuant to various 'drainage Acts', or provided up to a 50 per cent subsidy to local councils for constructing drainage infrastructure (mainly associated with catchments greater than 40 hectares in size).

Future urban stormwater services delivery

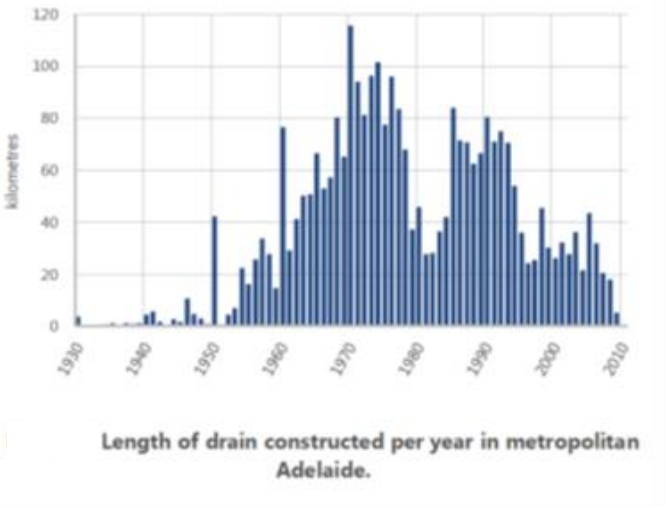
Considerable uncertainty exists in accurately identifying the funding that will be required to raise the State's urban drainage system to a level of performance that communities would support and expect, while also meeting contemporary expectations for environmental performance and opportunistic urban amenity enhancements. Factors that will influence the cost for renewing and where necessary upgrading our urban stormwater assets to meet our needs during the next century include:

- **Detailed flood mapping and stormwater management plans.** While considerable strides have been made by councils to undertake and complete flood maps and stormwater management plans for priority catchment areas identified by the councils and the Stormwater Management Authority, they have not been completed for all areas of the state where they will likely be required.
- **Adaptive management needs.** It may be necessary for assets to be upgraded in future as more is understood about likely future impacts, such as development and climate change implications on local catchments. This adaptive management approach could require reviewing and if necessary updating Stormwater Management Plans that have already been approved to keep them up to date in accordance with advances made in hydrological understanding, technological advancements, or other relevant changes.
- **Accurate information about the condition of existing flood and drainage assets**. At present drainage asset information is not fully complete across the State's entire stormwater network, with some uncertainties remaining about the condition of some parts of the drainage network and other stormwater management assets. This is being rectified, but it requires resourcing and will take time to complete.
- **Opportunities may also exist to deliver lower cost outcomes through alternatives to flood mitigation infrastructure approaches** (such as: through the State's planning system; enhanced flood warning services and community flood awareness; and through take up of promising emerging smart stormwater management techniques that will deliver the required performance at a lower cost compared to traditional approaches).
- **Community expectations** for how rain and runoff should be managed.

Stormwater Management Plans already approved by the Stormwater Management Authority include an indicative program of works in the order of $0.5 billion. Future funding needed by State agencies and SA Water for managing various inherited flood mitigation and drainage assets would be additional to this amount, as would be many of the costs for managing existing stormwater management assets. Most of the more than 500 individual programs and other actions outlined in the already-approved Stormwater Management Plans will provide drainage and flood related benefits, with fewer but still a large number of actions also offering water quality and other benefits.

There is also some uncertainty that provision has been made for replacement of ageing stormwater assets, which may vary in their effective service lives to 100 years or even longer for some assets, and ten years or even less for some recent 'water sensitive urban design' assets. Stormwater asset management plans, which are generally shorter term, do not provide for expected renewals that will be needed once the majority of ageing assets reach the end of their useful life. With many of the existing drainage networks having been completed in the 1930's to the 1970's, increased assets renewal may need to commence over the coming 10 to 50 years.

Figure 6. Age profile of metropolitan Adelaide's stormwater



Length of drain constructed per year in metropolitan Adelaide.

In 2006, the then Premier of South Australia guaranteed a minimum $4 million per year for thirty years (indexed against the Consumer Price Index) which is provided to the Stormwater Management Fund. This commitment represented a significant improvement on previous decades of variable annual state grants, and was supported by the Local Government Association, however it is likely that the total quantum of current state and local government funds will be not be sufficient to meet the long term future needs for infrastructure upgrades; based on a 50:50 funding split between state and local government for eligible works and other activities as has occurred previously.

Roles and Responsibilities

The Productivity Commission's research paper, *Integrated Urban Water Management – Why is a good idea so hard to implement* observes that "funding issues that relate to integrated urban water management (IUWM) projects are often symptomatic of other factors, such as lack of clarity about roles and responsibilities". The implication of this for stormwater management is that considerations for resolving funding issues should go hand in hand with clarifying the respective roles and responsibilities of the various stakeholders.

Approaches for managing drainage-related infrastructure differ markedly across jurisdictions within Australia and internationally. However, in some management models it is possible to broadly regard the stormwater drainage system as comprising three different elements comprised of private local, public local and regional stormwater systems:

- **The private local stormwater system:** is that part of the system that is within private property (e.g. a residential block or private commercial property). As well as roof gutters and downpipes, private properties may also contain other formal or semi-formal elements designed to drain stormwater to the public local stormwater system.
- **The public local stormwater system:** is designed to remove stormwater from areas such as streets and footpaths to provide pedestrian safety and convenience and vehicle access. This part of the system typically consists of street gutters, stormwater inlets and local surface drains or smaller underground pipe systems that transport water to the regional drainage system. In South Australia, in many situations this system has historically been considered to be within the sole province of local councils for managing and funding within catchments of less than 40 hectares, with (subject to other eligibility criteria) works within urban catchments larger than 40 hectares potentially being eligible for partial funding assistance from the state government.
- **The public regional stormwater system:** is that part of the overall drainage system that controls larger flows from heavier, less frequent rainfall events. It typically includes large constructed conduits and modified urban watercourses, but can also include some less obvious drainage ways such as over land relief swales and infrequent temporary ponding basins for 'flood storage'. These systems can sometimes be located (and owned) within private land holdings although they provide a stormwater management service for all upstream proprieties that would otherwise increase the flood risk for properties further downstream.

Considering these three elements of traditional drainage systems separately has enabled some Australian jurisdictions to articulate where the primary responsibility sits for each element of their system, and this has given rise to appropriate legislative frameworks, governance arrangements and funding mechanisms developed for each element. Table *3* shows how each of the three primary drainage elements are managed in other cities.

The management of stormwater in this way could also align with perspectives of:

- the Productivity Commission in respect of governments putting in place best practice institutional arrangements and governance for the delivery of stormwater services (see Productivity Commission's report into Australia's Urban Water Sector)
- the *Royal Commission into Natural Disaster Arrangements*, which identifies that risk should be managed by the lowest level of government that is best able to manage the risk
- views expressed in the Urban Water Reform Committee commissioned report, *Advancing the urban water sector - A framework and roadmap for coordinated action* that considers that the role of the urban water sector includes the provision of stormwater and drainage services in an economically efficient and sustainable manner
- views expressed in the *Institutional Arrangements for Urban Water* (commissioned by the Urban Water Reform Committee) that proposes stormwater services should be priced transparently and adopt sustainable funding sources which promote the long term interests of communities (users) and reflect user values and understanding of risk; and, advocates that the policy agenda should develop pricing principles and cost sharing arrangements with service providers being responsible for asset renewal, investment and cost recovery in accordance with that arrangement
- the Local Government Association commissioned report, *Options for funding stormwater management,* which recognises stormwater systems as key strategic infrastructure in urban environments, that need to be adequately funded and managed.

Table 3: Stormwater management in other Australian capital cities

City	Private storm water system	Local (minor) storm water system	Regional (major) storm water system	Regional stormwater system coverage (see links)	Drainage Charges
Sydney[1]	Private land owners	Councils	Sydney Water	Sydney Water: https://www.sydneywater.com.au/sw/water-the-environment/how-we-manage-sydney-s-water/stormwater-catchment-map/index.htm	Stormwater drainage service charge is determined by the independent pricing and regulatory tribunal (IPART NSW)
Newcastle[2]	Private land owners	Councils	Hunter Water	Hunter Water: https://www.hunterwater.com.au/our-water/stormwater/our-stormwater-network	Stormwater drainage service charge is determined by the independent pricing and regulatory tribunal (IPART NSW)
Melbourne	Private land owners	Councils	Melbourne Water	https://www.melbournewater.com.au/about/prices-and-charges/waterways-and-drainage-charge	Allowed by legislation. Special drainage charges need approval of the economic regulator (Essential Services Commission)
Brisbane	Private land owners	Brisbane City Council	Brisbane City Council	-	Brisbane City Council's drainage services are supported through council general rates
Perth	Private land owners	Councils	Water Corporation	https://www.watercorporation.com.au/Our-water/Wastewater/Sewerage-and-drainage-services	Drainage charges set by state government for the Water Corporation[3]

- [1]Sydney Water manages stormwater in some of Sydney's catchment areas and in the Rouse Hill area to the north-west (see link under the column 'regional stormwater system coverage')
- [2]Hunter Water also manages stormwater in some other catchments near Newcastle (see link under the column 'regional stormwater system coverage')
- [3]The Economic Regulation Authority may undertake inquiries and make recommendations to support government decision making.

Other jurisdictions

While there are differences between interstate models, most exhibit the following common attributes:

- The private local stormwater systems, located on private land, are usually managed by the land owner.
- Local (minor) stormwater systems are managed by local councils, perhaps reflecting the position of local councils as being best placed for delivering locally relevant community flood and drainage management services.
- Regional (major) trunk drainage services, typically involving conveyance of runoff from two or more council areas, are planned for, built and managed by a regional drainage service provider (which is typically, but does not necessarily need to be, a provider of other water services such as a provider of drinking water and sewerage services).
- Regional service providers often manage regional drainage conduits which convey stormwater to waterways and the waterways themselves, which ultimately discharge to the coast.
- Charges for regional drainage managers to provide regional services are transparently reviewed and are usually determined by the independent economic regulator. Charges are typically raised against those whose properties are within the broader catchment being managed by the service provider.
- Regional drainage managers are often able to give regard to multi-objective stormwater management considerations for those elements of the drainage system that they own and can control, for example, stormwater quality improvement and opportunistic stormwater harvesting. Additional revenue sources may be available to support such activities.[1]

[1] *For example, in Melbourne, an alternative option for new developments needing to meet stormwater quality requirements on-site, a voluntary stormwater quality offset contribution service is offered, with funds raised through the offset being used to help manage Melbourne's stormwater quality and river health.*